

28th International Conference on IT Applications and Management

International Collaboration in the Data-centered World

February 21 ~ 24 2024



International ITAM Society



Korea Data Strategy Society



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28th International Conference on IT Applications and Management

Theme: Data-centered Collaboration for enhanced social capability

Hosted and Supported by Korea Data Strategy Society, Korea Internet e-Commerce Association,

Korea Data Agency, Dayeh University

February 21 ~ 24 2024

Venue: Dayeh University, Changhua, Taiwan

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Compiled by

Sateesh Kumar Ojha (Lincoln U., Malaysia)

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Letter from the Chairman of IITAMS

On ITAM-28, Taiwan



Ladies and Gentlemen, Distinguished Guests,

It is with great honor and excitement that I welcome you to the International Conference on IT Applications and Management. As the Chairman of this prestigious event, I am thrilled to see such a diverse and accomplished gathering of professionals, scholars, and enthusiasts from around the world. This year, our conference is centered around a theme that is not only timely but also pivotal in shaping the future of technology and its impact on society—“Data-Centered Collaboration for Enhanced Social Capability.”

In the rapidly evolving landscape of Information Technology, we find ourselves standing at the crossroads of innovation and societal transformation. The digital era has ushered in unprecedented opportunities and challenges, and it is our collective responsibility to harness the power of data-centered collaboration to enhance our social capability. The decisions we make and the technologies we develop today will ripple through generations, influencing the way we connect, collaborate, and address the complex issues facing our global community.

As we delve into the heart of this year’s theme, let us first recognize the profound influence of data in our lives. Data has become the lifeblood of the digital age, driving advancements in artificial intelligence, machine learning, and analytics. It is the fuel that powers innovation and fuels the engines of progress. However, the true potential of data goes beyond its technical utility. It has the transformative power to connect us, to bridge gaps, and to empower individuals and communities.

In our pursuit of enhanced social capability, collaboration becomes the cornerstone. We are no longer isolated entities but interconnected nodes in a vast network of ideas, knowledge, and experiences. Data-centered collaboration unlocks synergies that can propel us towards solutions for the most pressing challenges of our time, from healthcare and education to environmental sustainability and social equity.

Let us reflect on the evolution of collaboration itself. Traditionally, collaboration was confined to physical spaces, limited by geographical constraints. The digital revolution has shattered these barriers, creating a borderless environment where ideas flow freely across continents. This interconnectedness presents us with a unique opportunity to leverage data as a catalyst for meaningful collaboration that transcends borders and cultural divides.

As we navigate the intricacies of data-centered collaboration, it is crucial to address the ethical considerations that accompany the vast amounts of data at our disposal. Privacy, security, and responsible use of data must be at the forefront of our discussions. We must ensure that the benefits of collaboration do not come at the

expense of individual rights and societal well-being. Striking the right balance is paramount to building trust in the digital ecosystem.

Furthermore, let us not forget the role of technology in promoting inclusivity. The digital divide remains a challenge, with disparities in access to technology persisting across regions and demographics. As we explore data-centered collaboration, we must be mindful of creating solutions that are accessible to all, leaving no one behind in the journey towards an enhanced social capability.

In conclusion, this conference serves as a platform for us to collectively envision and shape a future where data becomes a force for positive change. The theme of data-centered collaboration for enhanced social capability is not just a topic for discussion but a call to action. It is an invitation to collaborate, innovate, and pave the way for a more connected, inclusive, and empowered global society.

I am confident that the discussions and insights shared during this conference will contribute to the advancement of technology in a manner that aligns with our shared values and aspirations. As we embark on this journey together, let us embrace the opportunities that data-centered collaboration presents and commit ourselves to building a future that benefits all of humanity.

Thank you, and I wish you all a fruitful and inspiring conference ahead.

A handwritten signature in black ink, reading "Namjae Cho". The script is fluid and cursive, with the first name "Namjae" and last name "Cho" clearly distinguishable.

Namjae Cho

Chairman, International ITAM Society
Professor of Hanyang University, Seoul, Korea
Together with.

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The International Conference on IT Applications and Management (ITAM) is an international forum which is designed to facilitate the exchange of ideas, knowledge and advances in research and for discussion of the state of the art application and management of information technologies. Submissions of high quality papers are invited for peer review.

The main theme of the 28th ITAM conference (ITAM-28) is “**Data-centered Collaboration For Enhanced Social Capability**” This theme covers the technology-related business collaboration for the betterment of social relations, which is expected to transform the future of the quality of life. Changes in the work, life, business and infrastructure are expected to open up new opportunities as well as challenges. An affiliated symposium on “**The Future of Asia**” deals with international collaboration issues in education, management and culture. Post-conference events will include visits to Jinmen Island and industrial locations.

CFP: Topics for the submission include:

- Cases in International Data Collaboration
- Data Strategies and Data-driven Innovations
- Virtual International Collaboration
- Digital Twins in Production and Consumption
- Data Analytics and Business Informatics
- Management of Data Quality, Security and Privacy
- Managing Trust in Intelligent Technology Systems
- Creativity, Innovation and Technology Entrepreneurship
- Smart Connected Products and the Reformation of Business Relationships
- Design Thinking for Value Creation
- Digital Transformation of Industries and Social Infrastructure
- Digital Transformation of Tourism, Education, Commerce and Healthcare
- Management of Intelligence Technology
- Business Governance, Family Business and Entrepreneurship Succession
- Business Co-creation and Marketing in the age of Hyper Connectivity
- Paralleling Digital transformation with Business Sustainability and Resilience
- Culture, Knowledge and Geo-Technological Transformation
- Meta-verse and Hyper Connectivity
- Social and Psychological Identities of the Multiverse Life
- Humanity Value in the Age of Technology Abundance

Submissions:

Prospective authors should submit 6-10 pages of manuscript electronically. Submitted papers should follow ITAM paper format consistent to APA standard.

Submission: njcho@hanyang.ac.kr

Submission guidelines are at: <http://itam2024.concepts.tw>

Selected papers will be considered in a special issue of affiliated journals.

-Journal of IT Applications and Management (KCI listed).

-Asia Journal of Information and Communication (Korean Government publication)

Important Dates:

January 5, 2024	Extended Abstract Due
January 31, 2024	Camera-ready Paper Due
February 21~24, 2024	Conference, ITAM-28, Changhua, Taiwan

Registration Fee

Participants	Registration
All Participants	USD 200
Students and Accompanies	USD 100



International ITAM Society

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28th International Conference on IT Applications and Management

THEME: DATA-CENTERED COLLABORATION FOR ENHANCED SOCIAL CAPABILITY

Hosted and Supported by Korea Data Strategy Society, Korea Internet e-Commerce Association,

Korea Data Agency, Dayeh University

February 21 ~ 24 2024

Pre-Congress Industrial Visit and Transportation (February 21)

Time	Events
February 21, TUESDAY 08:30~21:00	08:30 Assemble in front of Hotel Midtown Richardson 09:00~15:00 Taipei Tour and industrial visit 16:00~19:00 Move to Changhua 19:00~21:00 Dinner at Grand View Hotel Accommodate at the conference hotel (Grand View Hotel)

[PROGRAM]

Conference Inauguration Plenary Session (February 22, 2024, THURSDAY)

Time	ITAM-28 Conference and Data-Centered International Collaboration Forum Program
08:30~09:00	Registration
	Plenary Inauguration Session
09:00~10:30	Opening Announcement - Yi-Fen Huang (Chair of Org. Committee, Dayeh U., Taiwan) Welcoming Remarks - Wen Chang Fang (President, Dayeh University, Taiwan) Greeting Speech - Jeong Hoon Lee (President of KDSS, Hansung U., Korea) - Chi Chien Wang (Dean, School of Business, Dayeh U., Taiwan) - Namjae Cho (Chairman, International ITAM Society, Hanyang U. Korea) Keynote Speech Speaker1: Alex Peter Queen (CEO, Queen & Co, Japan) Theme: Empowering Innovation in Asia: The Transformative Role of Low/No-code Tools Across Industries Speaker2: Kanes Rajah (Executive Director, CEPD London, UK) Theme: The Human Mind and AI in the Knowledge Hierarchy

Parallel Technical Sessions (February 22, 2024, THURSDAY)

Time	Track A	Track B	Track C
Session 1 10:30 ~12:10	Session A1 Intelligent Market Interaction Chair: Weishen Wu (Da-Yeh U., Taiwan)	Session B1 Trustworthiness in Business and Technology Chair: Yanki Hartijasti (U. of Indonesia)	Session C1 Designing Interaction with Intelligent Technology Chair: Tae Soo Moon (Dongguk U., Korea)
	A1.1 Will continue using SRT? The Impact of Smart Retail Technology (SRT) Attributes and Usage Assessment on Continuance Intention Fan-Yun Pai (Nat'l Changhua U. of Ed., Taiwan), Tsu-Ming Yeh, Yi-Zhen Jiang, Tan-Wei Chao (Nat'l Quemoy U., Taiwan)	B1.1 Evaluating Conversational AI Systems for Responsible Integration in Education: A Comprehensive Framework Utkarsh Mittal (The Gap Inc, USA) Namjae Cho (Hanyang U., Korea) online presentation	C1.1 Applying Deep Learning and Data Augmentation Techniques to Cardiac Arrhythmia Detection Yun-Wei Chu (Nat'l Defense U., Taiwan) Jun-Liang Guo (Ming Chuan U., Taiwan), Liang-Chu Chen (Nat'l Defense U., Taiwan)
	A1.2 Effect of information provision of e-commerce platform on reuse intention through customer satisfaction: Moderating roles of information recency and information playfulness Geukjoo Kang, Wonjong Kim (Gyeongsang Nat'l U., Korea)	B1.2 Customer Service Trust and Intention: The Conversational AI Satisfaction View Abbott Po Shun Chen, Yi Jie Lin (Chaoyang U. of Tech., Taiwan)	C1.2 Impact of Value and Feedback of Facility AI Platform Service on Organization Performance based on SERVQUAL Model Byongkoo Lee (ING Global, Korea) Taesoo Moon (Dongguk U., Korea)
	A1.3 Are you tired of scanning QR code? An empirical study of digital menu Chun Hua Hsiao, Shu Hsueh, (Kainan U., Taiwan)	B1.3 Analyzing the Effect of Trust in Reviews on Trust in a Product and a Company: Using the Trust Transfer Theory Namjae Cho, Xiaochen Li (Hanyang U., Korea) Giseob Yu (Kyungpook Nat'l. U., Korea)	C1.3 Decentralized Identifiers Threshold-Aware Authentication with Zero-Knowledge Proof You-Lun Yang, Yean-Fu Wen (Nat'l Taipei U., Taiwan), Chih-Chien Wang (Nat'l Taipei U. & Da-Yeh U., Taiwan)
	A1.4 Exploring the Customer Journey Map and Predicting Consumer Behavior by Applying Markov Chain and Machine Learning on the Food Industry E-commerce Google Analytics Data Jun-Heng Yeh, Ching-Yu Huang, Shi-Fu Lee (Feng Chia U., Taiwan)	B1.4 Using the DEMATEL Method to Exploring The Key Factors of Using the Interactive Intelligent Health Promotion Equipment Tsu-Ming Yeh, Hsiao-Yuan Lu (Nat'l Quemoy U., Taiwan) Fan Yun Pai (Nat'l Changhua U. of Education, Taiwan)	C1.4 Subliminal Perception Mechanism of Speech Emotion and Intelligent Computation Zerong Wang, Junren Wang, Jun Wang (Fudan U., China) Mingyue Xiao (U. of Liverpool, UK), Xuan Zhou (Zhejiang U., China) Weihui Dai (Fudan U., China)
	A1.5 A Study on the Relationship between Emotional Pleasure and Flow Experience of Taiwanese BL Game Players Yi-Lin Yu (Fu Jen Cath. U., Taiwan)	B1.5 A Review Paper on Artificial Intelligence in Service Industries Lysedie Mzwandile Matsimbie, Yi-Fen Huang (Dayeh U., Taiwan)	C1.5 Utilizing the n-back task to investigate working memory and extending gerontological educational tools for applicability in school-aged children Chih-Chin Liang, Si-Jie Fu (Nat'l Formosa U., Taiwan)
		B1.6 Share or Sell? Exploring Knowledge Monetization Business Models through Trust Transfer Theory Jung-Jung Chang (Ming Chuan U., Taiwan) Liang-Chu Chen (Nat'l Defense U., Taiwan) Yu-Ciao Huang (Ming Chuan U., Taiwan)	

12:10~ 13:20	Lunch Break		
Session 2 13:20 ~15:00	Session A2: Factors on the Use of Intelligent Technology Chair: Fan Yun Pai (Nat'l Changhua U. of Ed., Taiwan)	Session B2 Technology, HR and Skill Development Chair: Santosh Rangnekar IIT Roorkee, India)	Session C2: Technology and Entrepreneurship Chair: Wonjong Kim (Gyeongsang Nat'l U., Korea)
	A2.1 Design and Experi- ment of AI Chatbot for the Apprenticeship Program in Windfarm Hung-Yun Wu, Wei- Hsiang Wang (Nat'l Chung-Hs- ing U., Taiwan) Yuh-Wen Chen (Da-Yeh U., Taiwan)	B2.1 Exploring the Impacts of Perceived Usability, Usefulness, and Security on Usage Intention for Online Recruiting Platforms Chang-jung Lin, Chiao-Yin Hsieh (Providence U., Taiwan)	C2.1 The Effects of Entrepreneurs' Personal Characteristics on Busi- ness Management and Performance: Focused on Food and Beverage(F&B) Industry Wonjong Kim, Khongorzul Gantumur (Gyeongsang Nat'l U., Korea)
	A2.2 Continuous Usage Be- havior of Facility AI Platform Service based on Expecta- tion-Confirmation Model Byongkoo Lee (ING Global, Korea) Taesoo Moon (Dongguk U., Korea)	B2.2 Exploring The Professional Career Lattice Model: A Para- digm Shift In Career Development Nguyen Van Minh, Nguyen Thi Buoi, (Nguyen Tat Thanh University, Viet- nam) online presentation	C2.2 Multivariate Analysis of Cova- riance on Characteristics Influencing Technological and Managerial Barri- ers of Technology Startups Geonil Ko (ETRI, Korea) Namjae Cho (Hanyang U., Korea)
	A2.3 Analyzing the Effects of Anthropomorphism in NPCs Applied by GPT on User Satis- faction and Loyalty Namjae Cho, Zhilan Cao (Hanyang U., Korea) Giseob Yu (Kyungpook Nat'l U., Korea)	B2.3 Burnout and Engagement in the Context of Job Demands-Re- sources Model: The Mediating and Moderating Role of Self-Efficacy Hui-Ling Tung (Da-Yeh U., Taiwan), Hsu-Mei Lee (Chung Yuan Christian U., Taiwan) Munkhzaya Narantsetseg (Databank LLC, Mongolia)	C2.3 Construct Scientific Company Business Ecosystem-Taking B Scientif- ic Company as an Example Tzong-Ru Lee (Nat' l Chung Hsing U., Taiwan), Tuomas Lappi (U. of Oulu, Finland), Yong-Shun Lin (Ling Tung U., Taiwan), Love-Lyne Moise (Nat'l Chung Hsing U., Taiwan)
	A2.4 Anthropomorphic Pack- aging Perspectives: Empathy as a Mediator in Sustainable Consumer Engagement Phong Ba Nguyen, Weishen Wu (Da- Yeh U., Taiwan)	B2.4 Learning from Supervisor and Communicative Career Compe- tencies: A Moderation-Mediation Analysis Mohit Pahwa (NMIMS U., India) Santosh Rangnekar (IIT Roorkee, India)	C2.4 The Information Content between Stock Returns and Revenue Growth Rates: Evidence from Excel- lent Governance Companies in Taiwan Wen-Chi Liu, Kuo-Hui Chang (Da-Yeh U., Taiwan)
	A2.5 The Application of Innovation Diffusion Theory and Experimental Marketing Strategy in the Adoption of AI-Generated Technology Tsui-Hsu Tsai (Takming U. of Sci. & Tech., Taiwan) Michiko Miyamoto (Nagasaki U. Japan)	B2.5 Transformational Leadership and Employee Contextual Perfor- mance: Role of Self-determination and Competency Jyoti Arya (IIM Sambalpur, India) online presentation	C2.5 The Effect of Absorptive Capacity on Technology Collaboration Perfor- mance : Focusing on the Moderating Roles of Innovation Intermediaries Hyungju Lee, Geonil Ko (ETRI, Korea) Namjae Cho (Hanyang U., Korea)
15:00~15:30	Coffee Break		

	Session A3: Innovation and Business Practice Chair: Yi-Fen Huang (Dayeh U., Taiwan)	Session B3 Tourism, Culture and Technology Chair: Si-Jie Fu (Nat'l Formosa U., Taiwan)	Session C3: Innovation and Social Change Chair: Jeong Hoon Lee (Hansung U., Korea)
Session 3 15:30 ~16:50	A3.1 An Analysis of a Korean Little Giant Company in Semiconductor Industry: Analysis of TEMC Ping Lu, Namjae Cho (Hanyang U., Korea) A3.2 The Distinction and Balance of Exploration and Exploitation on Innovation Performance Yi-Fen Huang, Buyan-Undrakh. Ch, (Da-Yeh U., Taiwan) A3.3 The Impact of Collaboration Capabilities on the Supply Chain Performance: The Perspective of Resource Orchestration Theory Sungbae Kang, Taesoo Moon (Dongguk U., Korea)	B3.1 Study on Military Veterans Returning to Their Garrison in Kinmen: Nostalgia Tourism and Well-being Hsu P. S., Wu P. C. (Nat'l Defense U., Taiwan) B3.2 Rendang: Agent of Indonesian Culture in the International World Yanki Hartijasti (U. of Indonesia) B3.3 Tourism Management and Customers' Satisfaction: A Natural Language Processing and Machine Learning Framework Giulia Contu, Cinzia Dessi, Carla Massidda, Marco Ortu (U. of Cagliari, Italy) online presentation	C3.1 Challenges of obtaining data and availing them for future research on information and technology Pradeep Bastola, Sateesh Kumar Ojha (Lincoln U. College, Malaysia), online presentation C3.2 financial literacy: A bibliometric study, review, and direction for future research Rachit Dwivedi, Pragya Singh (IIT Allahabad, India) online presentation C3.3 Prediction of Consumer Behavior using decision trees and Random Forest Algorithm Sateesh Kumar Ojha (Lincoln U. Malaysia) Yashodham Tripathi (City Education Foundation, Kathmandu) online presentation
16:50~ 17:30	Valedictory Session Valedictory Remark Announcement of invitation to ITAM-29		
18:00~	Conference Banquet		

Post-Congress Industrial Visit and Cultural Activities (February 23 & 24)

Time	Events
February 23, FRIDAY 09:00~18:00	06:00~10:00 Move by Chartered bus from Dayeh University to Taichung Airport And Fly to Kinmen Island 13:00~17:00 Company Visit and University Visit
February 24, SATURDAY 09:00~18:00	09:00~15:00 Cultural Tour and industrial visit 16:00~18:00 Return back to Taipei

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Will continue using SRT? The Impact of Smart Retail Technology (SRT) Attributes and Usage Assessment on Continuance Intention

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Abstract

The application of smart technology has become a global trend. Retailers can employ smart retail technology to increase perceived value, satisfaction and revisiting intention. Most of previous research has focused on increasing consumer willingness to use smart retail technology (SRT). However, this study empathizes on the relationships among smart retail technology attributes (usefulness, ease of use, enjoyment, and interactivity) and the impact of usage experience assessment (perceived value and user satisfaction) and then the impact on intentions to use smart retail technology and retailers' loyalty. The research findings demonstrate that smart retail technology attributes indeed enhance perceived value and user satisfaction. Furthermore, usage experience assessment also contributes to the continued intention to use smart retail technology and retail store loyalty. Therefore, when consumers have a positive usage experience with smart retail technology, they are inclined to continue using this technology and revisit retail stores that utilize it.

Keywords

Smart retail technology, Smart retail technology attribute, Continuous usage, Retailer loyalty

Introduction

With the continuous innovation in technology and changes in consumer behavior, the retail industry has entered the era of 4.0. In retail industry, it no longer solely satisfies individual material needs but has gradually evolved into the development of service experiences and personalized demands. Consumers now have a more diverse range of choices when selecting brands, and in the environment of personalized technology applications, consumer behavior is no longer primarily focused on physical channels for the shopping experience. Instead, it combines virtual and physical retail channel environments to complete shopping and consumption behaviors.

The innovation in technology not only creates more sales channels but also generates additional opportunities for traditional sales channels. This results in the formation of an omnichannel marketing model in the retail industry [1] [2]

The advent of the retail era, driven by technological advancements, has ignited the trend of unmanned stores. For instance, since Amazon launched the unmanned store "Amazon Go" in Seattle in January 2018, equipped with cameras, sensors, weight and volume sensors, as well as

infrared sensors, the store has leveraged technologies like cloud computing, machine learning, computer vision, and sensor detectors to develop the "Just Walk Out Technology" business model. For consumers, this means they can simply walk out of the store, and the payment is automatically processed through their mobile phones, eliminating the need to wait in line and saving time. This design, which reduces non-monetary costs for consumers, essentially creates value. For retailers, it reduces labor allocation and accelerates operational efficiency, resulting in greater benefits for both buyers and sellers.

The integration of smart technology with retail services has already influenced or changed traditional retail business models. Smart retail has also altered traditional marketing approaches, demonstrating that physical spaces are not being replaced due to environmental changes. Smart retail technologies provide consumers with convenience, diversity, and entertainment, creating delightful consumption experiences and allowing consumers to explore the joys of smart retail [3].

This research incorporates rational attributes such as perceived usefulness and perceived ease of use, along with emotional attributes. It explores the impact of both

rational and emotional attributes on post-use evaluations of smart retail technology (perceived value and satisfaction), aiming to better reflect the real situations consumers face during decision-making. Finally, the study investigates the impact of post-use evaluations of smart retail technology on the intention to use smart retail and its influence on the loyalty towards retail stores implementing smart retail technology.

Literature Review

SST Attribute and SRT Value

The Technology Acceptance Model (TAM) originated from the Theory of Reasoned Action [4] and the Theory of Planned Behavior [5]. Derived from these theories, TAM is primarily used to explain and explore the driving factors influencing the adoption of new technology by individuals and organizations [6][7][8]. Researchers can effectively utilize the TAM model to identify the motivations and intentions of consumers to adopt new technology. For example, Roy et al. [9] indicate that the perceived usefulness and perceived ease of use variables within the TAM model are critical determinants of consumer behavior in the retail industry, with these two attributes having a positive impact on evaluations and attitudes toward usage.

On the other hand, although attitude is one of the variables influencing behavioral intention in the Theory of Planned Behavior [5], it often leans toward utilitarian or rational aspects. Similarly, the TAM model, derived from these theories, follows suit, with perceived usefulness and perceived ease of use being typical utilitarian factors influencing attitudes. Ahtola [10] argues that both utilitarian and hedonic aspects in consumer attitudes are essential when studying consumer behavior. Roy et al. [9] emphasize that perceived enjoyment and perceived interactivity are indispensable emotional dimensions in consumer attitudes.

Furthermore, when customers evaluate the overall experiential value, it encompasses the entire service process before, during, and after consumption [11]. Customer involvement in creating value is included in the evaluation process, gradually influencing satisfaction and loyalty to the brand or company. Therefore, when retailers provide smart retail technology, making customers perceive the convenience and interactive quality of the technology, customers find it interesting and beneficial compared to the effort they put in. Hence, perceived value is also one of the important variables influencing whether customers adopt new technology.

Perceived ease of use, on the other hand, refers to the degree to which users perceive technology as easy to use [12]. Chang & Chen [13] believe that perceived ease of use is the extent to which an individual can use a specific information technology effortlessly. In other words, when users operate an information system, they perceive the convenience of use and can quickly acquire information,

enhance learning, or improve creativity [14]. In summary, perceived ease of use refers to the extent to which users perceive a technology as simple and easy to operate, that is, users can operate the technology without expending too much time or effort to complete tasks.

Perceived value, as defined by Zeithaml [15], is the overall assessment by consumers of the utility obtained from a product or service, involving the perception between what is received and given. Roy et al. [9] and Chung et al. [16] suggest that smart retail technology (SRT) significantly enhances the shopping value by assisting consumers in efficiently selecting products, checking out, and packaging. It dramatically reduces manual checkout error rates and saves checkout and queuing time, enhancing shopping value. In other words, smart retail systems, by lowering the cost of mental effort, increase price value. Park & Chen [17] found that customers' perceived usefulness positively influences their willingness to use smart systems. Thus, when smart technology is simple and practical, consumers perceive greater value in using it. Therefore, we proposed the following hypothesis:

H1a : Perceived Usefulness is significantly and positively related to SRT value.

H1b : Perceived ease of use is significantly and positively related to SRT value.

Flow Theory suggests that enjoyment is an emotion generated through the interaction between individuals and their environment [18]. It describes a pattern of immersion in a shared experience where users focus their attention on a specific area, filtering out irrelevant perceptions or thoughts. Users become immersed and focused when certain situations or events make them feel novel and enjoyable.

Perceived interactivity was initially proposed by Newhagen, Codes, and Levy [19], defining it as the interactive characteristics between a user's inner self and information technology, representing the psychological perceptions users have about the interaction. In the rapidly evolving information age, perceived interactivity has become a crucial indicator. Good interaction with a particular technology has a positive impact on users' attitudes and behavior [20]. Heeter [21] suggests that due to individual differences, interaction with information technology leads to different self-perceptions, making perceived interactivity an aspect of cognition. It involves consumers' subjective perceptions and overall evaluations of the interactive aspects of smart retail systems. Thus, the design of smart retail systems in meeting consumer shopping goals and tasks depends on the degree of interaction provided to consumers. This study incorporates perceived interactivity as one of the attributes of smart retail technology.

When consumers use smart retail technology and perceive it as fun or entertaining, they immerse themselves in a pleasant atmosphere. Compared to traditional retail

services, smart retail technology offers more emotional benefits, making consumers more willing to use such services[22][23]. Moreover, many consumers using information technology tend to use the technology for enjoyment or fun, thereby increasing perceived benefits and usage intention.

Perceived enjoyment prompts consumers to immerse themselves in a delightful environment [25][26]. Therefore, the higher the level of fun in smart technology, the greater the perceived value consumers derive from using SSTs. Also, if SST can provide sufficient and rich information to meet consumers' objectives and can communicate effectively with consumers, it can enhance consumer trust and ultimately increase perceived value. In summary, when users feel that SST is fun and highly interactive, their perceived value of SST will increase. Therefore, we proposed the following hypotheses:

H1c : Perceived enjoyment is significantly and positively related to SRT value.

H1d : Perceived interactivity is significantly and positively related to SRT value.

SST and Satisfaction

According to [27], satisfaction is primarily the result of comparing perceptions before and after using a product. Therefore, if the actual effects of a product exceed the consumer's expectations, the consumer will feel satisfied. Shamsudin et al. [28] also define satisfaction as the comparison between consumer expectations and actual perceptions of a product, leading to feelings of pleasure or disappointment within the consumer.

When customers can enhance their work efficiency or performance through the use of information systems, they tend to generate positive emotional responses towards the system. This also signifies that perceived usefulness has a positive impact on satisfaction. Venkatesh [23] conducted research on the relationship between perceived usefulness and perceived ease of use, finding that the higher the individual's perception of the system's ease of use in controlling, and the efficiency improvement in shopping, the more positive the user's attitude towards the use of new technology or a specific system. The study also indicates that when perceived usefulness and perceived ease of use significantly positively influence the user's attitude towards usage, satisfaction tends to increase accordingly. In summary, when users engage with smart retail technology and can complete shopping more quickly while feeling it is easy to operate, their satisfaction with the use of smart retail technology also increases. Therefore, H2a and H2b were proposed.

H2a : Perceived Usefulness is significantly and positively related to satisfaction.

H2b : Perceived ease of use is significantly and positively related to satisfaction.

The entertainment or fun experienced by users during

the process of using information technology products has been a notable factor in recent studies on information technology adoption behavior. Therefore, if users generate a sense of fun or even immerse themselves in a pleasurable environment during the initial use of a new technology, it leads to satisfaction with adopting the new information technology system. This positive experience also influences the user's attitude towards the system, subsequently increasing the likelihood of continued adoption of information technology systems in the future.

Venkatesh & Davis (2000) pointed out that during the use of technology systems, user-friendly interaction design is a crucial factor. The friendly interaction process of the user interface has a positive impact on the user's satisfaction with the use of new technology. Therefore, applying the concept of interaction in this study, through the interactive features available in the system, users will develop a positive attitude towards the system's interactivity. This positive attitude also applies to the use of smart retail systems. H2c and H2d are proposed.

H1c : Perceived enjoyment is significantly and positively related to satisfaction.

H1d : Perceived interactivity is significantly and positively related to satisfaction.

SST value and Satisfaction

Perceived value is one of the factors influencing customer satisfaction [29]. Measuring satisfaction requires evaluating perceived value first. Research indicates that perceived value represents customers' perception of the nature of the exchange relationship with their supplier, and satisfaction reflects the overall sense customers derive from perceived value. Therefore, the lack of consideration for the assessment of customer perceived value dimensions may lead to discrepancies in product or service planning and execution. Value can directly impact consumers' satisfaction with the provider of the service or product. Fishbein & Ajzen [4] also proposed that perceived value is the result of evaluating benefits and total costs during the transaction process, while customer satisfaction is the overall perception consumers have after obtaining a product or service. Thus, when customers perceive a higher value in purchasing a product or service, the satisfaction obtained will also increase; if the cost incurred is higher than the perceived value, satisfaction will be reduced. H3 was proposed accordingly.

H3 : Perceived SST value is significantly and positively related to satisfaction.

SRT value, Satisfaction and Future Behavior

Davis [12] defines intention to use as the degree to which users are willing to use a specific information system, and user attitudes and perceived usefulness toward the system are important determinants of intention to use. In the Technology Acceptance Model (TAM), behavioral intention is defined as 'the degree to which users intend

to continue using a technology system after its initial use' [12]. Fishbein & Ajzen [4] argue that intention to use refers to an individual's willingness to engage in a specific behavior. Since intention is often used to represent actual behavior, most studies use intention to represent the individual's thoughts and feelings formed after trying something, resulting in behavioral intentions and reactions.

Sirdeshmukh et al. [30] pointed out that consumers evaluate the post-use value and assess their loyalty to the company. If the evaluation shows a higher value obtained, consumers will have higher loyalty. Therefore, service providers must understand consumer needs and enhance perceived value to meet diverse consumer demands, obtain profits, and make consumers willing to positively recommend the service provider to others [31]. Therefore, to maintain customer loyalty, customers must have a good perceived value, as perceived value can simultaneously affect both attitudinal and behavioral loyalty. If a company can provide value that differs from competitors, it can gain customer loyalty. Therefore, H4a and H4b were proposed.

H4a : Perceived SRT value is significantly and positively related to continuous usage intention toward SRT.

H4b : Perceived SRT value is significantly and positively related to customer loyalty.

Higher customer satisfaction leads to higher frequency and volume of product purchases by customers. Continuous intention is influenced by users' satisfaction with prior use [32]. Zeithaml et al. [15] point out that when consumers are satisfied with a company's service, they exhibit certain behaviors, including loyalty to the company, a willingness to pay higher prices, and a reduced likelihood of complaining to others about the company. Customer satisfaction arises from the company's ability to meet their needs and desires, leading to continued purchases and loyalty. Therefore, many companies aim to increase customer satisfaction and loyalty to enhance profitability. In other words, having many loyal customers means that more customers are willing to continue patronizing the company, ensuring a stable cash flow for the business. On the other hand, high loyalty implies that customers are willing to purchase from the company for an extended period, resulting in a higher customer lifetime value for the business. Therefore, how companies maintain relationships with customers, establish long-lasting positive connections, and enhance customer loyalty has always been a primary goal for businesses considering how to build or implement relationship marketing strategies [33]. Therefore, H5a and H5b were proposed.

H5a : Satisfaction on SRT is significantly and positively related to continuous usage intention toward SRT.

H5b : Satisfaction on SRT is significantly and

positively related to customer loyalty.

The proposed conceptual model is demonstrated in Figure 1.

Figure 1 Conceptual model
Research Method

We adopt survey as the research method, and the research design utilizes the Retrospective Self-Report approach for questionnaire development. Operational definitions for variables are established based on past literature, and questionnaire items are designed accordingly. The measurement of research variables across different dimensions is adapted from relevant literature and modified to align with the specific objectives of this study. The questionnaire scale ranges from low to high scores, with response options including "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree," corresponding to scores from 1 to 5, respectively. The definition and scale of variables are demonstrated in Table 1.

Table 1 Variables and scales		
Variables	Items	
Perceived use-fulness [12][25]	1.	Using SRT allows me to complete tasks or shopping more quickly.
	2.	Using SRT enables me to access more retail services and information.
	3.	Using SRT makes it more convenient for me to obtain retail services.
	4.	Using SRT makes me perceive smart retail as a very useful service.
Perceived ease of use [12][25]	1.	Using SRT makes me feel that it is easy to operate.
	2.	I can become proficient in using SRT in a short period.
	3.	I can easily use SRT to complete shopping or tasks.
	4.	I find it difficult to use SRT (R).
Perceived enjoyment [9]	1.	Using SRT makes me feel very interested.
	2.	Using SRT puts me in a pleasant mood.
	3.	Using SRT arouses my curiosity.
	4.	Using SRT makes me want to explore its features.

Perceived inter-activity [9][34]	1. The interactive quality provided by SRT can guide me in completing shopping tasks. 2. During the interaction with SRT, I can obtain the responses I want. 3. Overall, I really enjoy the feeling of interacting with SRT.
Perceived SST value [35]	1. Using SRT can provide me with more product information and services. 2. I am very satisfied with the performance of SRT. 3. Using SRT brings me a sense of pleasure. 4. Using SRT makes me feel good. 5. Using SRT can give me a sense of accomplishment. 6. Using SRT can boost my confidence.
Usage satisfaction [9][27]	1. The SRT provided by the retailer has practical value. 2. I feel confident when retailers offer SRT. 3. Overall, I am satisfied with the SRT provided by the retailer. 4. Overall, I am willing to use the SRT offered by the retail store.
Continuous usage intention [9][35]	1. I would be willing to try SRT of other retailers. 2. If possible, I intend to continue using SRT. 3. In the future, I will use SRT.
Loyalty on the store [36]	1. If I want to purchase the same product, I would prioritize buying it from the smart retail store. 2. I would be willing to recommend the smart retail store to friends and family. 3. I would be willing to revisit the smart retail store for future purchases.

The formal questionnaire was targeted at adult users who had experience with smart retail technology. It aimed to investigate the users' experiences in using retail technology in stores to purchase products or services. The questionnaire was distributed online and promotional posts were made on social media platforms such as Facebook and Instagram. Incentives, such as prize draws, were provided to enhance respondent participation and increase the credibility of the collected questionnaires.

Research Results

After data collection, this study received a total of 345 completed questionnaires. Ultimately, 311 valid questionnaires were used for model validation and analysis. The analytical method employed was Partial Least Squares Structural Equation Modeling (PLS SEM), and the analysis was conducted using Smart PLS.

Demographic Data of Respondents

Among the respondents, there were more females, with a total of 186 samples, accounting for 59.8% of the total sample size. The majority of respondents fell into the age group of 21-30 years, with 189 samples, representing 60.8% of the total sample size. Regarding occupation, students comprised the largest group with 114 samples, constituting 36.7% of the total sample, followed by 49 samples from the service industry, making up 15.8% of the total. In terms of location, respondents from areas outside the six major cities were the most numerous, with 111 samples, representing 35.7% of the total sample. The sample of this study covers a wide range of industries and is distributed across different regions. Although the majority are concentrated in the 21-40 age group, consumers with purchasing power and the willingness to use smart retail technology are likely to fall within this age range. Therefore, the sample should be considered representative.

Outer Model Analysis

There are eight variables in the proposed model. The composite reliability of all variables is greater than 0.8, meeting the standard of being greater than 0.7. Except for the Cronbach's α value of perceived interactivity, which is 0.792, the rest are all above 0.8. This indicates that the collected valid samples in this study are consistent and have good reliability.

Convergent validity is measured by factor loadings, average variance extracted (AVE), and composite reliability. Hair, Black, Babin, Anderson, & Tatham [37] suggested that factor loadings above 0.6 are preferable. In this study, the factor loadings for all constructs are above 0.6, and the AVE is above 0.5, demonstrating that the questionnaire in this study meets the standard and has convergent validity.

Discriminant validity refers to the correlation between different constructs. In this study, the square root of the AVE for each variable needs to be greater than the correlation coefficients between the variables. Therefore, the variables in this study meet the criterion for discriminant validity.

Following the analysis of reliability and validity, factor loadings, Cronbach's α , composite reliability (C.R.), and AVE are all within the standard, so no items were deleted.

Inner Model Analysis

Smart PLS 3.0 was employed for data analysis. According to Hu & Bentler [38], when the Standardized Root Mean Square Residual (SRMR) values of the saturated model and estimated model are both below 0.08, the model exhibits good fit. In this study, the SRMR values for the saturated model and estimated model were 0.073 and 0.077, respectively, both below 0.08. Therefore, this study demonstrates a good model fit.

The results of the Partial Least Squares (PLS) structural model analysis indicate, at the 0.05 significance level, support for hypotheses H1a, H1c, H1d, H2a, H2d, H3, H4a, H4b, H5a, and H5b. However, hypotheses H1b and H2c are not supported. The path analysis results in Figure 2 show R-squared values for perceived value, satisfaction, continued intention to use smart retail technology, and retail store loyalty as 0.739, 0.697, 0.624, and 0.599, respectively, indicating a significant explanatory power for the latent variables included in this study's model. Finally, the results of hypothesis testing and structural equation model path coefficients are summarized in Tables 3 and 4.

Table 3 Path coefficient

Hypothes	Path	STD Path coefficient	Standard deviation	t
H1a	Usefulness → perceived value	0.217	0.052	4.153***
H1b	Ease of use→ perceived value	-0.051	0.037	1.375
H1c	Enjoyment → perceived value	0.403	0.055	7.322***
H1d	Interactivity → perceived value	0.394	0.051	7.772***
H2a	Usefulness → satisfaction	0.318	0.067	4.714***
H2b	Ease of use→ satisfaction	0.168	0.044	3.807***
H2c	Enjoyment →satisfaction	-0.052	0.066	0.786
H2d	Interactivity →satisfaction	0.113	0.061	1.843*
H3	Perceived value → satisfaction	0.318	0.086	4.684***
H4a	Perceived value → continuous intention toward SRT	0.191	0.058	3.295***
H4b	Perceived value → loyalty	0.389	0.063	6.130***
H5a	Satisfaction → continuous intention toward SRT	0.635	0.057	11.143***
H5b	Satisfaction → loyalty	0.436	0.057	7.663***

*:p<0.05; **:p<0.01;***:p<0.001

Discussion and Conclusion

The transformation and application of smart retail have evolved with the times. Retailers integrating smart technology into their services has become a prevailing trend. Both retailers and consumers have altered their consumption behaviors due to the changes in the era. However, in the era of Smart Retail 4.0, retailers should also contemplate how to ensure customer satisfaction, usage intent, and store loyalty concerning the smart retail services provided. This study subdivides the attributes of smart retail technology into perceived usefulness, perceived ease of use, perceived enjoyment, and perceived interactivity, exploring the relationships between these attributes and usage evaluation and future usage intent. Based on the extension of the Technology Acceptance Model, the study investigates how retailers can influence consumer value and usage satisfaction through these attributes and whether it generates consumers' intent to use. The results show that the attributes of smart retail (perceived usefulness, perceived enjoyment, perceived interactivity) do enhance perceived value. Additionally, perceived usefulness, perceived ease of use, and perceived interactivity also contribute to increased usage satisfaction. The study finds that perceived value also has a positive impact on satisfaction. Furthermore, the results indicate that usage evaluation (perceived value, usage satisfaction) effectively enhances the continuous usage intent of smart retail technology and store loyalty. Therefore, the study suggests that retailers, to increase competitiveness, should not only utilize these attributes of smart retail technology but also consider which attributes of services or technologies consumers truly care about. By timely adjusting the provided technology or service information, retailers can enhance value and satisfaction in the process of using smart retail technology, ensuring continuous usage by consumers in the future.

Based on the empirical results of the research hypotheses, the study summarizes the following research findings as practical suggestion for retailers:

1. Utilize the attributes of smart retail technology (e.g., ease of operation, interaction processes) and other services to instantly provide consumers with the information and services they need, enhancing customer perceived value and satisfaction. This encourages consumers' willingness to continue using smart retail technology and store loyalty.
2. Among the attributes of smart retail technology, perceived usefulness has a greater positive impact on perceived value and user satisfaction compared to other attributes. Therefore, in the fast-paced retail market where users value whether technology can assist in their shopping process, enhancing customer perception of "usefulness" should be one of the most important considerations for retailers. Especially in situations where resources are limited, how to introduce smart technology to make consumers more efficiently complete the entire shopping journey, from data search and solution comparison to shopping and post-purchase behavior, should be a challenge for retailers.
3. The relationship between user attributes, usage evaluation, and future usage intent varies among users in different regions. Therefore, retailers should effectively grasp consumer information to precisely provide information or services on smart retail technology that consumers find more valuable and satisfaction-enhancing after use. In other words, as consumer preferences differ, one of the characteristics of smart retail is the collection of consumer behavioral data to provide personalized services. Therefore, companies should collect and analyze relevant data on consumer behavior on a large scale and use the data as a basis for decision-making.

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Effect of information provision of e-commerce platform on reuse intention through customer satisfaction: Moderating roles of information recency and information playfulness

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Abstract

This study investigates the relationship between information provision of e-commerce platform, customer satisfaction, and reuse intention of customer. Especially, we pay attention to the moderating roles of information recency and information playfulness and the mediating role of customer satisfaction between information provision and reuse intention. Although there have been some studies on e-commerce platform, the researchers relatively overlooked the multifaceted aspects of information delivered by the platform. In this study, we focused on the customers buying pension products that have been rapidly growing since the recent coronavirus pandemic, in order to scrutinize the effectiveness of information delivery online. As a result of the empirical analysis, there was a positive relationship between information provision and customer satisfaction. Also, the positive relationship between information provision and customer satisfaction was stronger when each information recency and information playfulness was higher, respectively. Finally, customer satisfaction partially mediated the relationship between information provision and reuse intention of customer. The findings of this study provide important theoretical contributions and practical implications for e-commerce platform, customer attitude, and behavioral intention of customer.

Keywords

Information Provision, Information Recency, Information Playfulness, Customer Satisfaction, Reuse Intention

Introduction

The tourism industry has achieved continued growth due to the full implementation of the five-day work week. The number of trips has increased, and the number of accommodations offering various experience programs has also increased. However, the COVID-19 pandemic has led to a decrease in outdoor activities and an increase in the proportion of online product purchases. The pension industry also had a high proportion of online sales, but its sales decreased. There were many reasons for this, but the high level of online advertising costs had a large impact. The sales of social commerce companies are generated through marketing activities targeting many subscribers. Small-scale pension operators can sign up as sellers of social commerce companies to carry out effective promotions at a low cost and generate high sales. Small pension operators who join social commerce companies face the following problems. First, the burden of fees is high. Second, product buyers of social commerce companies tend to concentrate on popular lodging

products. Thirdly, the problem of payment method arises. Except for some social commerce companies, payment is made over several weeks, so pension operators are bound to face management difficulties.

The scope is gradually shifting from the social commerce industry to the e-commerce platform industry. Naver is attracting consumers by combining the 4th industrial technology and shopping with its existing platform. Naver generates revenue from advertising and receives sales commissions from sellers (Jeong & Kim, 2019). What differentiates Naver Shopping from social commerce companies is its fees, additional services, and payment methods. Pension operators who signed up for Naver Shopping showed high overall satisfaction and transaction intention (Jeong & Kim, 2019). Previous research in the pension industry includes pension usage satisfaction, pension website quality, pension selection attributes, pension website image, pension service landscape, and social commerce subscription attributes (Kang & Jeong, 2015; Jeong & Cho, 2020; Cho & Cho, 2008; Han, 2008;

Han & Hyeon, 2010) were conducted. Studies verifying the influence of pension products on e-commerce platforms were very limited.

Although the importance of utilizing e-commerce platforms continues to increase, research in this field has been relatively insufficient. Accordingly, this study focused on pension products whose interest increased significantly during and after the COVID-19 situation unfolded.

The purpose of this study is to examine the relationship between information provision, customer satisfaction, and intention to continue using e-commerce platform users. This is presented in detail as follows. First, we will examine the relationship between information provision and customer satisfaction and expand existing understanding. Second, focusing on the pension industry on an e-commerce platform, we aim to provide useful implications for improving customer satisfaction by suggesting information recency and information playfulness as moderating roles that can increase customer satisfaction. Third, we aim to illuminate the causal relationship between customer satisfaction and reuse intention and at the same time verify the mediating role of customer satisfaction

Theoretical Background and Hypothesis **E-commerce platform Information Provision and Customer Satisfaction**

In the information age, a variety of information and data exist, and consumers are required to have the ability to select high-quality information. This ability entails the ability to search for valuable information that can be economically beneficial, as well as information about products and services.

In the Korean industrial market, the e-commerce market has grown rapidly along with the increase in the use of the Internet and mobile devices. The e-commerce industry is being divided according to changing times. The era of Commerce 1.0 centered on online shopping malls, the era of Commerce 2.0 with open markets as a transaction method between sellers and buyers, and the era of Commerce 3.0 with group purchasing centered on SNS, the era of commerce based on core technologies of the 4th industry. We have entered the era of 4.0 (Jeon & Kim, 2019).

E-commerce platform operators are advancing into various distribution industries by applying the 4th industrial revolution technology to PCs and mobile devices. As representative e-commerce platform companies, there are companies with IT technology such as Naver, Kakao, and Google, and they are introducing a method of providing product search, payment, and delivery all at once based on their platform.

Recently, consumers mainly use e-commerce platforms where they can obtain various information as part of the search process to purchase products. Information provision provided by an e-commerce platform is

the ability to provide information about products or services and satisfy customers (Gao & Koufaris, 2006). Additionally, sufficient information about products can help consumers' shopping process more efficiently and effectively (Yuan et al., 2018). Purchasing on e-commerce has the characteristic of relying on information and images provided by the website to make a purchase decision (Song, 2016).

According to previous studies at home and abroad, the provision of e-commerce information has been reported to have a positive effect on customers' attitudes and behavioral intentions (Oh et al., 2018; Choi & Yoo-jeong Choi, 2011; Hyun & Park, 2013; Hong et al., 2009; Gao & Koufaris, 2006; Ruihui & Cheol, 2018). However, empirical studies conducted on the domestic and foreign pension industry include online shopping malls, open markets, and SNS group purchasing methods. There is a significant lack of empirical research on the relationship between information provision, customer satisfaction, and reuse intention of e-commerce platforms.

Customers are paying attention to the information provided by e-commerce platforms in order to make correct purchasing decisions (Kim et al., 2009) and are relying on information on products and services provided by e-commerce platforms to make purchases (Tzeng et al., 2020). Consumers who do not receive sufficient product information make purchasing decisions based on inaccurate information. This is the main cause of increasing dissatisfaction with the product. As a result, customers' purchases do not continue. You will be leaving the e-commerce platform you are using. Providing quality information in e-commerce platforms is a decisive factor in significantly improving customer satisfaction. Accordingly, the causal relationship between information provision and customer satisfaction can be confirmed (Sabiote et al., 2012; Szymanski & Hise, 2000; Tzeng et al., 2020).

Based on the above discussion, we would like to propose the following hypothesis.

H1: The information provision of an e-commerce platform will have a positive relationship with customer satisfaction.

Moderating role of Information Recency

In this study, we aim to focus on the moderating effect of information recency in the relationship between the information provision of an e-commerce platform and customer satisfaction. Information up-to-dateness refers to the degree to which the latest product information is immediately delivered to consumers upon product launch, and the currentness of continuously updating the provided information. A variety of products are being released and product life cycles are shortening. It is very important to quickly deliver the latest information to consumers. The latest product information stimulates consumers' curiosity and increases purchase intention. Information recency

increases consumers' purchasing decisions.

According to previous studies at home and abroad, information recency has been reported to have a positive effect on the information provision and customer satisfaction of e-commerce platforms. It has been verified that the up-to-dateness of information on products sold in e-commerce has an influence on customer satisfaction (Shin & Cho, 2019; Lee & Lee, 2016). Accordingly, this study predicts that the positive relationship between information provision and customer satisfaction will be further strengthened by information recency.

Based on the above discussion, we would like to propose the following hypothesis..

H2: The higher the information recency of the e-commerce platform, the stronger the positive relationship between information provision and customer satisfaction.

Moderating role of Information Playfulness

Playfulness online refers to the degree to which users perceive the enjoyment, fun, and interest they feel. Playfulness is an important factor in making products and services more accessible to consumers as a means of enter-marketing that excludes commercial feelings (Jang et al., 2005). Playfulness is a factor that has a positive impact on customer satisfaction through interaction with e-commerce users. Playfulness refers to the pleasure and enjoyment of the information provided (Ballow & Pazer, 1985; Negash et al., 2003).

According to previous studies at home and abroad, information playfulness has been reported to have a positive effect on the information provision and customer satisfaction of e-commerce platforms. According to a study by Lee (2017), customers claimed that they have various enjoyable experiences through e-commerce shopping. In a study by Jeong (2015), it was explained that the elements of pleasure and mood change through shopping play a significant role. Accordingly, this study predicts that the positive relationship between information provision and customer satisfaction will be further strengthened by information playfulness.

Based on the above discussion, we would like to propose the following hypothesis.

H3: The higher the information playfulness of an e-commerce platform, the stronger the positive relationship between information provision and customer satisfaction.

Mediating role of Customer Satisfaction

Customer satisfaction is the state of meeting customers' expectations and desires regarding product or service attributes (Park & Cho, 1999). In order to increase customer satisfaction, efforts must be made to increase satisfaction by meeting customer needs and expectations. Intention is the user's desires and beliefs and consists of awareness for such actions (Beardsley, 1982). In addition, intention is an important factor that can predict customers' actual behavior. Types of intention include word of mouth

intention, recommendation intention, and reuse intention. In this way, intention has been measured from various perspectives (Roh et al., 2020; Moon & Byun, 2020; et al., 2014). Intention to reuse refers to the intention to continue using the product or service currently being used in the future.

The results of previous research measuring the mediating effect of customer satisfaction are as follows. In a study on the characteristics of online communities by Kim & Lee (2021), customer satisfaction was confirmed to have a significant mediating effect in the relationship between the characteristics of online communities and intention to continue using them. In a study on global e-commerce platforms, Kim et al. (2022) demonstrated that customer satisfaction has a significant mediating effect in the relationship between services provided by e-commerce platforms and intention to continue using them.

Accordingly, this study predicts that customer satisfaction will positively mediate the relationship between the information provision of an e-commerce platform and the intention to continue using it.

Based on the above discussion, we would like to propose the following hypothesis.

H4: Customer satisfaction will mediate the positive relationship between the information provision of an e-commerce platform and the intention to reusing it.

Methods

Respondent and Procedure

The purpose of this study is to examine the impact of the information provision of domestic e-commerce platforms on customer satisfaction and reuse intention.

Accordingly, a survey was conducted targeting consumers who used the Ecommerce platform and were over 20 years old and had experience purchasing pension products on the eCommerce platform.

A survey was conducted for approximately 30 days from May 1 to May 30, 2021. A total of 250 questionnaires were collected, of which, excluding insincere responses, the final data from 194 people were used for analysis.

Looking at the demographic characteristics of the sample, there were 84 men (43.3%) and 110 women (56.7%), and the average age was 21.9 years. Regarding marital status, 178 people (91.8%) were single and 16 people (8.2%) were married. The number of respondents' annual use was 58 people (29.9%) once, 73 people (37.6%) twice, 32 people (16.5%) three times, and 31 people (16.0%) four times. Accompanying customers included 49 family members (25.3%), 23 romantic partners (11.9%), 119 close friends (61.3%), and 3 co-workers (1.5%). These sample characteristics are considered appropriate for considering the influence of information provision, customer satisfaction, and reuse intention. Based on previous research, the causal relationship between each factor was reviewed and the influence relationship between factors was presented.

The specific model of this study is shown in <Figure 1>.

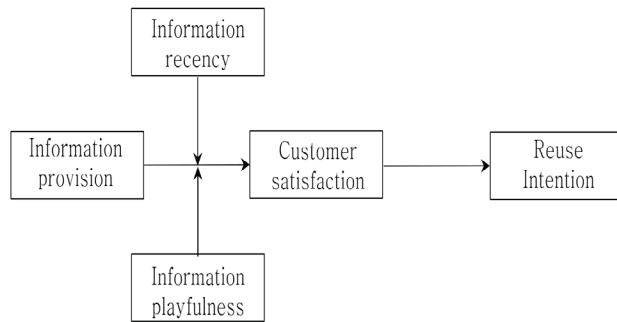


Figure 1 – Research model

Table 1 – Confirmatory Factor Analysis

VAR	Items 1	Items 2	Items 3	Items 4	Items 5	Cronbach's α
IP1	.75	.06	.29	.01	.20	.74
IP2	.67	.19	.09	.32	.09	
IP3	.62	.02	.22	.26	.15	
IP4	.61	.26	.10	.20	.10	
IR1	.16	.78	.16	.10	.21	.76
IR2	.18	.76	.17	.04	.20	
IR3	.01	.74	.13	.08	-.07	
IR4	.33	.53	.31	.24	-.20	
IPlay1	.20	.21	.78	.14	.21	.84
IPlay2	.24	.18	.73	.24	.12	
IPlay3	.12	.12	.71	.07	.26	
IPlay4	.22	.27	.69	.34	-.09	
CS1	.20	.05	.26	.79	.12	.83
CS2	.18	.19	.15	.73	.29	
CS3	.24	.11	.22	.69	.28	
RI1	.11	.07	.30	.11	.77	.76
RI2	.20	.04	.08	.35	.68	
RI3	.25	.11	.08	.47	.60	
Eigen value	2.39	2.39	2.73	2.51	1.97	11.99
Distributed explanatory	13.28	13.32	15.19	13.98	10.96	66.73

Measurement

The information provision of the e-commerce platform was measured using four questions measured by Lee (2016) among the measurement questions of Jang & Lee (2014), DeLone and McLean (2003), and Preece (1999). The contents of the survey questions were modified to suit the intent of this study. An example of a measurement item is “There are various types of information about pension products provided by e-commerce platforms.” am. It was measured on a 5-point scale from ‘not at all’ to ‘very much’.

The information recency of the e-commerce platform was measured using four questions measured by Shin & Cho (2019) among the measurement questions by Shin & Cho (2019), Lee (2016), and Cheon & Lee (2012). The

contents of the survey questions were modified to suit the intent of this study. An example of a measurement item is “Posts containing the latest pension information are posted frequently.” am. It was measured on a 5-point scale from ‘not at all’ to ‘very much’.

Table 2 – Descriptive Statistics and Correlation

Variable	Mean	sd	1	2	3	4	5	6	7	8	9
1. Gender	1.57	.49									
2. Age	1.19	.65	.06								
3. Married	1.08	.27	.03	.79**							
4. Number of product use	2.19	1.03	-.00	.03	.07						
5. Product search time	2.54	1.24	.18**	-.12	-.08	-.20**					
6. Information Provision	3.80	.54	-.14*	-.27**	-.18**	.03	-.05				
7. Information Recency	3.63	.56	-.07	-.14*	-.01	.22**	-.04	.46**			
8. Information Playfulness	3.70	.66	-.11	-.24**	-.11	.12	-.02	.56**	.53**		
9. Customer Satisfaction	3.85	.56	-.13	-.22**	-.12	.11	.01	.58**	.38**	.55**	
10. Reuse Intention	3.83	.58	-.06	-.09	-.02	.24**	-.01	.50**	.28**	.47**	.60**

* $p < .005$, ** $p < .001$

The information playfulness of the e-commerce platform was measured using four questions measured by Lee Sang-beom (2016) among the measurement questions by Kwak Bi-song (2013), Oh Mi-hyeon (2014), and Lee Sang-beom (2016). The contents of the survey questions were modified to suit the intent of this study. An example of a measurement item is “The e-commerce platform pension information stimulated my curiosity.” etc. It was measured on a 5-point scale from ‘not at all’ to ‘very much’.

Customer satisfaction of e-commerce platforms was assessed using three questions based on research by Choi (2018). The contents of the survey questions were modified to suit the intent of this study. An example of a measurement item is “I am satisfied with the information provided by the e-commerce platform.” am. It was measured on a 5-point scale from ‘not at all’ to ‘very much’.

The reuse intention of the e-commerce platform, 3 questions were used based on the research of Ahn et al. (2011) and Oliver (1981). The contents of the survey questions were modified to suit the intent of this study. An example of a measurement item is “I will continue to use the e-commerce platform.” It was measured on a 5-point scale from ‘not at all’ to ‘very much’.

Control variables used were demographic variables such as user's gender, age, marital status, number of uses, and accompanying customers. Gender was a dummy variable, coded as ‘1’ for men and ‘2’ for women, and age was a variable divided into four scales from 20s to 50s or older. Marital status was coded as ‘1’, single, and ‘2’, married. The number of times the product was used was used exactly as entered. Product search time was a variable divided into four scales, ranging from 1 hour to over 4 hours.

Confirmatory Factor Analysis

In this study, exploratory factor analysis was conducted to verify whether the variables were statistically independent of each other. As a result of factor analysis, information provision, information recency, information playfulness, customer satisfaction, and reuse intention were found to be clearly distinguished as shown in <Table 1>.

It was shown that the eigenvalues and explained variance for each factor had appropriate explanatory power. Additionally, the factor loading values of the questions constituting each variable were all found to be at a satisfactory level.

Results

Descriptive Statistics and Correlations

The analysis results of the mean, standard deviation, and correlation between variables for the main variables of this study are summarized in <Table 2>

Hierarchical Multiple Regression

To verify the hypothesis of this study, hierarchical multiple regression analysis was conducted, and the results are summarized in <Table 3>. Control variables included gender, age, marital status, number of product uses, product search time, and dummy variables.

First, the results of the e-commerce platform's information provision and customer satisfaction can be seen in Model 2. Information provision and customer satisfaction showed a significant positive relationship ($\beta = .55$, $p < .001$). Therefore, Hypothesis 1 was accepted.

Hypothesis 2 and Hypothesis 3 proposed the moderating role of information recency and information playfulness in the relationship between the information provision of e-commerce platforms and customer satisfaction. To verify this, information recency and information playfulness were added to each of Model 3 and Model 4, and an interaction term was calculated and included. In this process, a mean-centering method was used in which the values of the two variables included in the interaction term were multiplied by subtracting the average value of each variable. As a result, the interaction terms of information provision, information recency, and information playfulness all had a significant positive relationship with customer satisfaction ($\beta = .17$, $p < .01$; $\beta = .15$, $p < .01$). In order to confirm the significant moderating effect on customer satisfaction, the groups were divided into upper and lower groups based on ± 1 standard deviation from the average value of information recency and information playfulness. The relationship is shown in <Figure 2> and <Figure 3> (Cho & Shin, 2020; Aiken & West, 1991). The positive relationship between information provision and customer satisfaction was found to be strengthened as information recency increased. The positive relationship between information provision and customer satisfaction was found to be strengthened as information playfulness increased.

Hypothesis 4 proposed the mediating role of customer satisfaction in the relationship between the information

provision of an e-commerce platform and the intention to reusing it. This study conducted analysis according to Baron & Kenny's (1986) three-step regression analysis method to verify the mediating role of customer satisfaction. In the first step, the influence relationship between independent variables and dependent variables was confirmed, and in the second step, the influence relationship between independent variables and mediators was confirmed. Finally, in the third step, the independent variables and mediator variables were introduced simultaneously to confirm changes in the influence of the independent variables. Here, if the significance of the independent variable disappears, it can be interpreted as full mediation, and if the significance or regression coefficient of the independent variable decreases, it can be interpreted as partial mediation. First, in Model 6, the independent variable, information provision, showed a positive relationship with the dependent variable, intention to reuse ($\beta = .51$, $p < .001$), and in Model 2, the independent variable, information provision, was a mediating variable.

Table 3 – Hierarchical Multiple Regression

VAR	Customer Satisfaction				Reuse Intention			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Control								
Gender	-.12	-.05	-.04	-.03	-.09	-.02	-.00	.00
Age	-.37**	-.18	-.20	-.17	-.17	.01	.10	.13
Married	.14	.11	.11	.08	.09	.06	.01	-.01
product use	.12	.11	.07	.07	.26**	.25***	.21***	.19**
search time	.02	.05	.03	.02	.04	.07	.05	.05
Dummy1	-.26	-.16	-.21	-.17	.14	.22	.32	.32
Dummy2	-.25	-.17	-.25	-.24	.03	.10	.21	.18
Dummy3	-.34	-.19	-.25	-.23	.06	.19	.31	.30
Independent								
I.P		.55***	.47***	.36***		.51***	.28***	.21**
Moderating role								
IR			.12				-.05	
IP				.31***				.14
Interaction								
IPxIR			.17**				-.07	
IPxIR				.15**				-.02
Mediator								
CS							.48***	.42***
R^2	.10*	.37***	.40***	.45***	.09*	.32***	.46***	.46***
ΔR^2	□	.27***	.03**	.08**	□	.23***	.14***	.14***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

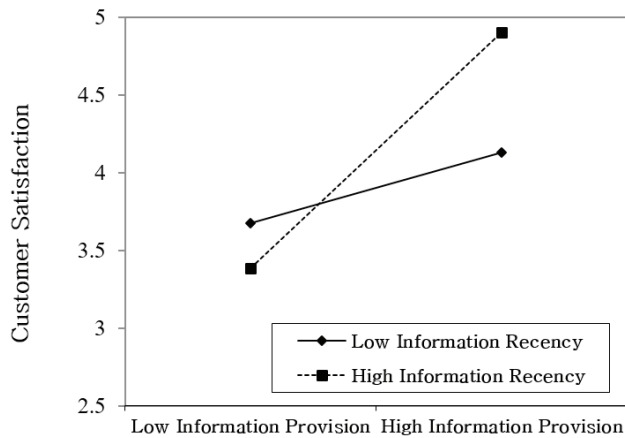


Figure 2 – Moderating role of information recency

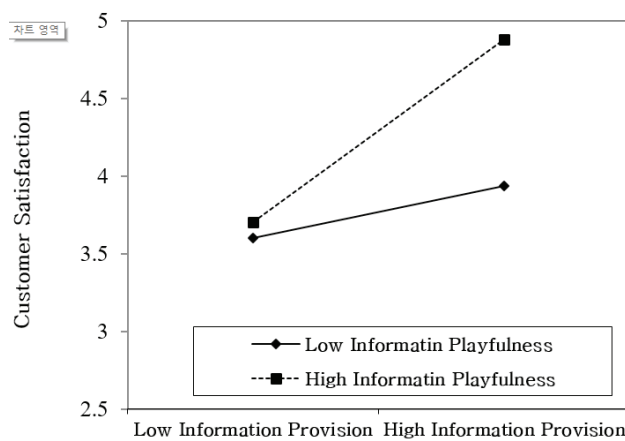


Figure 3 – Moderating role of information playfulness

It also showed a positive relationship with customer satisfaction ($\beta = .55, p < .001$). And when the mediating variable customer satisfaction and the two control variables and interaction term were input in Model 7 and Model 8, the influence of information provision was found to significantly decrease ($\beta = .28, p < .01$; $\beta = .21, p < .01$). In other words, customer satisfaction was found to partially mediate the relationship between information provision and reuse intention. Therefore, hypothesis 4 was accepted.

Discussion

This study examined the mediating effect of the information provision of an e-commerce platform on the intention to reusing it through customer satisfaction. In addition, the moderating effects of information recency and information playfulness on customer satisfaction were examined. In the relationship between information provision, customer satisfaction, and reuse intention, it was confirmed whether information recency and information playfulness strengthen the positive effect of customer satisfaction. The main purpose of this study is to provide implications.

As a result of the study, the information provision, customer satisfaction, and intention to reusing the e-commerce platform each showed a positive relationship. It was found to have a significant direct effect on both

variables. The positive relationship between information provision and customer satisfaction showed that information recency strengthened the relationship. Specifically, the positive relationship was stronger in the group with high information recency than in the group with low information recency. In the positive relationship between information provision and customer satisfaction, the positive relationship was stronger in the group with high information playfulness than in the group with low information playfulness. Lastly, customer satisfaction showed a positive mediating effect in the relationship between information provision, customer satisfaction, and reuse intention.

The academic contribution of this study is that existing previous research mainly focused on research on online shopping malls, open markets, and SNS group purchasing methods. This study examines the relationship between information provision provided by an e-commerce platform, customer satisfaction, and reuse intention, the moderating role of information recency and information playfulness, and the mediating role of customer satisfaction in the relationship between the information provision of an e-commerce platform and reuse intention. was considered. The discussion of existing e-commerce platform research was expanded.

The practical implications of this study include empirically verifying that customers' product purchase decisions vary depending on the type of information provided online. We would like to emphasize that the types of information provided on e-commerce platforms should be diverse, accurate, and informative, as well as reflect the latest information and be enjoyable. From a consumer's psychological perspective, efforts to deliver information on e-commerce platforms can greatly contribute to improving customer satisfaction.

Based on the limitations of this study, suggestions for future research are as follows.

First, this study used cross-sectional data collected over a specific period of time. Considering the size of the sample, it is somewhat difficult to generalize the analysis results. Therefore, future research should examine the causal relationship between variables more clearly.

Second, existing studies related to the quality and characteristics of information that this study focused on were studies that approached information in a multidimensional manner. In future research, there is a need to consider information-related variables from different perspectives and include them in the research model. This will lead to useful implications for practitioners.

Lastly, consumers' interest in and use of e-commerce platforms is increasing day by day. There is a need to improve their satisfaction and increase their intention to continue using it. Therefore, various considerations and attempts will be needed to further maximize the effectiveness of information delivery online.

References

References omitted for editing reasons.

Are you tired of scanning QR code? An empirical study of digital menu

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Abstract

Are you tired of scanning QR codes? QR codes are used everywhere, also include digital menu. QR code has become increasingly popular in recent years. To some extent, they echo the United Nations' 2030 Sustainable Development Goals (SDGs) very well. However, some consumers are hesitant to continue using QR codes due to security or privacy concerns. This study aims to propose a research framework for the continuous use of QR code menu. This study will use cost-benefit theory, individual attributes, and social influencing factor as the theoretical basis to determine the factors influencing the continued use of QR code menu. A survey method will be used to collect research data and structural equation modeling (SEM) will be performed for subsequent data analysis. research results will provide guidance to the government, businesses, and consumers, creating a win-win situation.

Keywords

QR codemenu, sustainable development goals, cost-benefit theory□social influence

Introduction

QR code is the abbreviation of quick response code. It is a two-dimensional barcode that can be read by a smartphone. QR codes were created for the Japanese automobile industry in 1994. QR codes first began to be widely used around 2010, but it did not seem to be popular at that time (as shown in Figure 1). The main reasons were the high entry barriers and the availability of smart devices. Not many people have cell phones. However, it was not adopted on a large scale until the recent COVID-19 outbreak around the world, with usage increasing by 98% from 2018 to 2020, and in 2022, the QR code was scanned a cumulative 6,825,842 times by users around the world, an increase from 433% in 2021, because it provides advantages including contactless, low-contact, safety and hygiene, effectively reducing human interaction in service scenarios (Gursoy et al., 2020).

So far, QR code is ubiquitous, and it has been widely used in marketing, information sharing and tracking, education and learning, transportation and tourism, and the currently popular digitalmenu. By reducing greenhouse gas emissions and energy consumptionrelated to paper production and printing, QR code usage can help mitigate climate change to achieve the goals of SDG 13-Climate Action (Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters

in all countries).

Under the promotion of government and private organizations, we see that the use of QR Code has the advantages of sustainability and convenience, and comparative advantages over traditional ways. On the other hand, consumers hold the concerns about the risks of using QR code such as personal information, security, and privacy (Tan et al., 2014). They are worried that scanning QR codes may lead to information leakage and misuse, so they hesitate to scan QR codes from unknown sources. Regarding the use of QR code menus, consumers are more receptive to QR code menus during COVID-19 (Iskender et al., 2022). However, after the pandemic, It can be seen that the rebound of consumers has led to a cooling trend in the use of QR code menus. However, few research has explored this phenomenon. According, the present study raise following research questions:

Research Question 1 Identify and test the appropriate theories for the continuance usage of QR code menu.

Research Question 2 Identify the critical factors influencing the continuance usage of QR code menu.



Figure 1 – QR code usage trends over the years

Literature review

This study intends to adopt the cost-benefit theory, in the following we will discuss the brief introduction of this theory. In addition to this theory, other influential factors of continuance usage of QR code menu will be adopted, including individual factors (need for human interaction and incumbent system habit) and social influence factor (subjective norm). Polites&Karahanna (2012) explains how existing system habits can negatively impact consumer intention to use a new system. Chen et al. (2018) indicated that location convenience and the need for human interaction have a positive impact on consumers' willingness to use self-service package delivery services. Social influence or subjective norms are important factors in determining behavioral intentions (Venkatesh et al., 2003).

Cost-benefit theory is a theory commonly used in economics and management to evaluate the balance between the costs and benefits of a action or decision. When making rational decisions, consumers will evaluate and compare costs and benefits among alternatives, and then select the one with the least cost and the greatest benefit (Hernandez-Ortega et al., 2017; Yang et al., 2016). Specific applications include public policy formulation, corporate investment decisions, environmental protection, etc.

According to the cost-benefit theory, when consumers make purchasing decisions, they will form a perceived value (Kim et al., 2007; Lin a& Lu, 2015), which in turn will Influence their willingness to use services or products (Yang et al., 2016). Taking the use of information systems as an example, when users adopt a specific information system, they will consider the required effort or financial expenditure in addition to benefits of using this system (Hernandez-Ortega et al., 2017), including time cost and financial cost, and conversion costs. Through the comparison of costs and benefits, users' perceived value is generated, which in turn affects their willingness to use the information system (Lin & Lu, 2015).

In the current study, perceived benefits (perceived convenience and perceived sustainable value) and perceived cost (perceived privacy risk) are postulated as the antecedents of perceived value (see Figure 2).

Perceived convenience refers to the extent to which consumers believe they can use technology to complete work at a convenient time, in a convenient place, and in a convenient way (Liu et al., 2015). Atkinson (2013) believes that the potential of conveying sustainability messages through QR codes is particularly important for so-called green or ethical consumers. Perceived privacy risk refers to perceived psychological cost of perceived value, referring to the concerns of leaking privacy information or information abuse (Liu et al., 2015).

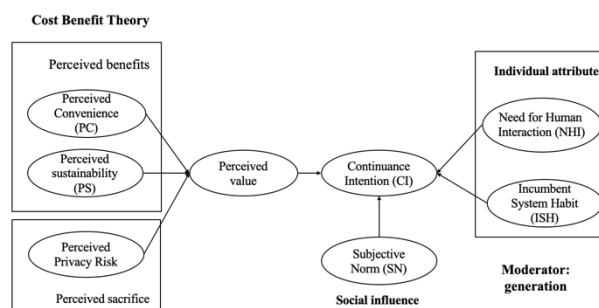


Figure 2–Research framework

Methods

Both qualitative and quantitative research method will be adopted with depth interviews and survey method, respectively. In addition to cost-benefit theory, the research framework intends to include other factors impacting on consumers' continuance usage of QR code menu through literature review and consumer depth interviews.

Depth interviews

In depth interviews, at least 20 consumers will be performed to acquire consumers' behaviors in the use of QR code menu, including the advantages, disadvantages, and challenges of using QR code menu. The results will be further analyzed as the base of selecting research constructs.

Questionnaire analysis method

All the instrument measuring items will be collected through existing theory. The questionnaire items included a screening question asking whether consumers have experience in using QR code menu. Liker scale with 7-point from 1 ("very disagreed") to 7 ("very agreed") are used. Research data will be collected through both online and paper-based questionnaire targeting on senior people.

Anticipated results

The application and sustainable development goals of QR code can be fully understood from the perspective of consumers. The research results and suggestions can make

society more inclusive and understand the challenges faced by seniors in using QR code menu. And it can be further extended to other technological applications for sustainable value promotion. Significant contributions are expected in terms of theoretical, managerial and practical implications.

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Exploring the Customer Journey Map and Predicting Consumer Behavior by Applying Markov Chain and Machine Learning on the Food Industry E-commerce Google Analytics Data

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Abstract

COVID-19 has turned consumers around the world to online shopping. According to the Global Web Index, 58.4% of the world's Internet users make weekly purchases online. The online food shopping population will grow by 35% in 2022, generating \$588 billion in revenue. Multi-channel marketing has become a trend in the face of cookieless. Consumers use seven to twelve channels before making a purchase. In this study, we use Google Analytics data, the concept of discrete Markov chain, and the combination of neural network, XGBoost, and random forest regression model to predict the probability of path shifting in the customer journey map of the food industry and to provide suggestions on multi-channel layout to assist in the development of future strategies.

Keywords

Markov chain, Transition matrix, Customer Journey Maps, Deep neural network, XGBoost, Random Forest Regression

Introduction

Currently, in the field of marketing, research on customer journey mapping is mostly based on qualitative methods such as in-depth interviews or focus group interviews. In contrast, there is a relative lack of quantitative research on the customer journey mapping of consumers' online behavior. The transformation of the food industry in the Internet environment after the epidemic has made this topic even more urgent. However, the main reason is that when it comes to revenue calculation, the industry is often reluctant to provide actual consumer information for research, which has resulted in a relative lack of relevant studies.

In collaboration with the food industry, this study utilizes machine learning and deep learning models, including XGBoost, Random Forest Regression, and Deep Neural Networks, to predict consumer journeys on the Internet. By comparing the performance of the models, this study aims to provide the industry with more effective multi-channel marketing strategies to optimize the customer journey maps for more efficient marketing planning.

According to PWC's 2020 Global Consumer Insights Report, more than 35% of consumers buy food online. This compares to just 9% before the outbreak. Of these, 86% of online shoppers will continue to purchase food

online after social distance controls are lifted. The outbreak has accelerated the change in consumer shopping habits and reflects the importance of marketing databases to understand customer preferences. This will be a key factor in the development of the industry's strategy.

With the advancement of technology, Database Marketing is rapidly being applied in today's MarTech (Marketing Technology) field. Adding the aid of machine learning, applying more complex and precise ways to collect and analyze customer information, to provide services that better meet the needs of customers, and increase customer loyalty and re-marketing opportunities. The company's marketing giant, Kotler, has been in the business for over a decade. Kotler, a marketing giant, once said, "Database marketing is the process of building and maintaining customer relationships and utilizing customer databases and other databases to reach and transact with customers". Database marketing is mostly about quantitatively recording data, and recording the behavior of the customer before, during, and after the transaction process. The ultimate goal is to create a win-win situation for marketers and customers by reducing marketing costs, increasing sales and profits, and building customer loyalty (Tao & Rosa Yeh, 2003). The marketing database not only quantifies customer behavior but also facilitates the use

of statistical models and different intelligent algorithms to build a more accurate map of the customer journey.

Methods

This study applied Markov chain, Transition matrix, Deep neural network, XGBoost, Random Forest Regression and other machine learning methods on Food Industry E-commerce Google Analytics (GA) Data to predict consumer behavior and present it visually in the form of a customer journey map.

Customer Journey Map

Customer Journey Maps (CJM) is a visual representation of a customer's interaction with a brand or a company's product or service. And it also combines time and space. CJM lists all possible organizational touchpoints that a customer may encounter during a service exchange. By having a clear understanding of a customer's touchpoints. Senior management can work with cross-functional team members to plan strategies to improve the customer experience associated with each touchpoint and enhance interactions with customers and customer service providers (Rosenbaum et.al., 2017). Therefore 'touchpoints' and 'touchpoints' between customers and stores are a very important concept in the customer journey map. However, Rosenbaum et.al (2017) also suggest that there are still flaws in customer journey maps, for example, their study states that CJM is inaccurate in assuming that all touchpoints are of equal importance, which can lead to retail managers and strategic planners to easily make incorrect judgments about the customer experience. If this defect can be improved, the customer journey will be an important concept to understand complex customer behavior and gain insights into his experience (Tueanrat et.al., 2021).

There are not a few research papers on customer journey mapping, currently researching customer journeys mostly using qualitative analysis (Barwitz& Maas, 2018) used focus groups, expert interviews, and ladder interviews with auto insurance customers to investigate the reasons for customer interaction choices. Many studies have investigated channel overflow and inertia like Gensler et. al.'s (2012) proposed study. The limitation of qualitative research is that it cannot understand the value distribution of target customers, make immediate judgments on marketing strategies, and consider the overall analysis of the industry, which makes it difficult to meet the current trend of big data research. Therefore, this study will be conducted quantitatively. By obtaining the customer behavior data from the GA database of the industry and building a marketing database. Then it will be combined with a machine learning training model to predict the customer journey map.

Markov Chain

Markov chain is proposed by Russian mathematician Andrey Markov. This study is mainly based on the discrete-time Markov chain (DTMC). The state transfer rates used in Markov chains are based on the conditional rates (Cheng et.al., 2012). It is a random process of transition from state to state in state space, which is also known as the Markov process. In addition, the main advantages of this model are its flexibility, probabilistic approach, and mature theory. (Ma et.al., 2008)

Markov chain is a method of random process prediction. The state of the system in the past period is used to predict the state of the system in future periods and the potential for it to occur (Kunming Gao, 2006). The probability distribution ($n+1$) of the next state in a Markov chain is only affected by the current state (n), in other words, the previous events in the time series are irrelevant. It is also called memorylessness. If X_n is used to represent the occurrence of an event, $n=0,1,2,\dots$, this property can be expressed as:

$$Pr(X_{n+1} = j | x_n = i, x_{n-1} = i-1, \dots, x_0 = i_0) = P(X_{n+1} = j | x_n = i) \quad (1)$$

Markov chain consists of state space, a set of all possible states in a system, and a transition matrix. Each node (A, B, C) in Figure 1 is a state, and the arrows represent the probability of moving from one state to another. Figure 2 represents the mathematical representation of the transition matrix of the Markov chain, in addition, the transition matrix has the following characteristics:

1. The sum of the probabilities of each column is 1;
2. Each value in the matrix ≥ 0 is expressed as follows:

$$\begin{aligned} 1. & P_{1,1} + P_{1,2} + \dots + P_{1,j} = 1, \\ & P_{1,1} + P_{1,2} + \dots + P_{2,j} = 1, \dots \\ 2. & P_{i,j} \geq 0 \end{aligned} \quad (2)$$

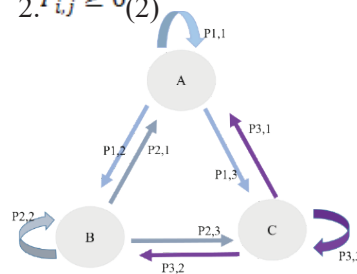


Figure 1 MarkovChainFigure 2TransitionMatrix

Neural Network

Artificial Neural Network (ANN) also called neural network was proposed in 1980. However, the application of neural networks has been limited due to the failure to solve the backpropagation problem, which is the problem of finding out the minimum value of the error. It wasn't until 30 years later that Hinton solved this problem and returned with a new name for deep learning. Hinton is therefore also known as the "Father of Deep Learning". Currently, neural-like networks are widely used in various fields and are a technique to optimize data sets for data fitting and prediction applications. (Chhajer et.al., 2022). Lee & Shih (2009) pointed out that the training dataset is necessary for training the neural network model. To train the model well, a larger training set of data should be created. And more possible features should be included to better recognize the customer groups.

The operation of a neural network is to input the input values to the neurons in the input layer, get the output values through the activation function, and then transfer the output values to the next neuron, and repeat the above actions until the last layer outputs the predicted results, which is the basic framework of a neural network. Neural networks are mostly used in recognition, decision making, control, prediction, etc. The activation function has a non-linear characteristic. It can strongly change a linear function into a non-linear one, so that its value is between 0 and 1, and its formula is as follows:

$$Y = a(W * X + b) \quad (3)$$

Where x is the input vector, y is the output vector, b is the bias, W is the weight, and a() is the activation function is a non-linear function.

eXtreme Gradient Boosting (XGBoost)

The concept of Ensemble learning is to combine multiple weak models of supervised learning into one strong model. The idea is that although a single model does not predict dataset data with high accuracy, a better model can be generated if their respective strengths and weaknesses are combined to complement each other to achieve higher prediction accuracy. In addition, Ensemble Learning can be further divided into three categories, namely Bagging, Boosting and Stacking, and eXtreme Gradient Boosting (XGBoost) belongs to the Boosting method. The special feature of Boosting is that it adjusts the weights of the data according to the results of the previous round of learning. By increasing the weights of models with low error rates and decreasing the weights of models with high error rates in each round of training, the model will ultimately have better results.

The XGBoost objective function generates a tree:

$$Obj = \sum_{i=1}^n l(y_i, \hat{y}_i) + \sum_{k=1}^K \Omega(f_k)$$

Leaf Node Grouping:

$$\sum_{j=1}^T [(\sum_{i \in I_j} g_i) W_j + \frac{1}{2} (\sum_{i \in I_j} h_i) W_j^2] + \gamma T$$

Final Target Function:

$$\sum_{j=1}^T [G_j W_j + \frac{1}{2} (H_j + \lambda) W_j^2] + \gamma T$$

Optimization:

$$W_j^* = -\frac{G_j}{H_j + \lambda}, \quad Obj = -\frac{1}{2} \sum_{j=1}^T \frac{G_j^2}{H_j + \lambda} + \gamma T$$

Leaf Node Splitting:

$$Gain = \frac{1}{2} \left[\frac{G_L^2}{H_L + \lambda} + \frac{G_R^2}{H_R + \lambda} - \frac{(G_L + G_R)^2}{H_L + H_R + \lambda} \right] - \gamma \quad (4)$$

Random Forest Regression

The concept of Randomized Forest Regression is the Bagging of Ensemble Learning. In each round, n training samples were taken from the original sample set. The samples are taken from the original sample set and put back after being taken. Therefore, the samples may be taken more than once or not at all. After n rounds, n training sets will be obtained. These n training sets are independent of each other. In regression, all models are eventually averaged. In addition, averaging is used because bagging considers all models to be of equal importance.

$$f(x) = \frac{1}{K} \sum_{k=1}^K f_k(x) \quad (5)$$

Research Methods and Experiments

In this study, we use the data from the Google Analytics (GA) platform and apply Markov Chain Theory for data processing. The one-hot encoding method is applied to encode the data to build a dataset. The data is then imported into the model for training and continuous adjustment of parameters. Improve the accuracy of the model. The model with the best accuracy is then used to predict the data and generate the probability transition matrix. Finally, it is presented as a visual graphic.

This study uses an Application Programming Interface (API) to export the GA database of several food companies. We obtained a series of behavior data of customers entering the official website from the multi-channel program pipeline grouping paths in GA. In addition, the food industry in this study is defined as

companies or brands that produce their food and have their own sales channels. The period of data collection is from November 2021 to October 2022.

Data Processing Stepwise

1. Add Start and Conversion

Firstly, to know the source of the first access to the official website by the consumers of the path, and the source of the final conversion, this study adds Start at the beginning and Conversion at the end of each piece of data.

The conversion can be decided by each industry in connection with their official websites. Table 1 shows the set conversion of the data in this study and the automatically pre-set explanation of items and terms in Google's GA.

Table 1 The Explanation of Conversion

Conversion	Explanation
purchase	CompletePurchase
first_open	Openingtheapplicationfor thefirsttime
Account Login	Complethelloginpage
Sign Up	Complete the registration page
Add to Cart	AddtoCart
Check Out	GotoCheckout
Order Completed	Completionof order
Fill in the information	Complethetheform
Product Page View	ViewProductPage
Contact us	Callto us

2. Split the Data into Two Fields -Path1 and Path2.

Secondly, this study uses discrete Markov chains to present the path of the customer journey. This theory has the concept of memorylessness. It means that the probability of influencing the occurrence of the next event is only affected by the current decision, not the previous events. Therefore, the data in this study will only have two columns, path1 and path2. As shown in Table 2, A, B, C, and D in the table are the nodes of the path.

Table 2 The Presentation of Data Processing

Before dataprocessing	After dataprocessing	
First: A → B → C Second: A → C Third: A → D → C	Path1	Path2
	A	B
	B	C
	A	C
	A	D
	D	C

Path nodes are formally known as multi-pipeline program pipeline nodes in GA, including Direct, Social, Organic Search, Referral, Paid Search, Display, Email, and Others. Table 3 explains the definitions of the terms.

Table 3 The Glossary of GA Trail Terms

Direct	Direct access to a website by link, e.g. by typing the URL directly into the browser, by link into the website, by QR code, or through a link on the App.
Social	Access to web pages from social platforms, e.g., FB, IG, X, and other social networking sites.
Organic-Search	This is known as Organic search, which comes to the site by typing in keywords.
Referral	Entering the site from other sites (e.g. media, blogs, etc.), these pipelines from external sites are considered referral traffic.
Paid-Search	By clicking on a keyword advertisement in the search results to enter the site, the pipeline will be categorized as a paid search.
Display	Visitors entering the website through the media network advertisement GDN
Email	Visitors can access the site by clicking on the email link.
Other	Flow classifications that do not belong to each of the above pipelines will be classified as other.

3. One-Hot Encoding

This research data is encoded by one-hot encoding. When the data is Categorical Features, it is necessary to convert the data to Numerical Features. In this study, the concept of one-hot encoding is applied to split the category into several columns, and the value in each column is replaced by 1 and 0. If the data exists in the row's category, it will display 1, if not, it will display 0. Therefore, it is appropriate to use this code when there is no size relationship between the data. Table 4 is the presentation of the data encoding.

Table 4The Presentation of Data Encoding

Before Data Encoding		After Data Encoding							
Path1	Path2	A1	B1	C1	D1	A2	B2	C2	D2
A	B	1	0	0	0	0	1	0	0
B	C	0	1	0	0	0	0	1	0

4. Split the Data into Training and Testing Sets.

The data are split into 80% training data and 20% testing data. To minimize the error of the prediction results, each piece of data could become the training data and testing data, so the data will be further divided into five, assuming that there are a total of 100 pieces of data, Table 5 is the presentation of the data splitting.

Table 5The Presentation of Data Splitting

Training Data	Testing Data
The first 80th data	Information of the 81st to 100th
Information on the 1st to 60th and 81st to 100th	Information on the 61st to 80th
Information on 1st to 40th and 61st to 100th	Information of the 41st to 60th
Information of 1st to 20th and 41st to 100th pen	Information of the 21st to 40th
21st to 100th data	The first 20th of the data

Model Building

Neural Network

The deep neural network (DNN) and the Sequential model of DNN are applied in this study. The data encoded in path 1 is brought into the input layer, and the data encoded in path 2 is brought into the output layer. Table 6 Model training results after parameter adjustment. The parameter adjustment includes one input layer, three hidden layers and one output layer, as well as the number of neurons and activation function of each layer.

XGBoost

The parameter adjustment of XGBoost found that changing the Learning Rate, the required minimum sample weight, and $n\_estimators$ had little effect on the model with the data in this study. In addition, silent is fixed to 1. In this study, the mean square error (MSE) and mean absolute error (MAE) are measured, and Table 7 shows the results of parameter adjustment.

Table 6 Parameter Adjustment of DNN model

Parameter Adjustment	Metrics	Part1	Paart2	Paart3	Paart4	Paart5	average
Input Layer 6,Relu□	MSE	0.0536	0.0564	0.0711	0.0775	0.0800	0.06772
Hidden Layer 256,Relu□128, Relu□ 64,Relu							
Output Layer 6,Softmax	MAE	0.1027	0.1077	0.1400	0.1479	0.1570	0.13106

Input Layer 6,Relu□	MSE	0.0552	0.0558	0.0673	0.0779	0.0786	0.06696
Hidden Layer 256,Relu□ 128, Relu□ 64,Relu							
Output Layer 6,sigmoid	MAE	0.1023	0.1076	0.1267	0.1465	0.1492	0.12646
Input Layer 6,Relu□	MSE	0.0524	0.0574	0.0698	0.0763	0.0811	0.0674
Hidden Layer 256,Relu□ 128, Relu□ 64,Relu							
Output Layer 6,Tanh	MAE	0.1032	0.1149	0.1392	0.1527	0.1613	0.13426
Input Layer 6,Relu□	MSE	0.0541	0.0574	0.0677	0.0761	0.0800	0.06706
Hidden Layer 128,Relu□ 64, Relu□ 32,Relu							
Output Layer 6,Softmax	MAE	0.1015	0.1093	0.1305	0.1455	0.1542	0.1282
Input Layer 6,Relu□	MSE	0.0546	0.0603	0.0674	0.0780	0.0787	0.0678
Hidden Layer 128,Relu□ 64, Relu□ 32,Relu							
Output Layer 6,sigmoid	MAE	0.0999	0.1047	0.1259	0.1483	0.1499	0.12574
Input Layer 6,Relu□	MSE	0.0552	0.0604	0.0696	0.0789	0.0782	0.06846
Hidden Layer 128,Relu□ 64, Relu□ 32,Relu							
Output Layer 6,Tanh	MAE	0.1108	0.1196	0.1374	0.1561	0.1563	0.13604

Table 7 Parameter Adjustment of XGBoost

Parameter Adjustment	Metrics	Part1	Paart2	Paart3	Paart4	Paart5	average
learning_rate= 0.1 max_depth= 7	MSE	0.1389	0.1389	0.1389	0.1389	0.1389	0.1389
	MAE	0.209	0.209	0.209	0.209	0.209	0.209
learning_rate= 0.5 max_depth= 7	MSE	0.1389	0.1389	0.1389	0.1389	0.1389	0.1389
	MAE	0.209	0.209	0.209	0.209	0.209	0.209
learning_rate= 0.1 max_depth= 20	MSE	0.139	0.1058	0.0614	0.0269	0.0203	0.07068
	MAE	0.2085	0.1645	0.1171	0.0788	0.0724	0.12826

Random Forest Regression

For Random Forest Regression in this study, bootstrap samples are used and the minimum number of samples to be included in the leaf nodes is set to 3. The minimum number of samples required for decision tree segmentation is 6. Table 8 shows the parameter tuning for Random Forest Regression.

Table 8 Random Forest Regression Parameter Adjustment

Parameter Adjustment	Metrics	Part1	Paart2	Paart3	Paart4	Paart5	average
n_estimators=100, max_depth=80, max_features=3,	MSE	0.1369	0.1059	0.0616	0.0269	0.0203	0.07032
	MAE	0.2334	0.1645	0.1171	0.0788	0.0726	0.13328
n_estimators=300, max_depth=80, max_features=3,	MSE	MSE	0.1059	0.0615	0.0269	0.0202	0.07052
	MAE	MAE	0.1644	0.117	0.0788	0.0723	0.13332
n_estimators=500, max_depth=80, max_features=3,	MSE	0.1368	0.1058	0.0615	0.0269	0.0203	0.07026
	MAE	0.2336	0.1646	0.1171	0.0788	0.0724	0.1333
n_estimators=100, max_depth=100, max_features=3,	MSE	0.1379	0.1059	0.0614	0.027	0.0202	0.07048
	MAE	0.2338	0.1647	0.1169	0.0789	0.0722	0.1333

n_estimators=300, max_depth=100, max_features=3,	MSE	0.1372	0.1059	0.0615	0.0269	0.0203	0.07036
	MAE	0.2336	0.1645	0.1169	0.0788	0.0725	0.13326
n_estimators=500, max_depth=100, max_features=3,	MSE	0.137	0.1059	0.0614	0.0269	0.0202	0.07028
	MAE	0.2338	0.1644	0.1172	0.0788	0.0722	0.13328
n_estimators=500, max_depth=100, max_features=5,	MSE	0.1405	0.1058	0.0615	0.0269	0.0203	0.071
	MAE	0.2369	0.1645	0.1171	0.0785	0.0725	0.1339

Comparison of Three Models

Comparing the results of the three models with the best training, it is found that the neural network has the best performance in this data.

Table 9 Comparison of Three Models

		Average Accuracy
DNN	MSE	0.0678
	MAE	0.12574
XGBoost	MSE	0.07068
	MAE	0.12826
Random Forest Regression	MSE	0.07026
	MAE	0.1333

Markov Chain Transfer Matrix and Visualized Graphs

The following figure shows the predicted probability conversion results based on the adjusted parameter model. Apply the concept of the transition matrix of the Markov chain to obtain the result of path transformation from Part 1 to Part 5. Figure 3 shows the conversion of the prediction probability after using the deep neural network model, which has been taken to the fourth decimal place. And the visualization graph in Figure 4.

Index	Conversion2	Direct2	Organic Search2	Other2	Referral2	Social2
Direct	0.1273	0.8297	0.0033	0.0388	0.0007	0.0002
Organic Search	0.1238	0.5195	0.0882	0.226	0.0251	0.0174
Other	0.1265	0.3174	0.1281	0.3665	0.0294	0.0321
Referral	0.1148	0.6516	0.0533	0.1532	0.0165	0.0105
Social	0.197	0.368	0.1271	0.2473	0.0326	0.0279
Start	0.0844	0.3715	0.1812	0.2699	0.0501	0.0428

Figure 3 Transition matrix

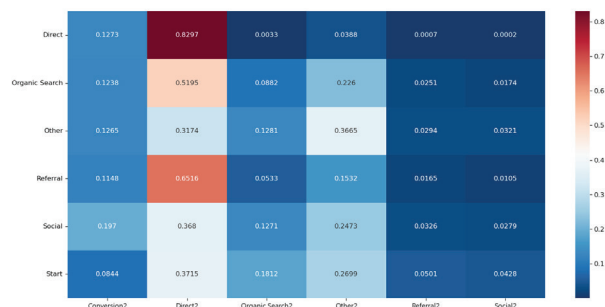


Figure 4 Data Visualization Graph Heatmap

Conclusion

The contribution of this research is to utilize the real industry food industry in GA data. This study contributes to obtaining the customer journey maps of consumers on the Internet by using consumer behavior data from the multi-channel program pipeline segmentation paths. Using the predictive models, including DNN, XGBoost, and Random Forest Regression, we compare the DNN model with the best accuracy and use this model to predict the conversion of path chances. In this way, it is possible to know which path will have a higher chance to be re-entered next time if it is entered from Direct, Social, Organic Search, Referral, and Other respectively. Then, the industry can plan the marketing strategy to increase the chance of marketing success. The experimental data can be discussed as follows:

1. Consumers in the food industry mostly enter by Direct.
2. Consumers who enter by Direct one time and enter by Direct the next time have the highest probability (0.8297).
3. If a consumer enters by Referral one time and Direct the next time, the probability of this path is the second highest among all, accounting for 0.6516.
4. If a consumer enters by Organic Search one time, and then enters by Direct the next time, the probability of this path is the third highest among all, accounting for 0.519.
5. The path that eventually leads to conversion is Social, which is the highest at 0.197, but it is not much different from the other paths, although it is the highest among them.

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A Study on the Relationship between Emotional Pleasure and Flow Experience of Taiwanese BL Game Players

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Abstract

This research aims to investigate the factors influencing Taiwanese gamers' preferences for Boys' Love (BL) games and how these factors contribute to the generation of positive emotions influencing their consumption behavior. Utilizing a quantitative research approach, this study targeted Taiwanese BL game players and collected 533 valid responses through surveys. The findings revealed that factors such as young and attractive character designs, voice actors and soundtracks, exquisite visual design, original storytelling, fan-created content, and the satisfaction of erotic fantasies are key reasons for gamers' affinity towards BL games. These factors also serve as fundamental elements influencing consumers' experiences of positive emotions. This study contributes to the academic field by exploring a new research area, particularly in understanding how BL games impact and reflect issues of gender identity. Recognizing the significance of BL games to consumers and their unique position in Taiwanese culture and economy holds positive implications.

Keywords

BL game, pleasant emotions, fan culture, online community

Introduction

Research Background

Anime, manga, games, and novels produced in South Korea and Japan, collectively known as ACGN (Anime, Comic, Game, Novel), have gained immense popularity among consumers in Taiwan. Consumers also exhibit a preference for playing Japanese and Korean games. From a business perspective, the success and development of the industry in the 21st century have shifted from industry-led to consumer-oriented. Corporate profitability now relies on consumer preferences, with a focus on both the male and female markets within the ACG industry. BL games, centered around emotional relationships between males, encompass various creative forms such as novels, manga, games, and fan work. The BL culture, with a history of over 50 years in Japan, has evolved into a subculture well-known among anime enthusiasts, attracting an increasing number of followers in Taiwan.

Purpose of this research

With the rise of the home economy and the flourishing development of digital games, many scholars have engaged in research related to digital games. However, existing studies often focus on exploring players' violent behavior and addiction phenomena (Hinduja & Patchin, 2008; Grossman, Paulsen & Miserany, 2016), or concentrate on players' motivations and behaviors

(Schneider, Lang, Shin, & Bradley, 2004; Castronova, 2005). In recent years, some scholars have started to pay attention to the pleasurable emotions experienced by players in digital games (Sherry, 2004; Zhang Yupei, 2011). In these studies, research on the "flow" experience generated by players in BL (boys' love) games and related emotional pleasures is relatively scarce.

This study aims to explore the reasons behind the formation of the industry and how BL games captivate consumers, providing insights into the immersive experiences consumers seek in these games and whether emotional satisfaction influences their willingness to continue usage. The research proposes the following two research hypotheses:

Hypothesis 1: There is a significant correlation between the factors of flow experience and the generation of pleasurable emotions in BL game players during the gaming process.

Hypothesis 2: The influence of social gender issues has a significant impact on players' willingness to participate in games.

Characteristics of BL game fans

"Fans" is typically translated as "fan," while "fandom" is rendered as "fan group" or "fan community." Scholar

Santilli, in his definition, characterizes a "fan-group" as individuals or groups expressing intense enthusiasm and affection for specific entities known as "fan-objects" (2010). Unlike regular consumers, the primary distinction among "fans" lies in their emotional investment in the "object of obsession" (Santilli, 2010). Previous studies have underscored the role of "fans" as active participants rather than conventional consumers (Laverie, 2000; Milner, 2009). Jenkins' research findings (2006) indicate that in the ACG (Anime, Comic, and Games) industry, fans are more than just consumers; they actively engage in the industry's operation and are considered integral to its media landscape. Jenkins further notes that the cultural characteristics of ACG fan group participation encompass easily accessible involvement, encouragement of creative exchanges, sharing of experiences, and the establishment of social connections and self-identity among fan group members. The products and activities stemming from the culture and collective wisdom of these fan groups not only showcase the fans' innovative abilities but also gradually evolve into the mainstream of the ACG industry (Oatley, Keltner, & Jenkins, 2006).

The fandom of Boys' Love (BL) games shares many similarities with fandoms in other media. According to the research by scholar Yu (2019), BL game fandoms also exhibit some unique characteristics: (1). Fans of BL games show immense passion and engagement with the male characters in the games. They eagerly anticipate love stories between different characters and actively participate in discussions, creative works, and content sharing related to these characters. (2). BL game fans excel in creative appropriation. They create fan fiction, artwork, comics, and even game mods that reinterpret the characters and plots from the original games, infusing them with their own ideas and emotions. (3). BL game fandoms typically establish communities on online social platforms to interact with other fans. These communities provide a space for members to share their creations, discuss game plots, and build friendships with each other. (4). BL game fans not only adore the characters in the games but also enjoy participating in shaping the images and stories of these characters. They often engage in fan works that contribute additional background stories and emotional depth to the characters. Community interactions not only deepen friendships among fans but also facilitate knowledge exchange and shared creative endeavors. For instance, members of the fandom may discuss interpretations of specific game scenarios on forums, share in-depth analyses of characters, or discuss their favorite game plots (Condry, 2013).

Flow theory

The Flow Theory is primarily used to examine the immersive and pleasurable states generated by players during game participation. American psychologist Mihaly

Csikszentmihalyi (1975) initially explored the sources of people's happiness and, through extensive interviews, discovered this shared experience known as the flow experience. Subsequently, many scholars have asserted that two key factors contribute to entering a state of flow: individual "skills" and the perceived "challenges" during the activity. In the gaming process, a balance between skills and challenges must be achieved to gradually gain a sense of control over the situation and derive the pleasurable satisfaction of problem-solving, reaching the optimal state of flow (Csikszentmihalyi, 1990; Trevino and Webster, 1992; Hoffman and Novak, 1996; Chen, Wigand, and Nilan, 1999). This study will utilize Csikszentmihalyi's eight flow experience factors to examine the continuous behavioral manifestation of pleasurable emotions in BL game players due to flow experiences during the gaming process.

Mihaly further subdivided the entire experiential space and identified eight key factors that constitute the flow experience, including: 1 clear goals, 2 immediate feedbacks, 3 balance between challenge and skill, 4 sense of control, 5 eliminations of distractions, 6 focus on the current task, 7 loss of self-awareness, and 8 distorted senses of time. The first three are considered the conditions for the flow experience, serving as prerequisites to trigger flow. The fourth, fifth, and sixth factors are known as process factors of the flow experience, as the sense of control and elimination of distractions often occur during the flow state. The last two factors, seven and eight, are outcome factors of the flow experience, representing phenomena that occur after the flow experience has taken place. Mihaly emphasizes that these features do not need to be present simultaneously to achieve a state of flow; the eight characteristics are sufficient conditions rather than necessary ones. This study will utilize the eight flow experience factors proposed by Mihaly to examine the pleasure emotions experienced by players of BL games as a result of the flow experience during gameplay.

The correlation between pleasure experience and BL games

In numerous studies exploring the pleasurable experiences of game players, self-identity is considered a significant source of pleasure. Salen and Zimmerman's (2003) research found that pleasure arises not only from the experience of the game itself but also from physiological, emotional, psychological, or conscious sensations. Chen Yi-An (2002) pointed out that in online games, players can experience joy and achieve a sense of self-identity by simply playing their roles well. Especially for female players, the virtual world's self-identity is closely related to their situation in real society.

The anonymity, equality, and situational integration features of games provide women with the opportunity

to escape the limitations of real social life, thereby gaining the pleasurable experience of self-identity. Scholars Zhang Yu-Pei and Qiu Jia-Xin (2017) explored BL games with themes centered around male-male love, particularly those involving explicit exposure of genitalia or descriptions of sexual activities. These erotic game texts objectify the male body, reversing the long-standing male gaze in game culture, enabling female players to deconstruct patriarchal structures in heterosexual love and express suppressed and overlooked female sexual subjectivity under traditional moral views. These games allow female players to gain control over the plot and experience joyful emotions through fantasies. This study operationally defines emotional pleasure as the ability to release suppressed emotions and achieve a sense of pleasurable satisfaction in the game.

The relationship between gender issues and BL games in Taiwan

In the 21st century, we can observe that BL (Boys' Love) games and their player base are no longer confined to heterosexual women. Whether male, female, or transgender, and whether homosexual, bisexual, pansexual, or asexual, an increasingly diverse group of people are participating in the world of BL creation and gaming, making the development of BL games more varied. Taiwan is a relatively open and diverse society, and LGBTQ+ (lesbian, gay, bisexual, transgender, etc.) issues are relatively popular in Taiwanese society. This may make it easier for the BL gaming industry in Taiwan to exist in the market and possibly be more popular among players (Luo, 2017). In contrast, the cultural and social attitudes of other countries may influence the development and acceptance of BL games. Taiwanese BL games have their unique characteristics in terms of creative style and themes, with creators emphasizing in-depth character development, emotional expression, and storylines that explore diverse interpersonal relationships within the games.

In addition, against the backdrop of Taiwan's growing gender equality awareness and the establishment of the legitimacy of same-sex marriage, the flourishing development of BL culture and games in Taiwan has provided a novel perspective and a space for freedom. Simultaneously, it has altered societal perceptions of homosexuality, fostering greater understanding and inclusivity towards gender and sexual orientation (Weng, 2019). Taiwan's BL culture and games are not merely forms of entertainment; they symbolize a societal transformation and represent gender equality. Furthermore, they showcase the diversity of art and creativity, injecting new elements and vitality into Taiwanese culture.

Methods

This study will employ a quantitative questionnaire

survey method with the sample comprising Taiwanese players who have had prior experience with BL games and are currently enthusiastic about them. Age groups will be categorized as follows: below 19 years old, 20-29 years old, 30-39 years old, and 40 years old and above. Additionally, basic player information such as daily average gaming time, weekly expenditure on in-game items, gaming experience, and reasons for enjoying games will be collected. To enhance response rates, advertising students from Fu Jen Catholic University were commissioned to actively solicit willing participants during the Taipei Comic Expo 2023. Table 2 presents the basic information of the survey respondents, aiming to understand the fundamental motivations of BL game players.

The independent variable in this study is "flow experience," and the dependent variable is "pleasurable emotions." The Likert 5-point scale is employed to measure the level of pleasurable emotions and willingness to use, where participants respond to questionnaire items, with response options ranging from "strongly agree," "agree," "neutral," "disagree," to "strongly disagree." Scores are assigned accordingly, with a range from 1 (strongly disagree) to 5 (strongly agree) (Babbie, 2001). Based on the research hypotheses, SPSS statistical software is employed as the questionnaire analysis tool. The analysis encompasses descriptive statistics, reliability analysis, correlation analysis, and regression analysis to comprehend whether the eight "flow experience" factors influence the pleasurable emotions generated by BL game players during the process. Additionally, it aims to ascertain whether these factors impact players' intentions to continue using the game.

Questionnaire Statistics

A total of 533 valid questionnaires were collected, with 59 male respondents, constituting 11%, and 463 female respondents, accounting for 86%. Additionally, 11 respondents indicated the option to choose "other" in terms of gender. The researcher respects respondents' choices regarding gender identity and considers these responses as valid questionnaires. The data indicates that the primary consumers of BL games are females, with males representing a minority. Furthermore, some respondents chose not to answer the gender-related questions, suggesting potential variations in gender awareness. The study did not specify a required gender for the sample, and participants were accepted regardless of their gender identity.

Table 1- Gender, age, and educational level sample data

	Number	Percentage

Gender	Male	59	11%
	Female	463	87 %
	Other	11	2%
Age	19 years old and below	80	15 %
	20 to 29 years old	373	70 %
	30 to 39 years old	64	12 %
	40 years old and above	16	3 %
Education	High school/vocational school or below	69	13 %
	University/College	405	76 %
	Master's	48	9 %
	Other	11	2 %

According to the statistical data, the majority of respondents have a gaming experience ranging from 6 to 10 years, totaling 213 individuals (40%). Following this, those with over 10 years of gaming experience comprise 171 individuals (32%). The third category consists of individuals with 1 to 5 years of gaming experience, totaling 133 individuals (25%), and the last category comprises individuals with less than 1 year of experience, totaling 16 individuals (3%).

Regarding the respondents' daily gaming time, the majority falls within the range of 3 to 4 hours, with a total of 251 individuals (47%). The next most common category is 2 to 3 hours, with 154 individuals (29%). Following this, there are 69 individuals (13%) who play for over 4 hours, and finally, there are 59 individuals (11%) who play for 2 hours or less. It is evident that spending several hours playing BL games is a common daily routine for the respondents.

Concerning the monthly expenditure on BL games, the highest bracket is 1001 to 3000 New Taiwan Dollars, comprising 229 individuals (43%). The next category is 501 to 1000 New Taiwan Dollars, with 170 individuals (43%). The third category is 3001 New Taiwan Dollars and above, with 107 individuals (20%), and the last category is below 500 New Taiwan Dollars, with 27 individuals (5%). Table 2 presents the statistical summary of gaming experience, daily gaming time, and expenditure amounts.

Table 2- Statistics of Gaming Experience and Daily Gaming Time

		Number	Percentage
Gaming Experience	Less than 1 year	16	3 %
	1 to 5 years	133	25 %
	6 to 10 years	213	40 %
	More than 10 years	171	32 %
G a m i n g Time (Daily)	below to 2 hours	59	11 %
	2 to 3 hours	154	29 %
	3 to 4 hours	251	47 %
	More than 4 hours	69	13 %

To gain a deeper understanding of which types of BL peripheral products are favored, four categories were formulated based on the literature. Statistical data reveals that character standees are the preferred choice, with a total of 224 individuals (42%). Following this are BL dolls, with 186 individuals (35%). Subsequently, BL character stationery is the choice of 64 individuals (12%). Lastly, other options are chosen by 59 individuals (11%). Refer to Table 3 for the statistical breakdown of consumption categories and peripheral products.

Table 3-Consumption Categories and Peripheral Products

		Number	Percentage
Category	BL Original Works	181	34 %
	BL Doujinshi	197	37 %
	Peripheral Products	128	24 %
	Digital Games	27	5 %
Peripheral Products	Character Stationery	64	12%
	Dolls	186	35 %
	Character Standees	224	42 %
	Other □ □ □	59	11 %

Table 4 presents the statistical analysis of reasons for liking BL games across different age groups. This aspect aims to understand the factors contributing to players' preferences for BL games. On one hand, it allows inference regarding the rapid popularity of BL games in Taiwan. On the other hand, it serves as an initial exploration to determine whether respondents who favor BL games do so as a form of protest against Taiwan's patriarchal society and rebellion against gender differences, observing and satirizing the expressions of male-male romance from a third-party perspective.

The statistical data reveals that the differences in the proportions of the top five reasons for liking BL games (young and handsome characters, voice actors and music, exquisite visual design, original story, derivative games fulfilling erotic imagination) are not substantial across various age groups. This may be attributed to the targeted nature of the survey conducted during a comic exhibition, where consumers have a clear focus. It is inferred that the characteristics of these five types of BL games indeed contribute significantly to respondents' liking of the games. As for protesting against patriarchal society (2%) and rebelling against gender differences (4%), within the scope of this study, these factors do not constitute the primary reasons for liking BL games.

Table 4- Reasons for Enjoying BL Games Grouped by Age

Reasons for Enjoying BL Games Grouped by Age				
Category	19 years and below	20 - 29 years	30 - 39 years	40 years and above
Young and Handsome Characters	27 %	26 %	30 %	28 %
Voice Actors and Music	14 %	14 %	11 %	16 %
Exquisite Visual Design	17 %	15 %	14 %	14 %
Story	15 %	16 %	16 %	13 %
Fan-created Games	12 %	14 %	12 %	15 %
Fulfilling Erotic Imagination	14 %	12 %	15 %	14 %
Protest Against Patriarchal Society	0 %	2 %	0 %	0 %
Gender Difference Rebellion	1 %	1 %	2 %	0 %

Table 5- Reliability Analysis for Each Variable

Variable	Mean	Cronbach's α Coefficient	Items
Clear Goals	4.548	.861	4
Feedback	3.175	.627	3
Challenge and Skill	2.779	.718	3
Control	3.172	.735	3
Distraction Exclusion	4.005	.787	3
Current Task	4.338	.849	3
Loss of Self-awareness	3.803	.801	3
Time Distortion	4.068	.819	3
Pleasant Emotions	4.366	.856	5

Table 5 shows that the study examined the eight factors of the independent variable "flow experience" in relation to the dependent variable "pleasure emotion." Each variable consists of three items, and therefore, item-total consistency reliability tests were conducted. According to the criteria proposed by George & Mallery (2003), a Cronbach's α coefficient exceeding 0.7 indicates optimal internal consistency among measurement items. The Cronbach's α coefficients for each dimension of the variables were all greater than .70, indicating an acceptable level of internal consistency within the scale items. This suggests that the measurement items within each variable demonstrate reliability, as presented in the reliability analysis.

Regression Analysis

This study employs linear regression analysis to investigate the causal relationship between flow experience and pleasure emotions. Babbie (2001) explains that regression analysis can utilize the R^2 value to assess the fit of the model and analyze the VIF value to determine the presence of collinearity issues. The analysis of p-values in regression analysis observes whether the determined variables in the study have a significant impact as independent variables on the dependent variable in linear regression. Utilizing eight factors of "flow experience" as

independent variables and player "pleasure emotions" as the dependent variable, the regression analysis reveals a change in the F-value of 71.408 (p-value less than 0.001). The adjusted overall coefficient of determination (R^2) is 0.424, indicating that 42.4% of the variability in "pleasure emotions" can be explained by the eight factors of "flow experience." This validates a certain influence of the eight flow experience factors on pleasure emotions, as detailed in Table 6.

Table 6- Regression Model for Flow Experience Factors on Pleasure Emotion

Model Summary							
Variable	R	R ²	Adjusted R ²	Standard Error of the Estimate	Adjusted Statistic		
					R ² Change	Significance	
							F-Statistic
	.748 ^a	.424	.420	.32581	.274	71.408	.000

Predictor Variable: (Constant), Eight Flow Experience Factors, Predicted Variable: Player Pleasure Emotion.

Table 7-Regression Analysis Variance Analysis Table

	Sum of Squares	Degrees of Freedom	Quadratic Mean	F	Statistical Significance
Regression	545.481	8	57.274	43.761	.000
Residual	326.227	425	1.407		
Total	1213.178	533			

□N=533□

At the same time, the results of the analysis of variance (Table 7) also revealed that the explanatory power of this regression model has reached a statistically significant level, with $F(8,425) = 43.761$, $P < 0.01$.

In the statistical section of the regression coefficient table (Table 8), the relative influences among variables can be observed. The results indicate a significant relationship between "goals" and "pleasure emotions" with a β of .216, $p < .01$. This suggests that there is a statistically significant positive correlation between "goals" and "pleasure emotions," meaning that as "goals" increase, so does the strength of "pleasure emotions". Similarly, there is a significant relationship between "control" and "pleasure emotions" with a β of .082, $p < .01$, indicating a statistically significant positive correlation. As the "control" increases, the strength of "pleasure emotions" also increases. The variable "Current Task" is also significantly related to "pleasure emotions" with a β of .103, $p < .01$, suggesting that higher levels of "Current Task" correspond to stronger "pleasure emotions." Additionally, "loss of self-awareness" and "pleasure emotions" show a significant difference with a β of .053, $p < .01$, indicating that higher levels of "loss of self-awareness" correspond to stronger "pleasure emotions."

As for the remaining variables, "feedback" ($\beta = -.037$), "challenge and skill" ($\beta = -.055$), "distraction Exclusion" ($\beta = -.043$), and "time distortion" ($\beta = -.048$) are shown to be related through correlation analysis, but the regression analysis does not present significant results.

Table 8-Coefficient Table for Regression Analysis

	Unstandardized Coefficients		Standardized Coefficients		Significance	Multicollinearity Statistics	
	B	Standard Error	β	T		Tolerance	VIF
(Constant)	.513	.206		2.131	.010		
Goals	.241	.037	.216	.467	.003**	.315	3.637
Feedback	-.015	.055	-.037	-.082	.631	.326	1.565
Challenge and Skill	-.014	.067	-.055	-.120	.554	.277	2.445
Control	.184	.055	.082	.326	.005**	.314	3.753
Distraction Exclusion	-.032	.055	-.043	-.334	.247	.273	1.885
Current Task	.083	.059	.103	.407	.008**	.224	3.316
Loss of Self-awareness	.155	.064	.053	.371	.010**	.327	3.892
Time Distortion	-.049	.059	-.048	-.142	.280	.361	2.174

DependentVariable: Pleasure Emotions

Note: The asterisks (*) represent the level of statistical significance, with * indicating $p < 0.05$, and ** indicating $p < 0.01$.

The results of the overall statistical analysis and the validation of the hypotheses proposed in this study were summarized. It was found that respondents' thoughts on the pleasurable emotions and the willingness to continue using BL games were investigated. Hypothesis 1 suggested a significant correlation between the flow experience factors and the pleasurable emotions generated by BL game players during the gaming process. However, the correlation analysis indicated that the factors of Feedback, Challenge and Skill, Distraction Exclusion, and Time Distortion were related to pleasurable emotions, but the differences were not statistically significant. Therefore, Hypothesis 1 was considered partially supported.

Hypothesis 2 proposed the impact of social gender issues on the willingness of players to participate in games is not significantly influential. According to descriptive statistical data, respondents are not intentionally engaging in BL games as an act of resistance or rebellion against patriarchy or social gender differences. The primary reasons for participation are a fondness for in-game characters, narrative storytelling, voice actor performances, music rhythms, peripheral products, and

fan creations. Therefore, this assumption is not valid.The hypothesis verification results are presented in Tab9.

Table 9-Research Hypothesis Results

Hypothesis	Results
Hypothesis 1: There is a significant correlation between the factors of flow experience and the generation of positive emotions in BL game players during the gaming process.	partially valid
Hypothesis 2: The influence of social gender issues has a significant impact on players' willingness to participate in games.	not valid

Research Findings

Several research findings are outlined below:

- (1) The study explores the correlation between emotional pleasure and flow experience factors among Taiwanese BL game players. It was observed that female players exhibit high levels of engagement in BL games, aligning with existing literature. This heightened participation does not necessarily reflect the pressures women face in a male-dominated society. Instead, these players steer the narrative in the virtual game towards their imagined direction, experiencing a sense of achievement and pleasure upon realizing specific outcomes.
- (2) Taiwanese BL game players engage in games not as a form of protest against patriarchal society or gender issues but out of affection for the youthful and attractive in-game characters. They appreciate the autonomy to control characters and shape the story's development. The allure of multi-branch storylines, intricate artistic designs, music, and game features satisfying their imagination of romantic relationships between male characters further contributes to their involvement. Some players even become creators of fan works and purchase related game merchandise.
- (3) Through regression analysis, the study establishes relationships between eight flow experience factors and players' pleasurable emotions. Specifically, "clear goals," "sense of control," "elimination of distractions," and "loss of self-consciousness" show significant positive correlations with pleasurable emotions. This confirms Mihaly Csikszentmihalyi's perspective that these features do not need to coexist simultaneously; possessing a few of these characteristics is sufficient to achieve a state of flow.

The study concludes that emotional experiences and social interactions within BL games do generate a flow experience, bringing players a sense of pleasure. In a relaxed and free atmosphere, emotions are fermented and imaginatively expanded through character dialogues and physical interactions, ultimately resulting in a sense of belonging and the pleasurable emotion of love. This

sense of pleasure not only influences the level of player engagement in the game but also positively impacts their willingness to continue using the game.

Recommendations

The following are several research recommendations, explained as follows:

(1) This study focuses on BL games, and the communication characteristics and interaction modes on different media platforms, such as BL movies, TV shows, internet literature, virtual communities, etc., often vary. This leads to consumers having different types of pleasurable experiences in the BL industry. These pleasure patterns are not independent; they often overlap or interact with each other. Therefore, in future research, exploring the relationship between players' composite pleasurable experiences and their sustained usage intentions could be investigated based on this foundation.

(2) The questionnaires were distributed during the exhibition period of the "2023 Taipei Comic Expo," and the number of collected questionnaires was limited. Furthermore, the research used quantitative questionnaire surveys, which only provide information about the respondents' usage status during a specific period and cannot reveal profound psychological thoughts. It is suggested to include qualitative interviews in the future to understand the motives and purposes of game users.

(3) The majority of questionnaire respondents were young females, with only a few males participating. It is challenging to explain the apparent gender differences in BL games. Is it due to the content of the game or other influencing factors? In the future, it is recommended to explore the usage intentions of male gamers regarding BL games.

(4) The research can also focus on BL game fan communities in different regions and cultural backgrounds to gain a more comprehensive understanding of the diversity and influence of this fan culture. As a unique cultural phenomenon, BL game fan communities are worth further in-depth research and understanding.

In conclusion, this study not only reveals the critical role of flow experience and pleasurable experiences in players' gaming experiences but also provides practical application value. In the future, with the continuous development of technology, virtual reality (VR) and augmented reality (AR) technologies will further change gaming experiences. These technologies provide deeper perceptual and cognitive experiences, making it easier for players to enter a flow state while increasing pleasure. In the field of BL game design, research on flow experience and pleasure will continue to influence the development of games.

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Design and Experiment of AI Chatbot for the Apprenticeship Program in Windfarm

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Abstract

As AI technologies advance, they offer potential applications to improve training and education. Ørsted, a global offshore wind leader, partnered with Da-Yeh University in Taiwan to launch the Greater Changhua offshore wind farm projects. Da-Yeh University innovatively used the generated AI from ChatGPT to promote training and educational quality during the apprenticeship of the projects. This study will show how Da-Yeh University developed a chatbot using WebEx and Augmented Reality (AR) to design and explore new apprenticeship training methods.

Keywords

Apprenticeship, Windfarm, ChatGPT, Chatbot

Introduction

With global climate change and environmental problems becoming increasingly severe, governments are establishing renewable energy development strategies to reduce the reliance on traditional fossil fuels [1]. As an island nation with limited resources, Taiwan's active development of wind energy has become a meaningful way to stabilize the energy supply and reduce carbon emissions [2]. The construction and expansion of wind farms in Taiwan have grown in recent years. With the advancement of technology, wind farm operators are actively seeking digital transformation to improve operational efficiency and maintenance management.

Changhua has Taiwan's largest offshore wind farm, and the central and local governments are pushing for offshore wind power. The average density of wind power in the coastal area of Changhua is more than 750 watts per square meter, and the year-round wind speed is more than 7 meters per second[3]. In 2019, Ørsted Energy, the world's leading offshore wind power company, joined hands with Da Yeh University to set up a wind power research and education training center and invested resources such as expert workforce and teaching cabins in the Da Yeh Offshore Wind Power Apprenticeship Program for the Greater Changhua offshore wind farm projects [4].

The wind farm projects are developed at four sites in the Taiwan Strait, approximately 35km to 60km offshore Changhua County in Taiwan. The total power generation capacity of the wind farms is 2.4GW. Greater Changhua offshore wind farms include Greater Changhua 1 and 2a

wind farms with 900MW capacity, Greater Changhua 2b and 4 wind farms with 920MW capacity and a future 600MW Greater Changhua 3 project[5].

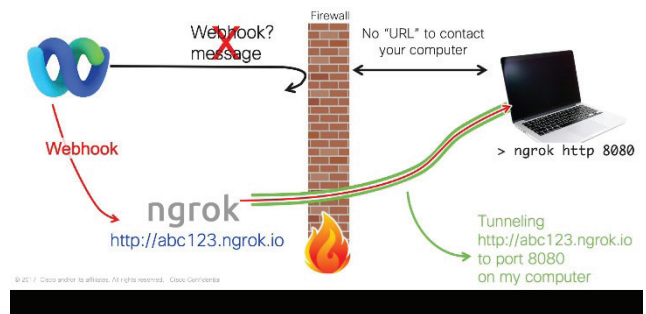


Figure 1–Location of Greater Changhua Offshore Wind Farm Projects

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Ørsted allowed students to work on crew transfer vessels (CTVs) and service operation vessels (SOVs) and participated in the operation and maintenance of wind turbines, drones, and uncrewed underwater vehicles. Apprentices will receive scholarships and have living expenses covered during the bachelor study. All students will receive salaries in the fourth grade, which includes on-the-job training. After graduation, Ørsted offered job opportunities to the students, and those selected will travel to Denmark to attend an inauguration course [6].

The Research, Education, and Training Center of Da-Yeh

University not only cultivates offshore wind power talents in Changhua but also catches the AI trend to apply the AR, VR, and ChatGPT[7][8] for training maintenance, which allows students to simulate the related maintaining skills in a safer way in the indoor area before they go out to the sea to repair the turbines in person.

The main goal of this study is to leverage AI technology to enhance learning outcomes within the field of education and training [9]. Similar to its application in other domains, AI offers the advantages of increased computational capabilities and customized content for learners. The integration of AI into education, known as AI in Education (AIEd), closely aligns with the broader advancements in the AI field [10]. Multiple studies have highlighted the potential of AI in promoting engagement, streamlining repetitive tasks, personalizing educational materials, and identifying emerging gaps in learning within traditional classrooms [11].

According to Roll et al. [12], the AIEd system encompasses three essential components: the domain model, the pedagogical model, and the learner model. One of the strengths of AIEd lies in its ability to select relevant content from the domain model tailored to the specific requirements of the learner (model), all while monitoring and tracking the intermediate interactions (pedagogical model) [13]. As a result, AIEd facilitates the delivery of customized content, aligning with the individual needs of each learner.

This paper is organized as follows: we briefly introduce the motivation for this study in Section 1. Section 2 describes the technology background of this study, which is a platform to assist apprentices training across the field of chatbots via ChatGPT, AR, and WebEx. Section 3 presents the practical application scene of this study. Finally, we summarize our findings and hint at the possible directions for future research in Section 4.

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Technical Background

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In recent years, with the development of artificial intelligence, generative language modeling has quietly changed our lives. Generative language modeling is a kind of artificial intelligence model designed to generate natural language text, such as articles, sentences, or dialogues. Based on machine learning and neural network techniques, these models are trained on large amounts of textual data to understand a language's structure, grammatical rules, and semantic meaning. They can then generate contextualized and contextualized text[14].

A Large Language Model (LLM) is a powerful deep learning model designed for natural language processing (NLP) tasks, boasting an impressive arsenal of over 100 billion parameters[15]. This model undergoes extensive training on a vast corpus of textual data, encompassing sources like news articles, books, audio recordings, videos, and more. This rigorous training equips the LLM

with a multifaceted capacity, enabling it to perform various language-related functions such as recognition, summarization, translation, prediction, and content generation. In essence, it serves as an intricate reservoir of knowledge, adept at absorbing and applying vast information in practical ways[16].

Simply put, an LLM can be likened to a memory powerhouse, assimilating copious amounts of knowledge and then utilizing that knowledge to answer questions, generate text, translate languages, and perform many other tasks. Practical applications of LLMs span diverse domains, including generating product descriptions, addressing frequently asked questions (FAQs) and analyzing customer feedback gleaned from social media and product reviews.

The term "big" in LLM alludes to the model's parameter count, which signifies the extent to which the model can autonomously adjust itself during the learning process. Larger parameter sizes translate into a more expansive reservoir of knowledge, allowing the model to handle a broader spectrum of tasks. What is particularly noteworthy is that the knowledge scope of LLMs extends beyond human language, encompassing domains such as biological language, e.g., proteins and molecular sequences, and computer language (code). This versatility has led to the widespread utilization of LLMs across various fields, including healthcare, software development, and natural sciences, underscoring their immense potential for innovation and problem-solving[17].

OpenAI's ChatGPT is one of the mainstream models built on top of the LLM architecture. It learns how to generate natural and smooth conversations by training many conversational texts and articles. The critical feature of ChatGPT is its ability to understand context and context and to generate appropriate and suitable responses. Thus, it has a significant position in the language generation model because it not only creates text but also realizes the naturalness and fluency of conversations, can adapt to various conversation topics and scenarios, and participates in communication naturally[18].

Therefore, providing a more human, real-time, and practical apprenticeship service experience through natural language understanding and generation makes intelligent training service possible and helps streamline the organizational workforce. However, with the development of generative language modeling comes some dilemmas and challenges. One is the need for more complex or ambiguous content. Although it performs well in most cases, in some specific situations, the model may need to be more accurate or provide accurate responses, giving the user the impression that the generative language model's responses are serious and nonsensical.

The most crucial thing of Da-Yeh University (DYU) to apply intelligent training service is to provide immediate and accurate responses for apprentice training, which is also the weakness of the current generative language

model. The natural and smooth dialogues supported by the generative language model such as LLM and the responses with correct information will help the educational quality and windfarm workforce load. Therefore, how to train DYU's LLM model is an important and urgent issue for the success of apprenticeship project.

OpenAI recently released the fine-tuning function for ChatGPT-3.5 and even the ChatGPT-4 model. This project apply OpenAI's Fine-tuning API to improve the performance and accuracy of the model by fine-tuning specific tasks or domains based on the trained model so that the output of the information can be more in line with the needs and expectations of the apprenticeship program. Compared with the prompts of the instructions, if the fine-tuning is good, the ChatGPT output is more accurate.

ChatGPT output is better when fine-tuned compared to command prompts. Using shorter commands to achieve the desired output reduces token usage, which reduces the expenditure cost and speeds up the response time. In addition, Fine-tuning allows models to adapt to different tasks or domains to meet other application requirements without retraining new models from scratch.

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Design and Experiment

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We chose Cisco WebEx [19], with over 300 million daily participants [20], as our platform for chatbots. In this study, we'll build an interactive WebEx chatbot that utilizes OpenAI's API for generating responses. Here's how the process works: whenever a user provides input to the chatbot, the logic interacts with OpenAI's API, using the user's input as a prompt. Subsequently, it retrieves the generated response from the API and sends it back to the user.

Since we learned our interaction with ChatGPT is a dialog model in Section 2, and Cisco's WebEx Teams provides an API for ChatBOTS, we can ask ChatGPT questions about apprenticeship training through WebEx Teams. Chatbots are similar to regular WebEx users. Bots enable WebEx users to access external services directly from their WebEx space. Bots help users automate tasks, bring external content into the discussion, and increase efficiency. The easiest way to integrate this is to use WebEx Teams' Webhook to intercept the question message in the chat space and then pass the question back to ChatGPT as an API, as shown in the Figure 1 below. Webhooks are applications that notify you when specific activity occurs in your WebEx. The benefit of using Webhooks is that they allow your application to receive data from WebEx in real time and, therefore, know the status of your resources. In addition, we use the Ngrok server (<https://ngrok.com/>) as the mediation to pass the webhook from the WebEx cloud back to the user to prevent blocking from the firewall (Figure 2).

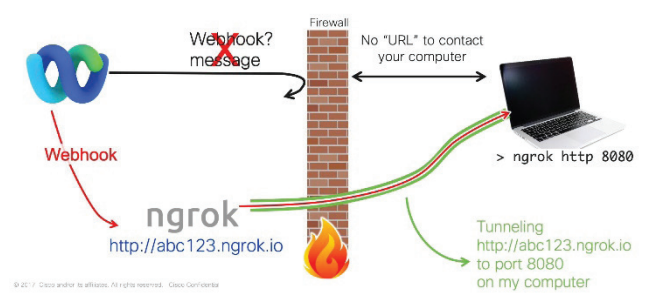


Figure 2–AI Chatbot Framework

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The experimental platform for chatbot is launched by the following steps:

Step 1 Create a Webex Bot

If the WebEx user logged in, creating a Webex Bot is straightforward: the user needs to select My Webex Apps from the menu under the user's avatar at the top of this page, click "Create a New App," then "Create a Bot" to start the wizard.

Step 2Write the code based on PyCharm IDE

The user should install PyCharm IDE to write the following codes. We establish two python files here. The first one is "app.py", the second is the "openai_command.py". The first python file is used to set up the basic environment to interact between the WebEx bot and ChatGPT(Open AI), the full code of "app.py" is shown in Figure 3.

```

系統管理員: 命令提示字元 - ngrok http 80
ngrok
Build better APIs with ngrok. Early access: ngrok.com/early-access

Session Status      online
Account             pauldyu57@gmail.com (Plan: Personal)
Update              update available (version 3.5.0, Ctrl-U to
Version             3.3.0
Region              Japan (jp)
Latency              34ms
Web Interface        http://127.0.0.1:4040
Forwarding            https://f27be5debb59.ngrok.app -> http://lo

Connections          ttl    opn    rt1    rt5    p50    p90
0                  0      0.00   0.00   0.00   0.0
  
```

Figure 3–Code Sample

The second is modified from the sample provided by OpenAI (<https://platform.openai.com/docs/api-reference/introduction>)

). We use the second one as a class, which is called by the first one.

Step 3Install the Ngrok Server and Set the Tunnel

The apprentice may connect our development application to a secure network behind a firewall. To resolve/prevent access restrictions and blocking from the firewall, Ngrok runs a small client process on the machine that creates a private connection tunnel to the cloud service. Our localhost development server is mapped to a subdomain of ngrok.io that is accessible to remote users. There is no need to open ports, set forwarding, or make other network changes. The setting scene is shown in Figure 4, the operational process is also illustrated in Figure 1.

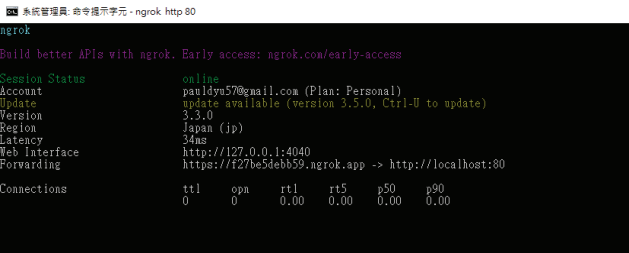


Figure 4 –Ngrok Server

We seek the possible AR devices to integrate with to strengthen the value of using WebEx. This study initially opted to launch an augmented reality (AR) experiment using both Microsoft HoloLens (<https://www.microsoft.com/en-us/hololens/hardware>) and Realwear HMT-1 (<https://www.realwear.com/>). However, after careful consideration, the windfarm team decided to employ Realwear HMT-1 for education and training due to its unique voice communication capabilities, which proved more advantageous than the hand gesture communication offered by HoloLens.

Realwear HMT-1 is an AR device featuring a compact digital screen positioned to the side of one of the user's eyes and integrated into a helmet (as illustrated in Figure 5, left). The device is meticulously designed to ensure that the screen remains precisely aligned with the user's field of vision. This screen is a platform for displaying slides or videos (as depicted in Figure 5, right).



Figure 5– Application Scene
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Notably, the HMT-1 is relatively lightweight, with the device itself weighing 0.37 kg, and when combined with the attachment hardware and helmet, the total weight is 0.76 kg. The choice of HMT-1 over HoloLens was primarily driven by the fact that safety helmets are not required within the engineering environment, rendering the additional weight of HoloLens redundant.

The experimental protocol is established and managed online through the WebEx meeting system (Figure 6). This platform allows any nurse from a children's hospital in the patient referral team to utilize the Realwear HMT-1 in conjunction with WebEx for real-time communication. The objective is to collaboratively determine the most suitable conditions for optimizing their maintenance performance. This innovative approach leverages AR technology and seamless communication to enhance the efficiency and effectiveness of apprentice training within an AI WebEx Bot setting. The content of Figure 6 presents a prompt about inquiring about "LCA" in windfarm management and the response from the AI WebEx Bot. The answer from the bot is quite good.

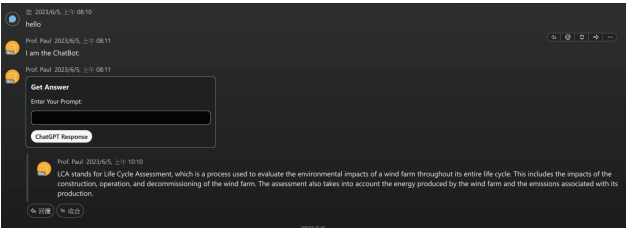


Figure 6–Response from AI WebEx Bot by Inquiring Life Cycle Assessment (LCA) in Windfarm
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In addition to the real-time inquiry from the bot, the Realwear HMT-1 also includes the IP cam on the helmet, which means the experienced technician could instruct the apprentice from a distance to deliver reliable and remote assistance by sharing the real-time video to save travel costs and delays.

In the apprentice training for windfarm maintenance, the DYU efforts introduce digital solutions and catch the young generation's preference to support the facilitation of basic knowledge recall and application. To foster a higher order of knowledge development across various scenarios, we must leverage digital interactive tools like ChatGPT to keep the teaching alive and vivid.

We also do a simple survey for the apprentice students for their degree of satisfaction using the Likert scale with 5 points. The students with the new AI WebEx Bot responded 4.4 points back, while the students with the traditional lectures returned 3.9 points; these facts show that the unique experience and stimulation to these young students have positive feedback. Considering the rapid AI evolution of educational technology and changing client expectations, the DYU education team can harness these tools' potential applications within both classrooms and simulators, harnessing them to their fullest extent.

In this study, we have introduced and validated the concept of integrating generated AI into apprenticeship education and training by implementing the WebEx Bot in a windfarm classroom environment. The new platform has showcased its utility, particularly in capturing the hobby of the young generation from training apprentice students in windfarm maintenance. The satisfaction assessment, conducted using the 5-point Likert Scale, revealed high satisfaction among maritime students regarding AI WebEx Bot with HMT-1 functionality.

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Conclusions and Recommendations

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Apprenticeship programs have emerged as a highly effective means of nurturing a workforce that caters to the diverse demands of various industries. These programs extend their benefits to technical trade-skilled roles and even entry-level positions in project development. Da-Yeh and Orsted's pioneering apprenticeship initiatives establish a mutually beneficial relationship between the wind energy sector and academic and training institutions. This collaborative effort ensures that students are equipped with the precise skills demanded by the windfarm industry. In an era where artificial intelligence (AI) trends are shaping the global landscape, the DYU Wind Power Research and Education Training Center has introduced an innovative approach to apprenticeship programs. They have harnessed the potential of Augmented Reality (AR) devices, integrated with ChatGPT, within the WebEx platform. This integration serves as a catalyst for the success of the apprenticeship program, aiming to enhance the quality of teaching while adding significant value to AI-based training methodologies.

However, it is crucial, within the context of our ongoing study, to recognize and address certain limitations. These limitations provide valuable insights that can guide future research endeavors. First and foremost, it is essential to acknowledge the diversity of approaches adopted by signatory states under the Standards of the Global Wind Organization (GWO) concerning Windfarm Education and Training and the utilization of technological resources. Our study, originally conceived as a proof of concept, was conducted within the confines of DYU, which offers distinct levels of wind farm education. It is vital to acknowledge that assumptions about the utilization of

technological tools, such as smartphones or laptops, to enhance knowledge acquisition within a B.Sc. program in windfarm maintenance, may exhibit significant variations across different nations and regions.

Furthermore, the relatively modest sample size used in our study, coupled with the specific contextual factors associated with the university, warrants caution when attempting to extrapolate our findings to other geographical regions. While our collected usability data has been benchmarked against generic standards from broader usability studies, there remains an acute need for deeper insights into the application of Artificial Intelligence in Education (AIED) tools within the framework of GWO standards.

In addition to this, a comprehensive analysis of the textual data generated during interactions with the AI WebEx Bot, employing conversation analysis techniques, could shed light on the intricate process of knowledge construction undertaken by windfarm trainees as they grapple with the complexities of the subject matter.

Looking towards the future, our research endeavors should adopt a comprehensive approach to explore the potential of AI chatbots and their capacity to enhance the educational components of B.Sc. programs in windfarm maintenance. Moreover, we must embark on a broader exploration of AIED applications within Windfarm Education and Training. This broader perspective is crucial in optimizing efficiency, fostering competence development, and promoting self-directed learning, all of which are essential elements in addressing the ever-evolving skillset requirements within the windpower domain.

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Continuous Usage Behavior of Facility AI Platform Service based on Expectation-Confirmation Model

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Abstract

Most manufacturing companies are enhancing existing labor productivity and accelerating efforts for the digital transformation of organizations through smart factory and AI platform. This study develops and empirically tests an Expectation-Confirmation Model (ECM) framework to investigate customers' continued usage behavior of facility AI platform service. Based on ECM model, this study analyzed the relationship between confirmation, perceived usefulness, satisfaction, and customers' continued usage behavior. Our findings indicate that customers can improve their continued usage intention through ECM-based framework to adopt reuse of facility AI platform service. This study collects 98 data from manufacturing companies which adopted their AI platform service. After analyzing the data, we conclude that digital transformation through facility AI platform service enables management innovation for sustainable growth of the firm.

Keywords

Facility AI Platform Service, Confirmation, Perceived Usefulness, Satisfaction, Reusage Intention

1. Introduction

With big changes in the business environment, such as the development of 4th industrial revolution technology, the change of consumer demand and the fierce competition in the industry, company strategy and business processes have undergone profound changes. The rapidly changing business environment is making efforts to secure a new competitive advantage by redesigning existing business processes and promoting automation by allowing companies to develop and implement strategies for digital transformation. Digital transformation has become an indispensable foundation and way for companies to face the direction of networking and intelligence, improve quality and efficiency, and reshape the firm's core competitiveness (Lu et al., 2019).

In other words, with the development of digital technology, the company's business environment has become more and more networked and an intelligent digital environment. However, previous studies on resource-based view and core competency theory have certain limitations when it comes to explain this new digital transformation phenomenon (Yu and Moon, 2021). The

success of an information technology (IT) depends on the continuance of its usage (Bhattacharjee, 2001). Following initial IT adoption, users cannot experience the benefits of a particular technology without continuing to use it. Therefore, it is no wonder that academics have occasioned IT continuance, a form of post-adoption behavior, to be a leading IT research area for some time (Hong et al., 2006; Al Mamun et al, 2020). As it investigates IT continuance, described in the expectation-confirmation model (ECM), this research introduces and examines the influence of facility AI platform service on customers' continued usage intention with feedback mechanism of supplier vendor.

The questions with this study are: 1) How do customers' confirmation and perceived usefulness have a positive impact on customers' satisfaction? 2) How do customers' perceived usefulness and satisfaction have a positive impact on customers' continued usage intention of AI platform service? To solve this question, this study suggests a research model based on MIS literatures and ECM theory. Thus, this study proposes a research model to analyze the relationship between confirmation, perceived usefulness, satisfaction, and continued usage intention through user's feedback mechanism. This study

focuses on facility AI platform service for smart factory of integrated enterprise systems, which understand both expressed and latent information needs or delivers superior value to the organization.

2. Literature Review

2.1 Digital Transformation of SMEs

In a couple of last decade, SMEs (small and medium enterprises) are small in scale and flexible in their business operations, and are most likely to organize production facility and equipment according to economic comparative advantages. With the increasing employment pressure in society, the advantages of SMEs in solving employment have also received more and more attention to digital transformation strategy like smart factory. Smart factory projects for digital transformation are particularly important for traditional manufacturing companies. With the deep integration of digital technologies in the manufacturing industry, there has been a digital transformation that has changed the traditional production and operations management methods and offers the potential for the improvement of product development, production efficiency and customer service (Wei et al, 2017). Digital transformation is an important phenomenon in the research of MIS, including the significant changes in society and industry through the use of digital technology. The digital technology trends and design principles used by SMEs in digital transformation process of 4th industrial revolution include artificial intelligence (AI), Internet of Things (IoT), big data analytics, cloud computing, 3D printing, mixed reality (virtual and augmented reality), simulation of connected machines (Paschou et al., 2020).

2.2 Facility AI platform service

POSCO developed PosFrame, the world's first smart factory platform that reflects the characteristics of steel continuous processes, in 2018, and is the world's first steelmaker to introduce artificial intelligence into an intelligent steel mill (POSCO, 2018). Through this, a barrier-free operation system is realized, quality defects are identified in advance to minimize defects, and risk factors in the workplace are identified in real time to realize a safe production environment. Various data collected in a smart factory can predict temperature changes through deep learning algorithms, which can be controlled in advance be developing into. As a result of the application of this case, it was selected as a "lighthouse factory in the world" to lead the future of global manufacturing at the 2019 Davos Forum in Dalian, China (Seo et al, 2022). SMEs that adopt digital transformation with information technology must be aware of both their product design and manufacturing environment. By constantly monitoring changes in the dynamic environments, SMEs

can gain awareness of opportunities for greater access to new markets as well as advancements in technological initiatives. Facility AI platform service in this study refers to the action of transforming existing employ handling operation into smart factory operation with robot, vision, IoT, and cloud computing technology. For example, robot and vision technology with software applications could be utilized for job shop operations during production process. Generally, digitization mainly refers to digital operation processes, but have an influence on the value creation of business activities. Companies enhance the user experience and create additional customer value by allowing more efficient configuration between business processes (Pagani et al., 2017).

2.3 ECM model

The expectation-confirmation model (ECM) (Bhattacharjee, 2001) was developed based on expectation confirmation theory (ECT) where satisfaction is the primary predictor of continuance intention followed by confirmation of post-adoption expectations, and it is a widely used model to investigate the continuance intentions of a consumer of IT.

The ECM explains that confirmation of the utilitarian value of any technology, perceived usefulness, leads to user satisfaction and satisfaction leads to the intention to continue to use that particular technology. Perceived usefulness and confirmation of expectation together determine satisfaction, and confirmation has an impact on perceived usefulness. The existing literature on ECM has predominantly focused on post-adoption expectation and perceived usefulness of ECT. In order to improve the explanatory power of the ECM, researchers have added many context-specific constructs into the model as antecedents, mediators or moderators of the existing structural components (Aker et al., 2013; Bhattacharjee, 2001, 2001a; Lin & Bhattacharjee, 2009). Considering these models and their empirical settings, it is evident that almost all of them examined IT as a utilitarian tool used to enhance user performance and productivity.

3. Research Model and Hypotheses

3.1 Research Model

Based on ECM theory (Bhattacharjee, 2001, 2001a; Lin & Bhattacharjee, 2009), most manufacturing companies have conducted smart factory strategy implementation to improve operational performance for obtaining competitive advantage. This study proposes new approach of facility AI platform service and explores the impact of usefulness and satisfaction of that service on customers' continued usage intention based on ECM model. This study developed a research model (Fig. 1), which explain facility AI platform service for obtaining the customers' continued usage intention.

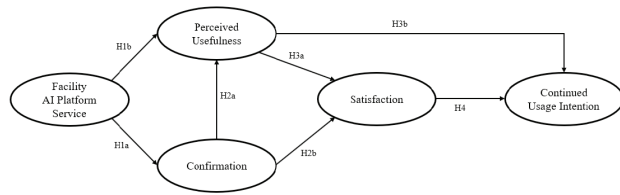


Fig. 1 Research Model

3.2 Research Hypothesis

Since this study has a research direction to explain the need for smart factory strategy implemented by AI platform service, an ECM research model with confirmation, perceived usefulness and satisfaction on continued usage intention, was suggested. The sustainable competitiveness of the firm can be obtained by the adoption and use of AI platform service for digital transformation.

H1: Facility AI platform service has a positive influence on (a) confirmation of customers and (b) perceived usefulness of customers.

H2: Customers' confirmation of facility AI platform service has a positive influence on (a) perceived usefulness of customers and (b) satisfaction of customers.

H3: Customers' perceived usefulness of facility AI platform service has a positive influence on (a) satisfaction of customers and (b) continued usage intention.

H4: Customers' satisfaction of facility AI platform service has a positive influence on continued usage intention.

4. Research Method

4.1 Operational Definition

The purpose of this study is to conduct an empirical study on the relationship between customers' confirmation, perceived usefulness and satisfaction on continued usage intention of facility AI platform service of the firm. Preexisting construct measures have been used in this study.

Table 1 - Sample Statistics

Item	Type	Freq	Ratio(%)
Industry	Automobile	51	52.0
	Mechanic	20	20.4
	Electronic	27	27.6

Facility Team Members	Under 5	65	66.3
	6~10	28	28.6
	11~20	2	2.0
	21-30	2	2.0
	Over 30	1	1.0
Smart Factory Project Period (Month)	Under 6	10	10.2
	7~9	60	61.2
	10-12	20	20.4
	13~18	7	7.1
	Over 18	1	1.0
4th ICT Technology Use (multiple choice)	AI	24	24.5
	IOT	86	87.8
	Big Data	32	32.7
	Cloud	4	4.1
	Mobile	3	3.1
	Robot	83	84.7
	Vision	27	27.6

According to previous studies of resource-based theory and dynamic capability theory, this study developed the operational definition and measurement items of independent variable (facility AI platform service), mediating variables (confirmation, perceived usefulness, and satisfaction), and dependent variable (continued usage intention). Some of questionnaire items were measured using a 5-Point Likert Scale ranging from 1 (very disagree) to 5 (very agree). Data was analyzed in three steps. First, we tested for outliers, normality, and missing values. Then, we evaluated the internal and external validity of the measurement scales, and finally, examined the reliability, validity, correlations, model fit and mediation effects.

4.2 Sample Statistics

This study collected the data for analyzing the level of smart factory readiness from 98 manufacturing firms. Survey respondents were comprised of decision makers (entrepreneurs) of 98 Korean SMEs, which were implemented smart factory project with robot and vision technology. The survey was conducted from March 2023 to May 2023. A total of 98 firm data was collected, and valid responses were analyzed using SPSS 27 and PLS 4.0.

Table 2 – Convergent Validity

Var	Items	Cross-Loading	AVE	Composite Reliability	Cronbach-a
AIP	3_1_1	0.874	0.670	0.894	0.874
	3_1_2	0.882			
	3_1_4	0.847			
	3_1_5	0.844			
	3_5_3	0.618			

Conf	3_2_1	0.769	0.641	0.817	0.813
	3_2_2	0.831			
	3_3_3	0.776			
	3_3_4	0.823			
PU	3_3_1	0.862	0.621	0.880	0.877
	3_3_2	0.827			
	3_3_3	0.725			
	3_3_4	0.707			
	3_4_1	0.789			
	3_4_3	0.806			
Sat	4_1_1	0.841	0.712	0.903	0.898
	4_1_2	0.872			
	4_1_3	0.902			
	4_1_4	0.785			
	4_1_5	0.815			
CUI	5_1_1	0.852	0.721	0.910	0.903
	5_1_2	0.784			
	5_1_3	0.897			
	5_1_4	0.874			
	5_1_5	0.833			

4.3 Validity and Reliability

The respondent of the firm was interviewed by field experts. Based on some of visits and interviews, the data were collected through self-diagnosis of level measurement and field survey by external smart factory experts of the promotion team. <Table 2> shows the sample statistics on 98 firms in this study.

Field survey has some advantage of exact diagnosis by external experts. Based on the level measurement, some questionnaires were organized into research variables in the research model. To establish convergent validity as recommended by Hair et al.(2014), factor loading and average variance extracted (AVE) were used.

Table 3 – Discriminant Validity

	AIP	Conf	PU	Sat	CUI
AIP	0.819				
Conf	0.608	0.801			
PU	0.749	0.775	0.788		
Sat	0.775	0.610	0.610	0.844	
CUI	0.627	0.596	0.646	0.802	0.849

All the loadings for the final model were above 0.618. Furthermore, all the construct measures met the criteria of AVE > 0.5 ranging from 0.621 to 0.721. To establish internal consistency, All the Cronbach-a values are above the threshold 0.7 value which ranged from 0.813 to 0.903.

4.4 Hypothesis Testing

The results of hypothesis testing in this study are summarized as follows. For H1a and H1b, the result shows that facility AI platform service influences positively on customers'

confirmation and perceived usefulness. For H2a and H2b, the result shows that customers' confirmation influences positively on perceived usefulness and satisfaction. For H3a and H3b, the result shows that perceived usefulness influences positively on customers' satisfaction and continued usage intention. For H4, the result shows that customers' satisfaction influences positively on continued usage intention of facility AI platform service. This result means that the usage of facility AI platform service enables the organizational members charged in facility maintenance to intend continued usage for improving organizational competitiveness.

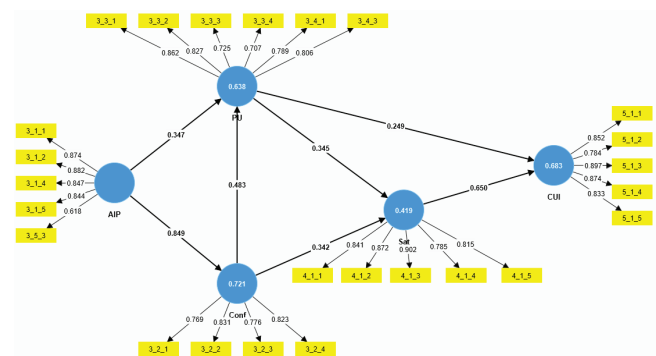


Fig. 2 The Result of Path Analysis

5. Discussion and Conclusion

The results from this study contribute to provide some theoretical basement for the development of corporate smart factory strategy. This study has suggested a new digital transformation strategy through facility AI platform usage. It emphasizes the importance of the relationship between customers' confirmation, perceived usefulness, and continued usage intention through satisfaction of platform service. This study has some limitations. It is difficult to generalize the results because of small data sample size and limited research variables. In the future research, we will study value perception and feedback mechanism through smart factory strategy and the use of facility AI platform service. Also, future research needs to enlarge the sample size and empirically examine the different industries to implement smart factory projects.

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Analyzing the Effects of Anthropomorphism in NPCs Applied by GPT on User Satisfaction and Loyalty

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Abstract

This research studies NPCs applied by Generative Pre-trained Transformer (GPT) Technology. This study set three independent variables as characteristics of the NPCs applied GPT. User immersion is set as a mediator variable, while user game satisfaction and loyalty are chosen as dependent variables. The Stimulus-Organism-Response (SOR) theory is employed to study user attitude changes, and immersion is examined through the Flow Theory.

Keywords

Non-player Characters, Satisfaction, Loyalty, Flow Theory, SOR Theory

Introduction

Games have the unique ability to enable users to construct their own worlds (Turkle, 1994) and find enjoyment through competition within the game (Zubek & Khoo, 2002). In this process, users reflect their identities through their game characters, leading to increased interest and engagement in the game (Hefner et al., 2007). Additionally, game characters positively influence users' game preferences and playing intentions (Kempf, 1999; Mandryk & Atkins, 2007). Therefore, game characters play a vital role in enhancing user concentration and retention within the game.

The concept of game characters, also known as avatars (Soutter & Hitchens; Wu & Hsu, 2018), can be understood as the user's representation in the virtual environment (Ducheneaut et al., 2009). Players often choose intelligent or powerful characters to achieve success in the game (Ko & Park, 2021). The importance of Non-player Characters (NPC), however, has recently gained prominence (Drennan et al., 2003). NPCs play significant roles in users' gaming experiences, providing assistance, challenges, and services (Warpefelt & Verhagen, 2017). Due to the significance of NPCs, most video games rely on them during game development (Aarseth, 2012; Warpefelt & Verhagen, 2016).

The relationship between users and NPCs is important because of the various impacts on users' gaming activities (Harth, 2017). Depending on the level of NPC's

technological sophistication, it can either enhance or hinder the enjoyment of the game (Bartle, 2004) and create intense experiences through emotional connections with the users (Ravenet et al., 2016; Yannakakis et al., 2011).

This study focuses on NPCs integrated with GPT technology. The target game is 'Justice Mobile'. The game involves a recent case in China where NPCs based on GPT technology were incorporated into the game setting. The study aims to investigate the influence of GPT-based NPCs on users' immersion, game satisfaction, and loyalty. Specifically, the study aims to assess users' responses based on the level of anthropomorphism among NPCs.

The research questions are as follows:

Q1: How does the anthropomorphic feature of GPT-based NPCs influence users' immersion?

Q2: Does the anthropomorphic feature of GPT-based NPCs have an impact on users' game satisfaction and loyalty?

To address the research questions, the theoretical background of Flow and SOR Theory is adopted. Flow theory is explained based on previous studies (Bartle, 2004) that suggested how NPCs' technological sophistication can

either enhance or hinder users' enjoyment. There are three factors in the SOR framework. First, the environmental stimulus represents the anthropomorphic characteristics of NPCs. Second, the organism state reflects users' level of immersion. Lastly, the behavioral response explains users' game satisfaction and loyalty.

This study holds two implications. It analyzes the characteristics of NPCs utilizing the recent technology, GPT, from the users' perspective. By examining users' psychological states regarding this new technology, this research can serve as valuable evidence for future technology applications. Additionally, it systematically approaches the relationship between NPC characteristics and users based on the theories. This is expected to contribute to the theoretical expansion of NPC-user relationships in the future.

Theoretical Background

Non-player Characters (NPCs)

Advancements in technologies such as automation and natural language processing systems (Luger, 2005; McCord et al., 2012) have greatly influenced the game industry. These technological developments have enriched the roles and values of NPCs within games. Generally, NPCs refer to characters in a game that are controlled entirely by the computer (Warpefelt & Verhagen, 2017). In most recently released video games, it is impossible for users to play without interacting with NPCs (Emmerich et al., 2018). During gameplay, users expect NPCs to perceive users' characters and to respond appropriately (Lankoski & Björk, 2007). This expectation causes users to trust the game and increases immersion in the game (Emmerich et al., 2018). NPCs have evolved from merely providing information to becoming cooperative entities that help users focus on and prolong their engagement in the game.

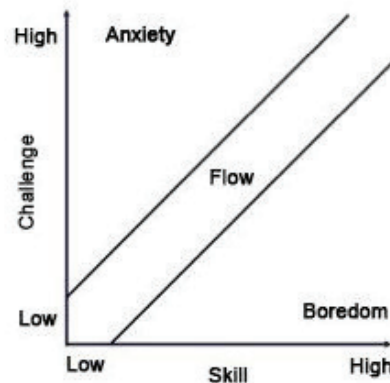
Warpefelt & Verhagen (2017), who have conducted research on NPCs, categorized them into 12 forms based on their roles. These forms include functional roles such as Vendor, Services, and Questgiver, as well as user adversaries such as Enemy and Opponent. There are also forms of interaction with users, including Sidekick, Ally, Companion, Pet, and Minion which are grouped under the category of Friends. Finally, NPCs serve as the provider, including Storyteller or Loot Provider. The diversity of NPC forms signifies their substantial role in games. Among them, NPCs that enhance user interaction, such as Sidekicks and Companions, support users to stay engaged in the game for longer periods (Warpefelt & Verhagen, 2017).

Recently, NPC development based on GPT technology has been actively pursued to enhance user interaction. In particular, the game 'Justice Mobile,' released in China in 2019, has achieved significant success by utilizing this

technology. In this study, the focus is on NPCs applied GPT technology and their anthropomorphic characteristics.

Flow Theory

Flow theory refers to the state in which a user intensely focuses on a specific activity, excluding any other thoughts or distractions (Csikszentmihalyi, 1990). Typically, individuals with a strong intrinsic motivation are more likely to become immersed in a particular activity and experience enjoyment (Csikszentmihalyi, 2003). In the context of gaming, the level of immersion in the game can be increased when users are exposed in challenges that are balanced with their abilities (Cho et al., 2021).



<Figure 1. Flow Theory>

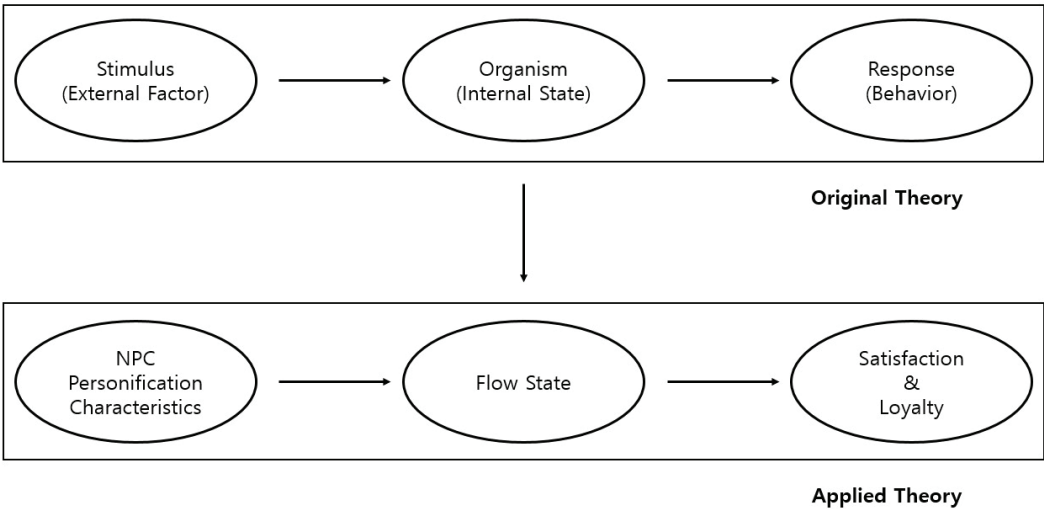
In order for users to become immersed in a specific situation, various characteristics are required. These characteristics include enjoyment, emotional control, deep concentration, pleasure in the given tasks, time distortion, and a balance between challenges and the user's abilities (Su et al., 2016; Fabito et al., 2020).

Among these characteristics, the balance between given challenges and skills to users is considered a key feature that induces user immersion in the game (Cho et al., 2021). In this study, we set the level of user immersion as a mediating variable to explore the impact of GPT-based NPC characteristics concerning game satisfaction and loyalty of users.

Stimulus-Organism-Response (SOR) Theory

The Stimulus-Organism-Response (SOR) theory refers to the cognitive response process in which specific stimuli influence human emotions and cognition, leading to observable behaviors (Mehrabian & Russell, 1974; Kamboj et al., 2018). According to this theory, external factors create certain cognitive and emotional responses in users, guiding them to engage in specific behaviors (Jacoby, 2002). As a representative theory in

environmental psychology, the theory has been applied and researched in various disciplines, including psychology, management, and computer science (Ali, 2016; Manthiou et al., 2017). Stimulus means the physical environment and factors that influence users (Mehrabian & Russell, 1974; Machleit & Davis, 2001), representing external stimuli that impact users' internal states (Belk, 1975). Organism, as a mediator between S and R, denotes users' internal states based on cognition and emotions (Mehrabian & Russell, 1974). Therefore, O represents users' affective and cognitive states (Kamboj et al., 2018) and can be defined in terms of users' attitudes, beliefs, and comfort levels (Bitner, 1992). Lastly, Response refers to behavior and includes psychological and behavioral reactions resulting from external stimuli and the organism's attitudes (Sherman et al., 1997). In this study, we apply the SOR theory to analyze how GPT-based NPCs influence users' internal states and produce certain outcomes. Specifically, we limit the external stimulus factor to the humanization characteristics of NPCs. As for the organism factor, we define it as the level of user immersion, while the response factor is represented by user game satisfaction and loyalty. The application of the SOR theory in this study is depicted as follows:



<Figure 2. Original Theory and Applied Theory>

Research Methodology

Hypothesis Development

Personification of NPC and Immersion

Personification stands for attributing lifelike characteristics and personality to non-human entities, making animals or objects appear human-like (Aggarwal & McGill, 2007; Waytz et al., 2008). The concept of personification has been studied in various contexts, such as religious contexts (Gilmore, 1919) and perspectives on animals (Cheney & Seyfarth, 1990), and more recently, applied to devices (Epley et al. 2008) across different academic disciplines. Personification encompasses a broad range of attributes, from attributing human-like physical appearances to making moral judgments (Golossenko et al., 2020; Kim & McGill, 2011; Puzakova et al., 2009). As the level of non-human personification increases, humans experience enhanced feelings of security and positive emotions toward the entity, while uncertainty decreases (Nowak & Biocca, 2003). These research findings are also evident in interactions between humans and computers, as users shows a similar response to computers like humans when users perceive social cues like human appearances and using language (Reeves & Nass, 1996). These phenomenon has led to investigations into humanizing Chatbots (DiSalvo et al., 2002), cars, graphic agents, humanoid robots (Bartneck, 2006), and robotic vacuum cleaners (Kwak, 2014), among other devices and systems. Considering the mutual perspective between humans and machines (Steuer, 1992), it can be emphasized that the level of personification of NPCs within games is crucial in shaping users' positive perceptions. Previous studies have explored the personification characteristics of NPCs, and notable research in this context includes interactions between avatars and players in games (Banks & Bowman, 2016), as well as studies in the field of artificial intelligence voice recognition (Wagner et al., 2019; Moussawi & Koufaris, 2019). The interactions between in-game characters and players can be understood from cognitive, emotional, and behavioral perspectives, where both players and

characters can serve as instruments of conveying meaning in digital and real-world contexts (Banks & Bowman, 2016). This underscores the importance of the social attributes possessed by characters (Waytz et al., 2010).

The second characteristic of NPCs is intelligence. Intelligence is a factor directly influencing the personification of characters, enabling efficient, effective, and goal-oriented behaviors (Moussawi & Koufaris, 2019). Intelligence is commonly defined by terms such as knowledge, mental strength, learning, and understanding (Legg & Hutter, 2007). Thus, NPCs can engage intelligently with players, serving as assistants in problem-solving and goal achievement.

The final characteristic is human-likeness (Wagner et al., 2019). Since personification entails attributes encompassing human characteristics and emotions (Epley et al., 2007), it is essential for NPCs to possess human-like features. It is considered to be highly humanized when interactions are smooth under the condition of question-and-answer exchanges between NPCs and players in games (Wagner et al., 2019).

This study selected three specific NPC characteristics that are clearly defined and described, among the various attributes. They include intelligence, sociability, and human-likeness in NPCs that are applied GPT. To analyze the impact of these three variables on users' game immersion, we formulated the following hypotheses:

H1: NPC intelligence will be positively associated with users' immersion.

H2: NPC sociability will be positively associated with users' immersion.

H3: NPC human-likeness will be positively associated with users' immersion.

To measure the variables in this study, the following measurement items are employed. To assess the sociability of NPCs, it has a total of 8 items including emotional investment and companion consciousness, proposed by Banks & Bowman (2016). Regarding the intelligence of NPCs, 5 items suggested by Moussawi & Koufaris (2019) are utilized. Additionally, for measuring human-likeness, a total of 8 items, encompassing autonomy and appearance, are selected (Banks & Bowman, 2016; Wagner et al., 2019). Each measurement item is properly modified in accordance with the NPC attributes and the specific objectives of this study.

Immersion, Users Satisfaction, and Loyalty

The optimal personal experience that users feel online can be defined as immersion (Hoffman & Novak, 1996). In the case of online games, providing users with an optimal immersive experience as an engaging medium leads to

overall satisfaction for users (Clark et al., 1994). The relationship between users' immersion and satisfaction is significantly crucial

As this immersive experience ultimately influences users' intention to continue using the online game (Hoffman & Novak, 1996),

Loyalty can be seen as a kind of user preference that emerges after satisfaction is formed (Aaker, 1991), and it causes a continuous and repetitive consumption attitude (Kotler & Keller, 2009). The user's positive perception should be researched in this area from immersion and satisfaction to loyalty when loyalty to a game leads users to engage in repetitive gaming activities.

To analyze the area, users' immersion is set as an independent and mediating variable, and the following hypotheses are established:

H4: Users' immersion will be positively associated with users' satisfaction.

H5: Users' immersion will be positively associated with users' loyalty.

H6-1: Users' immersion will have a positive mediating effect between NPC intelligence and users' satisfaction.

H6-2: Users' immersion will have a positive mediating effect between NPC sociability and users' satisfaction.

H6-3: Users' immersion will have a positive mediating effect between NPC human-likeness and users' satisfaction.

H7-1: Users' immersion will have a positive mediating effect between NPC intelligence and users' loyalty.

H7-2: Users' immersion will have a positive mediating effect between NPC sociability and users' loyalty.

H7-3: Users' immersion will have a positive mediating effect between NPC human-likeness and users' loyalty.

To measure the immersion variable, a total of 6 items are used based on Csikszentmihalyi's (1990) definition (Susan et al., 2010; Jackson, 1996). Users' satisfaction is composed of 4 items (Oliber, 1980; Garbarino & Johnson, 1999), and users' loyalty consisted of 6 items, including word-of-mouth recommendations (Methlie & Nysveen, 1999; Wong and Sohal, 2006). These scales are modified to proper the objectives of this study while ensuring that their meanings remained unchanged.

Research Results

A survey questionnaire was administered to users who had participated in a GPT-based NPC appearing game,

for the purpose of analysis in this study. Considering that the subject game, "Justice Mobile," operates within China, the study was conducted targeting users within China. To validate the research hypotheses, analysis was performed using SPSS 21 Version and AMOS 21 Version. Exploratory factor analysis, frequency analysis, and correlation analysis were conducted using SPSS. Hypothesis testing analysis was conducted through AMOS.

Characteristics of the Sample

Data collection was carried out both online and offline. A total of 201 data points were collected, and after excluding 6 instances of unreliable data, a total of 195 data points were used for analysis. Among the respondents, a higher proportion were female (Male: 84 individuals, 43.1%; Female: 111 individuals, 56.9%). The respondents were mainly in their 20s (20-25 years: 26 individuals; 26-30 years: 119 individuals). Regarding gaming frequency, a significant number of respondents played games more than once a day (101 individuals, 51.8%), and a substantial portion spent 5 to 8 hours (81 individuals, 41.5%) on gaming. Furthermore, a considerable proportion of respondents claimed familiarity with artificial intelligence. Detailed characteristics of the sample are presented in Table 1.

<Table 1. Characteristics of the Sample>

Classification	Response categories	Frequency	Rate	Total responses
Gender	Male	84	43.1	195
	Female	111	56.9	
Age	20 ~ 25 age	26	13.3	195
	26 ~ 30 age	119	61.0	
	31 ~ 35 age	30	15.4	
	36 ~ 40 age	11	5.6	
	More than 40	9	4.6	
Education	Graduated High School	23	11.8	195
	Enrollment in University	58	29.7	
	Graduated University	90	46.2	
	Enrollment in Graduated University	17	8.7	
	Graduated from Graduate School	7	3.6	
Game Frequency	Under 1 a Month	11	5.6	195
	Once a Month	18	9.2	
	2~3 times a Month	31	15.9	
	Once a Week	34	17.4	
	Over 1 time Everyday	101	51.8	
Daily Usage	Under an hour	32	16.4	195
	1~4 hours	30	15.4	
	5~8 hours	81	41.5	
	Over 8 hours	52	26.7	
Knowledge in AI	Not at all	4	2.1	195
	Have heard of it before	29	14.9	
	Have some knowledge of it	122	62.6	
	Very familiar with it	40	20.5	

Correlations and Means, Standard Deviations

The results of correlations, means, and standard deviations between variables are as follows. The range of mean values for the variables was derived between 3.4709 and 3.9321, and for standard deviations, values ranging from .7294 to .9463 were obtained. All correlations between variables were found to be significant, with the highest correlation observed between loyalty and satisfaction (result: .673). Detailed analysis results are as follows.

<Table 2. Correlations and Means, Standard Deviations Results>

	Mean	Standard Deviation	1	2	3	4	5	6
Interaction	3.9321	.74582	1					
Intelligence	3.8444	.74477	.557**	1				
human-likeness	3.4709	.9463	.533**	.600**	1			
Flow	3.8282	.72942	.547**	.581**	.591**	1		
Satisfaction	3.8526	.78918	.433**	.552**	.450**	.572**	1	
Loyalty	3.8188	.83123	.509**	.470**	.473**	.588**	.673**	1

Pearson: *, $p < 0.05$, **, $p < 0.01$

Exploratory Factor Analysis Result

After excluding items that did not meet the criterion in the exploratory factor analysis results, a total of 30 items were used for the analysis. While some items had values below the criterion of 0.6 (Interaction 7: .545, Intelligence 4: .560, Loyalty: .557), these items were deemed conceptually significant and were retained for analysis. The Kaiser-Meyer-Olkin value was .921, and the total explained variance yielded a result of 71.434. The results of the exploratory factor analysis are as follows.

<Table 3. Exploratory Factor Analysis Result>

Items	Factor Loading
Interaction1	.664
Interaction 2	.686
Interaction 3	.803
Interaction 4	.793
Interaction 7	.545
Intelligence3	.684
Intelligence 4	.560
Intelligence 5	.693
Human-likeness1	.828
Human-likeness 2	.824
Human-likeness 3	.710
Human-likeness 4	.735
Human-likeness 5	.725
Human-likeness 8	.620
Flow1	.700
Flow 2	.746
Flow 3	.604
Flow 4	.674
Flow 5	.854
Flow 6	.719
Satisfaction1	.814
Satisfaction 2	.772
Satisfaction 3	.749

Satisfaction 4	.842
Satisfaction 5	.707
Satisfaction 6	.707
Satisfaction 7	.657
Loyalty1	.587
Loyalty 2	.692
Loyalty 3	.557
Total explained variance: 71.434%	
Kaiser-Mayer-Olkin: .921	
Bartlett's chi-squared: 4351.091, the degree of freedom: 135, sig: .000	

Confirmatory Factor and Validity Analysis Results

The results of the confirmatory factor analysis are as follows. The model fit indices yielded the values of CMIN: 761.095, DF: 385, P: .000, CMIN/DF: 1.977. Additionally, RMR: .054, RMSEA: .071, GFI: .801, PGFI: .663, NFI: .835, IFI: .911, TLI: .898, and CFI: .910 were obtained, which generally or satisfactorily met the standard criteria. Based on these results, the model fit of the confirmatory factor analysis was found to meet the established criteria. Both Construct Reliability and Average Variance Extracted (AVE) analyses, conducted to assess the reliability and validity of the model, met the predefined criteria.

<Table 4. Confirmatory Factor and Validity Analysis Results>

Name	Items	Non-standardization coefficient / standardization coefficient	C.R.	p-value	AVE	Construct Reliability
Interaction	Interaction1	1.000 / .761	-		0.5988	0.8817
	Interaction 2	.937 / .736	10.154	***		
	Interaction 3	1.084 / .771	10.667	***		
	Interaction 4	.940 / .735	10.113	***		
	Interaction 7	1.043 / .725	9.995	***		
Intelligence	Intelligence3	1.000 / .710	-		0.6452	0.8445
	Intelligence 4	1.187 .832	10.307	***		
	Intelligence 5	.997 / .763	9.614	***		
Human-likeness	Human-likeness1	1.000 / .874	-		0.5557	0.8818
	Human-likeness 2	1.084 / .851	15.593	***		
	Human-likeness 3	.968 / .801	14.022	***		
	Human-likeness 4	.965 / .728	12.059	***		
	Human-likeness 5	.957 / .734	12.208	***		
	Human-likeness 8	.868 / .741	12.381	***		
Flow	Flow1	1.000 / .696	-		0.6071	0.9019
	Flow 2	.951 / .738	9.514	***		
	Flow 3	.989 / .840	10.696	***		
	Flow 4	1.048 / .841	10.713	***		
	Flow 5	.786 / .668	8.640	***		
	Flow 6	.923 / .704	9.084	***		
Satisfaction	Satisfaction1	1.000 / .808	-		0.6648	0.9326
	Satisfaction 2	.924 / .764	11.689	***		
	Satisfaction 3	1.010 / .876	14.199	***		
	Satisfaction 4	1.089 / .812	17.063	***		
	Satisfaction 5	1.019 / .734	11.176	***		
	Satisfaction 6	1.134 / .786	12.192	***		
	Satisfaction 7	.859 / .764	11.779	***		
Loyalty	Loyalty1	1.000 / .824	-		0.7077	0.8788
	Loyalty 2	1.099 / .864	13.732	***		
	Loyalty 3	1.078 / .784	12.142	***		

*** p < .001

Results of Hypothesis Testing

The results of hypothesis testing, analyzed using AMOS, are as follows. The variables of interaction, intelligence, and anthropomorphism, set as independent variables, were found to have significant impacts on user immersion. Particularly noteworthy is the impact of intelligence, indicating that if users perceive the GPT-based NPC as having its own intelligence when interacting with it, it can lead to an immersive effect through human-like interaction. Furthermore, the significant impact of interaction and anthropomorphism on immersion highlights the necessity for the GPT-based NPC to convey emotions naturally in conversations with users.

Regarding immersion, it was found to have significant effects on both loyalty and satisfaction. As observed in various prior studies, when users become immersed in a game, their satisfaction increases, and they develop a willingness to continue playing. The variables related to the NPC were found to mediate the effects on user satisfaction and loyalty through immersion. Detailed results of hypothesis testing are presented in Table 5 and Table 6.

<Table 5. Results of Hypothesis Testing>

Path Analysis (Direct Effects, H1 ~ H5)						Estimate	S.E.	95% CI		p
								Lower	Upper	
H1	Flow	<-		<-	Interaction	.319	.121	.066	.547	.004
H2	Flow	<-		<-	Intelligence	.294	.125	.043	.544	.011
H3	Flow	<-		<-	Human-likeness	.237	.117	.032	.478	.014
H4	Satisfaction				Flow	.415	.124	.171	.664	***
H5	Loyalty				Flow	.450	.117	.208	.665	***

** p < .05, *** p < .001

Path Analysis (Total Effects, H6-1 ~ H7-3)						Estimate	S.E.	95% CI		P
								Lower	Upper	
H6-1	Satisfaction	<-	Flow	<-	Interaction	.118	.147	-.175	.379	.457
H6-2	Satisfaction	<-	Flow	<-	Intelligence	.613	.119	.410	.888	.002
H6-3	Satisfaction	<-	Flow	<-	Human-likeness	.010	.126	-.230	.263	.984
H7-1	Loyalty	<-	Flow	<-	Interaction	.468	.140	.212	.759	.002
H7-2	Loyalty	<-	Flow	<-	Intelligence	.132	.159	-.200	.436	.377
H7-3	Loyalty	<-	Flow	<-	Human-likeness	.118	.140	-.171	.397	.415

** p < .05, *** p < .001

Path Analysis (Direct Effects, H6-1 ~ H7-3)						Estimate	S.E.	95% CI		P
								Lower	Upper	
H6-1	Satisfaction	<-	Flow	<-	Interaction	-.015	.139	-.310	.246	.894
H6-2	Satisfaction	<-	Flow	<-	Intelligence	.491	.131	.268	.771	.002
H6-3	Satisfaction	<-	Flow	<-	Human-likeness	-.088	.130	-.353	.169	.441
H7-1	Loyalty	<-	Flow	<-	Interaction	.325	.141	.065	.619	.016
H7-2	Loyalty	<-	Flow	<-	Intelligence	.000	.162	-.335	.315	.978
H7-3	Loyalty	<-	Flow	<-	Human-likeness	.011	.126	-.238	.251	.998

** p < .05, *** p < .001

Path Analysis (Indirect Effects, H6-1 ~ H7-3)						Estimate	S.E.	95% CI		P
								Lower	Upper	
H6-1	Satisfaction	<-	Flow	<-	Interaction	.132	.073	.020	.306	.016
H6-2	Satisfaction	<-	Flow	<-	Intelligence	.122	.062	.015	.272	.028
H6-3	Satisfaction	<-	Flow	<-	Human-likeness	.098	.059	.010	.233	.034
H7-1	Loyalty	<-	Flow	<-	Interaction	.143	.068	.024	.289	.016
H7-2	Loyalty	<-	Flow	<-	Intelligence	.132	.067	.015	.286	.027
H7-3	Loyalty	<-	Flow	<-	Human-likeness	.107	.060	.009	.243	.034

** p < .05, *** p < .001

Conclusion

In this study, we analyzed the impact of GPT-based Non-Player Characters on user game satisfaction and loyalty. The characteristics of the NPC were chosen as independent variables, and user immersion was set as a mediating variable. User satisfaction and loyalty were selected as dependent variables. The results of this study are as follows.

Firstly, the characteristics of the GPT-based NPC, chosen as independent variables, were found to impact user immersion. Notably, the interaction with the NPC had the greatest impact, highlighting the significance of the NPC. Moreover, the results indicated that NPC intelligence significantly influences user immersion. This suggests that if the NPC possesses conversational capabilities beyond adhering to predefined protocols, such as delivering information users desire or require during interactions, it can enhance user immersion and extend their time spent within the game. The significant impact of anthropomorphism on immersion suggests the need for NPCs to exhibit qualities like natural conversation and usage of relatable language, closer to real-life interactions. If NPCs developed with enhanced human-like expressions and thoughts via chatbot technologies, the competitive edge of games could be amplified.

Secondly, NPC intelligence was found to have an indirect mediating effect on satisfaction through user immersion. When NPCs intelligently respond to user queries or actions, users become more immersed, which subsequently elevates their satisfaction. Additionally, the interaction between the NPC and the user was found to indirectly affect loyalty through immersion. As users engage in interactions with the NPC, a common goal is established, indicating their willingness to invest time and resources into the game. However, although anthropomorphism exhibited an indirect mediating effect, it did not show significant direct or total effects. This suggests that users expect NPCs to engage in smooth and intelligent activities akin to collaborators rather than human-level conversations or interactions. These results also imply the potential challenges arising from the current state of GPT-based NPCs, which may not yet possess full human-like qualities or have achieved widespread development.

The significance of this study lies in the following aspects. Firstly, we analyzed the attributes of GPT-based NPCs using characteristics of existing NPCs. This study identified the applicability of NPC characteristics while revealing different variables that bring about mediating effects on user satisfaction and loyalty. Secondly, we empirically examined the importance of user immersion as an internal state. Immersion takes precedence over satisfaction or loyalty, and this understanding confirms the potential to extend user engagement within the game. The limitations and future directions of this study are as follows. The ages of the respondents participating in

the survey were concentrated within specific groups. To generalize the results in the future, research focusing on diverse user groups will be necessary. Additionally, conducting analyses considering gaming frequency and usage could uncover new insights.

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Anthropomorphic Packaging Perspectives: Empathy as a Mediator in Sustainable Consumer Engagement

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Introduction

The increasing harmful impacts of pollution and waste on the natural world have led to a widespread adoption of environmental sustainability practices (Kunzig, 2020). In 2015, the United Nations established a plan for 2030 which encompasses 17 Sustainable Development Goals which focuses on "Responsible Production and Consumption," with the aim of promoting economic growth, societal integration, and environmental protection. In line with these principles, an increasing number of companies have been transitioning to more sustainable production methods in order to capitalize on emerging business prospects (Vătămănescu et al., 2021). They are trying to work towards these objectives through various means, including environmentally friendly production processes, investments in cutting-edge technologies, the attainment of high-quality standards and certifications, investment in brand image and equity, and the creation of new eco-friendly products (Kamboj & Rahman, 2017; ShabbirHusain & Varshney, 2019; Watz & Hallstedt, 2022). Moreover, some companies are also striving to encourage participation from consumers in sustainable efforts aimed at promoting the use of environmentally friendly products and contributing towards a sustainable future. Concurrently, in scientific studies, previous research has also investigated consumer motivation for engaging with sustainable initiatives (Townsend & Niemtzow, 2015; White et al., 2019; Zammit-Lucia, 2013).

However, the above research places less emphasis on using anthropomorphism to involve consumers in sustainable initiatives (Zong & Wang, 2016). While examples of anthropomorphism abound, in this study, we focus specifically on anthropomorphic packaging.

The study aims to explore how anthropomorphic packaging, along with color packaging, influence consumer engagement with sustainable initiatives, with empathy serving as a key mediating factor in this relationship.

Theoretical Foundation

Product packaging and Anthropomorphism

Product packaging encompasses all the processes involved in creating and fabricating the enclosure for a product. (Kotler & Keller, 2006). Due to the demands of distribution processes, packaging has become essential for products. Product packaging serves three main purposes: protecting the product, improving its functionality during use, and conveying brand values and product details (Underwood & Klein, 2002).

Previously, existing research has presented a wide range of package components – 62 in total, which offer consumers verbal or visual information (Orth & Malkewitz, 2008). Non-verbal or pictorial stimuli are utilized to extract visual information, whereas text-related cues are indicative of verbal information (Rettie & Brewer, 2000; Schmitt et al., 1993). Following this classification, the visual aspect of packaging could also be segmented into two subordinate categories: graphic and structural components (Underwood, 2003). The first category encompasses visuals such as images, logos, and color schemes, while the second one refers to the dimensions and shape of a package, among other aspects. Kotler et al. (2003) gives examples of a package which has six major elements: form, size, colour, material, text and brand.

According to Twedt (1968), marketing managers can utilize specific elements of packaging to ascribe human traits to product packages, creating their unique personality, a concept known as anthropomorphism. Modern anthropomorphism is often linked to the marketing strategies of companies, which commonly encourage consumers to perceive their products and brands as having human-like qualities (Wan & Aggarwal, 2015). Accordingly, companies that are able to "humanize" their brand are frequently considered as more promising prospects for sustained business growth (Aggarwal & McGill, 2007).

In this study, we examine the components of visual design in packaging, which are capable of being anthropomorphized and can significantly impact the effectiveness of marketing tactics.

Construal level theory

Construal Level Theory (CLT) is a theory in social psychology that centers on how individuals' attitudes and behaviors can be influenced based on their emotional responses to an object or event. In the framework of CLT, as the psychological distance between individuals and an event increases, they are inclined to utilize higher levels of construals in representing the event. High-level construal conveys abstract, decontextualized representations. In contrast, low-level construal involves concrete, contextualized representations (Liberman & Trope, 1998; Liberman et al., 2007; Trope & Liberman,

2003). Over subsequent years, many studies broadened insights to encompass various types of psychological distance—temporal (e.g. now, near future vs distant future), spatial (e.g. here, near place vs distant place), social (e.g. self, similar person vs dissimilar person), and hypothetical (e.g. reality; high probability vs low probability) (Fujita et al., 2006; Huang et al., 2016; Liberman & Trope, 1998; Wakslak et al., 2006). Beyond the four types of psychological distance, the characteristics of construal levels are varied, encompassing a wide range of interpretations related to objects, individuals, and behaviors (Fiedler et al., 2012; Liberman & Trope, 2014; Soderberg et al., 2015).

Black-and-White versus Color Imagery and Construal Level

Colors play a crucial role in advertisements, especially in printed ads. Early studies concentrated on the impact of color in advertising and found that the use of certain colors can greatly capture the attention of audiences (Groenhaug et al., 1991). In addition, numerous researches have concentrated on common aspects of advertising color, including the comparison between color and black-and-white. Several studies indicate that viewers remember content more effectively when presented with color pictures as opposed to black-and-white ones (Panigyrakis & Kyrousi, 2015; Wichmann et al., 2002); Some research suggests that both color and monochrome advertisements can have a significant impact on viewers under specific circumstances or in particular situations. For example, Lee and Aaker (2004) utilized construal level theory to illustrate the cognitive processing of color information in advertising. Their five experiments validated that black-and-white visuals prompt viewers to adopt a high-level construal, whereas colorful imagery encourages low-level construal thinking among viewers.

In this study, we suppose that when anthropomorphic packaging and colors are combined to align with construal levels, non-anthropomorphic packaging would be better suited for black-and-white imagery than anthropomorphic packaging. Additionally, consistent alignment between the construal level of anthropomorphic packaging and color imagery enhances consumer engagement with environmental initiatives.

The mediating effect of empathy

Empathy can be broadly defined as the comprehension and sharing of others' emotional experiences. It comprises two main elements: cognitive and affective. The cognitive aspect involves understanding another person's emotions through adopting their perspective, while affective empathy entails connecting with and sharing in the emotional reactions of another individual. These components are viewed as interconnected rather than distinct from each other (Tam et al., 2013). Prior studies on altruistic actions have demonstrated that the extent of empathy towards individuals in distress can significantly influence one's intentions and conduct (Batson et al.,

1997).

In addition, Riek et al. (2009) observed that individuals tend to show more empathy towards robots that resemble humans. Batson et al. (1997) also recognized the challenge of comprehending the environment without personalization. They posited that consumers' empathy for the environment hinges on them being in particular circumstances where external stimuli can evoke their empathetic response (Streimikis et al., 2021). Anthropomorphic existence provides the basis for consumers to have a sense of empathy with their environment. Moreover, according to Gray et al. (2007), the greater individuals' perception of non-human entities having feelings and awareness, the lower their inclination to cause harm, along with a heightened display of empathy, increased moral judgment, and stronger dedication to environmental protection (Berenguer, 2007). Based on these studies, this paper asserts that anthropomorphizing express packaging can be mediated by empathy and consequently impact consumer involvement in environmental efforts.

Method and procedure

In this experiment, we used a factorial design with two factors: packaging (anthropomorphic vs non-anthropomorphic condition), color (black and white vs. color). We conduct three pre-experiment tests to ensure the reliability of the main experiment: (1) to determine whether participants would perceive anthropomorphic vs non-anthropomorphic condition; (2) to determine whether participants would view a packaging as black and white vs color.

Experiment procedure and dependent measures

The study developed an online survey using Google Forms.

To investigate the impact of anthropomorphism on perceived social distance, we conducted *Study 1*. To measure participants' perceptions of social distance, we developed two questions adapted from a previous study (Liviatan et al., 2008):

- (1) Do you believe the individual in the image is dissimilar to you or not?
- (2) Do you believe the individual in the image is distant from you or not?

Study 2: We randomly generate four sets of advertisements with corresponding questionnaires, which were then distributed to the participants.

These advertisements varied in terms of anthropomorphic condition, color. After viewing the image, participants completed the survey, which included measurements of a dependent variable (consumer engagement with environmental initiatives) and demographic questions. We evaluated a dependent variable with 02 items.

Study 3: Assessing empathy as mediator

We evaluate empathy for the effectiveness of anthropomorphic packaging to engage consumers with

environmental initiatives. Empathy was measured by two items (derived from Streimikis et al. (2021))

Contributions of the study

Through exploring the resonance (emotional connection) of these elements with consumers. The results are expected to offer insights into how companies can leverage anthropomorphized packaging, color choices to enhance their sustainability efforts and attract environmentally conscious consumers.

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The Application of Innovation Diffusion Theory and Experimental Marketing Strategy in the Adoption of AI-Generated Technology

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Abstract

The rapid advancement of AI technology has led to the emergence of various AI-generated applications across industries. The successful adoption and diffusion of these innovations are crucial for their commercialization and widespread use. This research aims to investigate the role of innovation diffusion theory and experimental marketing strategy in the adoption of AI-generated technology. By applying a comprehensive questionnaire based on a reference paper, this study seeks to gain insights into the factors influencing the adoption of AI-generated technology and how experimental marketing can effectively facilitate its diffusion. With cross country analysis between Japan and Taiwan.

Keywords

AI-generated technology, innovations diffusion the experimental marketing strategy, cross country analysis.

Introduction

A. Background and significance of AI-generated technology

Artificial Intelligence (AI) has revolutionized numerous industries by providing sophisticated solutions to complex problems. AI-generated technology encompasses a wide range of applications, including natural language processing, computer vision, and machine learning algorithms [1]. These technologies have the potential to reshape industries, enhance efficiency, and improve decision-making processes across various domains, such as healthcare [2], finance [3], transportation [4], and customer service [5].

The significance of AI-generated technology lies in its ability to automate tasks, augment human capabilities, and drive innovation [6]. By understanding the background and implications of AI-generated technology, we can harness its potential for transformative change while addressing potential challenges, such as ethical considerations [7], data privacy [8], and workforce displacement [9].

B. Diffusion of Innovations Theory

Everett Rogers' Diffusion of Innovations theory (1962) is a well-known framework that describes how new ideas, innovations, products, or technologies spread and are adopted by individuals and within societies [10][11]. The theory provides insights into the factors influencing

the adoption and diffusion process. It's often used to understand the dynamics of introducing and popularizing innovations. Diffusion of Innovations theory outlines the stages in the adoption process:

1. Innovation: The new idea, product, or technology being introduced.
 2. Early Adopters: The first to embrace the innovation, influencing others.
 3. Early Majority: Follow the early adopters, requiring more information.
 4. Late Majority: Adopt after seeing benefits.
 5. Laggards: The last to adopt, often resistant to change.
- Key factors influencing adoption include the innovation's relative advantage, compatibility, complexity, trialability, and observability. Communication channels and opinion leaders, especially early adopters, play pivotal roles in the diffusion process. This theory is used in various fields to understand and promote the adoption of new ideas and technologies. In the adoption and acceptance of AI technologies, tech influencers, industry leaders, and media outlets have been pivotal. Their role in promoting AI, shaping public perceptions, and driving adoption cannot be overstated. Furthermore, the influence of social media platforms in disseminating information about AI has significantly contributed to its swift and

widespread adoption [12].

The Innovation Diffusion Theory (IDT) provides a comprehensive framework to understand the adoption and diffusion of innovations within a social system. IDT focuses on the factors that influence the rate and pattern of adoption of new technologies [11]. It considers various aspects such as the characteristics of the innovation, the communication channels, the social system, and the adopters themselves.

By applying IDT to AI-generated technology, we can examine the factors that drive or hinder its adoption across different user groups, organizations, and industries. The theory enables us to analyze the relative advantage, compatibility, complexity, observability, and trialability of AI-generated technology, thereby providing insights into its diffusion process [11].

C. Experiential Marketing Strategy

Experiential Marketing Strategy (EMS) is a highly effective and fast-paced marketing strategy in today's business landscape. Fundamentally, experiential marketing is a dynamic approach that centers on crafting tangible, interactive encounters to captivate and involve consumers [13]. EMS involves the systematic design, implementation, and evaluation of marketing initiatives to understand consumer behavior and preferences [14]. It allows marketers to test and refine their strategies by conducting controlled experiments in real-world or simulated environments. EMS leverages techniques such as A/B testing, eye-tracking studies, and neuroimaging to measure consumer responses and optimize marketing interventions [15].

Smilansky [16] characterizes experiential marketing as the "process of discerning and satisfying customer needs and desires in a profitable manner, engaging them through two-way communication that animates brand personalities and provides value to the target audience." Experiential marketing is instrumental in crafting customer experiences and evoking emotions. You-Ming [17] suggests that experiential marketing primarily serves as a communication method that heightens customers' physical and emotional sensations. Hauser [18] defines experiential marketing as a comprehensive approach to the relationship between customers and brands.

Cantone and Risitano [19] affirm that numerous companies are adopting Customer Experience Management (CEM) strategies, which underscore the significance of emotions, feelings, sentiments, passions, and experiences in consumer-brand relationships. According to Yuan and Wu [20], experiential marketing can be viewed as a marketing strategy developed by businesses to orchestrate the entire physical environment and operational processes for customers to undergo. It's noteworthy that all these definitions underscore that experiential marketing is primarily concerned with emotions, feelings, and sensory experiences, and it is less focused on cognition and human intentions.

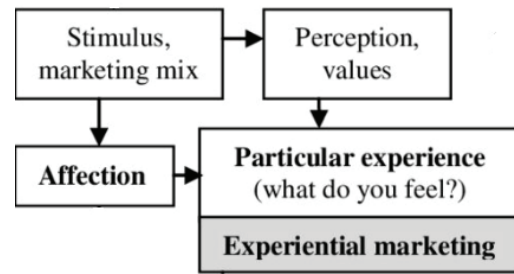


Figure 1. The Experiential Marketing Model (Source: adaptation of Leppiman, Same [21])

Prominent international brands such as Porsche, Nike, Coca-Cola, and the United States Army utilize Experiential Marketing by incorporating live demonstrations and test drives to enhance brand recognition, stimulate sales, and craft memorable consumer encounters [22].

Applying EMS to AI-generated technology research can help us assess the effectiveness of different marketing strategies in promoting the adoption and acceptance of AI solutions. By conducting experiments to manipulate variables such as product design, pricing, branding, and communication channels, we can gain valuable insights into the factors that influence consumers' perceptions, attitudes, and intentions regarding AI-generated technology [4].

I. RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

The research objectives of this study are as follows:

- 📁🔍 To investigate the factors that influence the adoption and diffusion of AI-generated technology across different user groups and industries.
- 📖🔍 To understand the role of innovation characteristics, communication channels, and social systems in the adoption process of AI-generated technology.
- 📊🔍 To explore the impact of experimental marketing strategies on the acceptance and adoption of AI-generated technology.
- 📋🔍 To identify practical implications and recommendations for organizations and policymakers to facilitate the successful integration of AI-generated technology.

The research questions that will guide this study are as follows:

- 📁🔍 What are the key factors influencing the adoption and diffusion of AI-generated technology?
- 📖🔍 How do the characteristics of AI-generated technology influence its adoption rate and pattern?
- 📊🔍 What is the role of communication channels and social systems in the adoption process of AI-generated technology?
- 📋🔍 How can experimental marketing strategies be leveraged to enhance the acceptance and adoption of AI-generated technology?

What practical implications can be derived from the study to facilitate the successful integration of AI-generated technology across industries?

In conclusion, this research paper introduces the background and significance of AI-generated technology, highlighting its transformative potential. It proposes the use of the Innovation Diffusion Theory (IDT) and Experimental Marketing Strategy (EMS) as theoretical frameworks to explore the adoption and diffusion of AI-generated technology. The research objectives and questions outlined will guide the investigation, providing valuable insights for practitioners, researchers, and policymakers in harnessing the benefits of AI-generated technology while addressing potential challenges.

II. LITERATURE REVIEW

The literature review will be conducted into four parts: A. Overview of AI-generated technology and its applications; B. Innovation Diffusion Theory: Key concepts and models; C. Experimental Marketing Strategy: Principles and techniques;

D. Prior studies on the adoption of AI-generated technology.

A. Overview of AI-generated technology and its applications

AI-generated technology, encompassing artificial intelligence (AI) and machine learning (ML), has emerged as a transformative force across various domains. AI refers to computer systems capable of mimicking human intelligence to perform tasks traditionally requiring human intervention. ML algorithms enable systems to learn from data and improve performance over time.

Numerous applications of AI-generated technology have been explored across industries. In healthcare, AI has shown promise in diagnosing diseases [23] and analyzing medical images [24]. In finance, AI algorithms have been employed for fraud detection [25] and stock market prediction [26].

AI-powered chatbots have been utilized in customer service [27], while autonomous vehicles have leveraged AI for improved driving capabilities [28].

The development of AI-generated technology has been driven by advances in computational power, data availability, and algorithmic innovation. Deep learning, a subset of ML, has gained prominence due to its ability to process vast amounts of data and extract meaningful patterns [29].

Reinforcement learning has enabled AI systems to learn from interactions with the environment [30]. Natural language processing techniques have facilitated language understanding and generation [31].

B. Innovation Diffusion Theory: Key concepts and models

Innovation Diffusion Theory (IDT) provides insights into the adoption and spread of innovations within a social system. Key concepts within IDT include innovation attributes, adopter categories, and the diffusion process.

Rogers [11] proposed five innovation attributes influencing adoption: relative advantage, compatibility, complexity, trialability, and observability.

IDT introduces adopter categories based on individuals' willingness to adopt innovations: innovators, early adopters, early majority, late majority, and laggards [11]. The diffusion process comprises stages such as knowledge, persuasion, decision, implementation, and confirmation. Various IDT models, such as the Bass diffusion model [32], the Technology Acceptance Model [33], and the Unified Theory of Acceptance and Use of Technology [34], provide frameworks to understand and predict innovation adoption.

C. Experimental Marketing Strategy: Principles and techniques

Experimental marketing strategy involves designing and implementing controlled experiments to understand consumer behavior and improve marketing outcomes. It allows marketers to test hypotheses, assess the effectiveness of marketing tactics, and optimize strategies. A key principle of experimental marketing is the use of randomization to assign participants to different treatment groups, ensuring unbiased results.

Various experimental techniques have been employed in marketing research. A/B testing, also known as split testing, involves comparing two variants of a marketing element to determine which performs better [35]. Field experiments, conducted in real-world settings, enable researchers to capture authentic consumer responses [36]. Eye-tracking studies analyze consumers' visual attention to understand how they interact with marketing stimuli [37].

D. Prior studies on the adoption of AI-generated technology

Numerous studies have investigated the factors influencing the adoption of AI-generated technology. Davis [33] proposed the Technology Acceptance Model (TAM), which has been extensively used in the context of AI adoption.

TAM posits that perceived usefulness and perceived ease of use influence individuals' intention to adopt technology. Recent research has expanded on TAM by incorporating additional factors. Venkatesh et al. [38] developed the Unified Theory of Acceptance and Use of Technology (UTAUT), which includes performance expectancy, effort expectancy, social influence, and facilitating conditions. Other studies have explored the impact of trust [39], perceived risk [40], and personal innovativeness [41] on AI adoption.

III. RESEARCH MODEL AND HYPOTHESES

In this paper, combination of Diffusion of Innovations theory and Experimental Marketing Strategy are adopted as frameworks for analysis. We use structural equation modeling, which stands out as one of the most widely

Based on the literature review, we assess the research model as shown in Figure 2.

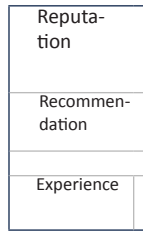


Figure 2 The Research Model

The following hypotheses are proposed and are examined by the research model.

H1: There is a significant, positive relationship between the effectiveness of marketing tactics and Reputation & Recommendation.

H2: There is a significant, positive relationship between Reputation & Recommendation and Incentive.

H3: There is a significant, positive relationship between Incentive and Compatibility.

H4: There is a significant, positive relationship between Compatibility and Easy to use.

H5: There is a significant, positive relationship between the effectiveness of marketing tactics and Easy to use.

IV.

SURVEY

A. Data

Data for Japanese corporations were collected through an online survey conducted on July 27, 2023. A sample of the survey was selected from database of Freeasy which has the largest scale online survey monitors in Japan with more than

4.5 million people registered. In addition to basic information such as age, gender, and living area, they have prepared some attributes, including occupation and industry. Those who are age between 15- and 99-year-old, working full-time, fixed-term contract workers or dispatch workers were selected. The survey was sent to those monitors up to reach 500 responses.

Table 1. Sample Statistics

Ages and Gender types (Japanese corporations)

(1) Ages and Gender types (Taiwanese corporations)

N			N		
%			%		
18-25	2	9.1	Female	15	68.2
36-45	2	9.1	Male	7	31.8
46-55	10	45.5	Total	22	100.0
56 over	8	36.4			
Total	22	100.0			

Data for Taiwanese corporations were collected online and amassed 22 valid responses. Those respondents are age between 18 and over 56-year-old.

Most of the population are aged between 40s and 60s.

There are more male respondents (405) than female (95) for Japanese corporation, whereas more female for Taiwanese ones.

Most of the questionnaires are asked by 4 to 5-point scale. A summary statistic in terms of ages and gender types are listed in Table 1.

B. Variables

A list of variables which are used in the analysis is shown on Table 2.

Table 2. A list of variables

Various goodness-of-fit indices, such as the Comparative Fit Index (CFI) [42], Incremental Fit Index (IFI) [43], and Normed Fit Index (NFI) [43], enable the assessment of the estimated matrix against the observed sample covariance matrix to determine the acceptability of the hypothesized model. Generally, fit indices (e.g., CFI, IFI, NFI) exceeding

N		%
20s	7	1.4
30s	39	7.8
40s	124	24.8
50s	184	36.8
60s	122	24.4
70s	22	4.4
80s	2	0.4
Total	500	100.0

0.90 indicate good model fit [44]. Since all our indices for the Japanese model meet these criteria, and our findings are considered acceptable.

The structural model was fitted to validate the hypotheses proposed in Section IV, examining the underlying relationships among effectiveness of marketing tactics, Reputation & Recommendation, Incentive to try, Compatibility with current processes and systems, and Easy to use. The path diagram in Figure 6 illustrates positive and significant relationships for all hypotheses.

A. *Japanese Corporations (n=500)*

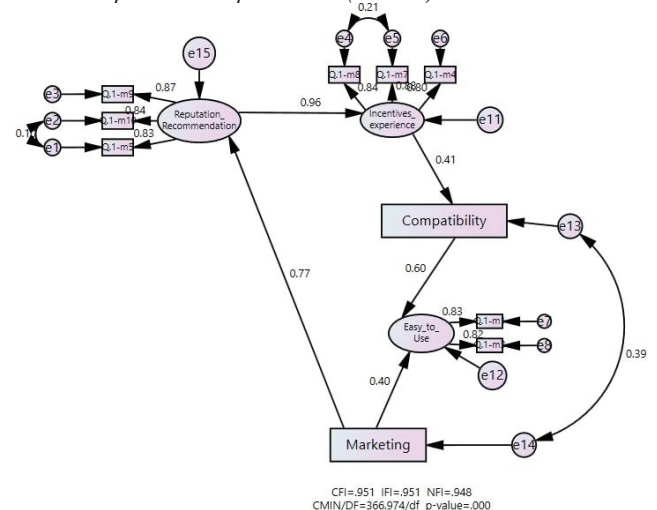


Figure 3 Results for the Research Model for Japanese Corporations

Table 3 The Path Coefficients of Research Model

Reputation & Recommendation	Success stories and reputation Recommendations from experts Experience of other companies
Incentives to try, experience with demo, try before deciding	Opportunities and incentives to try Opportunity to experience with interactive demo Opportunity to try before deciding
Compatibility	Compatible with current processes and systems
Efficient and easy to use, easy to understand	Efficient and easy to use Compatible with current processes and systems Easy to understand and use
Experimental Marketing	Customized marketing information and materials

Construct

Std.

Unstd.

S.E.

C.R.

p-

		weigh	Weight	(t-value)	value
Reputation Recommendation <--- Q.1m6		0.761	0.761 0.029	26.112	***
Incentives experience <--- Reputation Recommendation		0.956	0.956 0.034	27.73	***
Q.1m2 <--- Incentives experience		0.385	0.385 0.041	9.397	***
Easy to Use <--- Q.1m2		0.534	0.534 0.026	20.24	***
Easy to Use <--- Q.1m6		0.328	0.328 0.024	13.795	***
Q.1m5 <--- Reputation Recommendation		1	1		
Q.1m10 <--- Reputation Recommendation		1.036	1.036 0.033	31.69	***
Q.1m9 <--- Reputation Recommendation		1.007	1.007 0.033	30.835	***
Q.1m8 <--- Incentives experience		1	1		
Q.1m7 <--- Incentives experience		1.05	1.05 0.028	36.938	***
Q.1m4 <--- Incentives experience		0.931	0.931 0.034	27.146	***
Q.1m1 <--- Easy to Use		1	1		
Q.1m3 <--- Easy to Use		1.003	1.003 0.037	27.326	***

V.

RESULTS

The effectiveness of the structural equation model was assessed using AMOS 29, and the main outcomes of the analysis are depicted in Figure 3 and Figure 4. The path diagram emphasizes the structural connections, with measured variables enclosed in boxes, latent variables circled, and arrows denoting relationships, while open arrows represent errors. When employing SEM to validate a theoretical model, a higher goodness of fit is essential [Byrne, 2010]; the closer the fit, the more alignment between the model matrix and the sample matrix.

Table 4 Reliability Test

FIT indices Recommended level Japanese model

CFI	>0.90 (Bentler, 1990)	0.951
IFI	>0.90(Bollen ,1989)	0.951
NFI	>0.90 (Bentler and Bonett, 1980)	0.948
p-value	>0.05	0

The followings are results of hypotheses for Japanese corporation.

H1: There is a significant, positive relationship between the effectiveness of marketing tactics and Reputation & Recommendation.H2: There is a significant, positive relationship between Reputation & Recommendation and Incentive.

H3: There is a significant, positive relationship between Incentive and Compatibility.

H4: There is a significant, positive relationship between Compatibility and Easy to use.

H5: There is a significant, positive relationship between the effectiveness of marketing tactics and Easy to use.

B. *Taiwanese Corporations (n=22)*

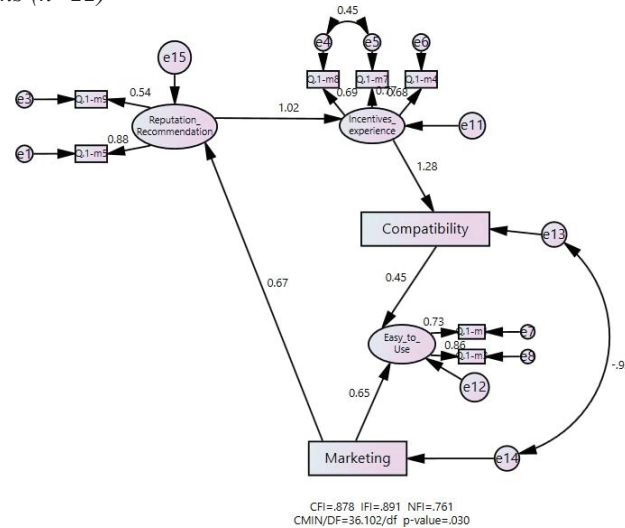


Figure 4 Results for the Research Model for Taiwanese Corporations

Table 5 The Path Coefficients of Research Model

H1: There is a significant, positive relationship between the effectiveness of marketing tactics and Reputation & Recommendation.

H2: There is a significant, positive relationship between Reputation & Recommendation and Incentive.

H3: There is a significant, positive relationship between Incentive and Compatibility.

H4: There is a significant, positive relationship between Compatibility and Easy to use.

H5: There is a significant, positive relationship between the effectiveness of marketing tactics and Easy to use.

The hypotheses examined in this study for both countries offer important insights: Asserts a significant, positive relationship between the effectiveness of marketing tactics and Reputation & Recommendation. Posits a significant, positive relationship between Reputation & Recommendation and Incentive. Suggests a significant, positive relationship between Incentive and Compatibility. Indicates a significant, positive relationship between Compatibility and Easy to use. And, also suggests a significant, positive relationship between the effectiveness of marketing tactics and Easy to use.

VI. CONCLUSION

This research explores the impact of innovation diffusion theory and experimental marketing strategy on the adoption of AI-generated technology in a cross-country analysis between Japan and Taiwan. The study, conducted through a comprehensive questionnaire, reveals the following key relationships; a significant, positive relationship exists between the effectiveness of marketing tactics and Construct

Std. Unstd.

Reputation Recommendation	<--- Q.1m6	0.669	0.68	0.199	3.418	***
Incentives experience	<--- Reputation Recommendation	1.016	0.435	0.127	3.417	***
Q.1m2	<--- Incentives experience	1.278	2.417	0.682	3.542	***
Easy to Use	<--- Q.1m2	0.453	0.267	0.108	2.468	0.014
Easy to Use	<--- Q.1m6	0.649	0.316	0.1	3.149	0.002
Q.1m5	<--- Reputation Recommendation	0.877	1			
Q.1m9	<--- Reputation Recommendation	0.544	0.249	0.089	2.786	0.005
Q.1m8	<--- Incentives experience	0.687	1			
Q.1m7	<--- Incentives experience	0.768	1.236	0.277	4.457	***
Q.1m4	<--- Incentives experience	0.678	1.661	0.559	2.971	0.003
Q.1m1	<--- Easy to Use	0.726	1			
Q.1m3	<--- Easy to Use	0.856	1.551	0.439	3.53	***

weigh Weight S.E.

C.R. p-
(t-value) value

Reputation & Recommendation; a significant, positive relationship is observed between Reputation & Recommendation and Incentive; a significant, positive relationship is identified between Incentive and Compatibility; a significant, positive relationship is found between Compatibility and Easy to use. And there is a significant, positive relationship between the effectiveness of marketing tactics and Easy to use. These findings contribute valuable insights for understanding factors influencing the adoption of AI-generated technology and the role of _____

Table 6 Reliability Test

Fit indices	Recommended level	Taiwanese model
CFI	>0.90 (Bentler, 1990)	0.878
IFI	>0.90 (Bollen, 1989)	0.891
NFI	>0.90 (Bentler and Bonett, 1980)	0.761
p-value	>0.05	0.03

As for the model of Taiwanese corporation, all indices are close to 0.90 but less, due to small sample size (n=22). Path coefficients between Reputation & Recommendation and Incentive & Experience, Incentive & Experience and Compatibility are greater than one. Unlike a correlation coefficient they are not bound between -1 and 1, path coefficients like standardized regression coefficients can be larger than 1. However, when these values exceed this range, it often raises concerns, particularly regarding issues related to multicollinearity.

The followings are results of hypotheses for Taiwanese corporations.

experimental marketing in facilitating its diffusion across different cultural contexts.

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An Analysis of a Korean Little Giant Company in Semiconductor Industry: Analysis of TEMC

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Abstract

This report delves into the challenges and strategies faced by small and medium-sized enterprises (SMEs) in South Korea, operating in an environment dominated by conglomerates. Using TEMC, a young company in the South Korean semiconductor industry, as a case study, it explores how TEMC strategically navigates the landscape and achieves success in the competitive business environment. The analysis provides insights into the unique approaches and business strategies that contribute to TEMC's accomplishments within the dynamic South Korean business ecosystem.

Keywords

Technology Business Analysis, Korean ICT Industry, Case Study, VRIO Analysis

1. Introduction

In a world immersed in an information revolution, where distances collapse through the interconnected web of the internet, the possession of cutting-edge information and communication technologies has become a linchpin in the global landscape. This era is akin to a digital frontier where staying ahead in the international political economy is contingent on technological prowess.

As I witnessed the vibrancy of the semiconductor industry during my engagement in rare gas trade and participation in the 2023 Seoul Semiconductor Exhibition, the relevance of this industry became palpable. The semiconductor industry, often likened to the 'crude oil of the information era,' symbolizes the critical role of semiconductor devices as the brains behind a myriad of products we encounter daily.

From consumer electronics to industrial robots, these devices are the unsung heroes, rendering products useless without their silicon brains. This realization amplifies the significance of the semiconductor industry, not just as a technological cornerstone for high-tech goods but also as a driving force behind the development of commonplace items like VCRs and calculators.

Therefore, as we embark on this exploration, delving into companies like TEMC within the semiconductor realm, we are essentially navigating the terrain of an industry that shapes the very fabric of our modern existence. This endeavor aims to uncover the strategies and factors influencing the position of companies like TEMC in a landscape that blends the transformative currents of

the information revolution with the tangible impact of semiconductor technologies on our everyday lives.

2. Nature of the Semiconductor Industry in South Korea

The semiconductor industry in South Korea has been one of the major drivers of economic growth in the country over the years. This journey started in the early 1960s, when the South Korean government realized that technology would play a vital role in developing a local domestic semiconductor industry.

Establishing a strong semiconductor manufacturing base was an intensified effort in the 1970s and 1980s. For instance, the government took the lead in starting important projects and offering funds to companies that desired to produce semiconductors. It was this era that laid a foundation for the country's technological base and made its industry the foundation of South Korean technology.

The turnaround came in the 1990s, when South Korean semiconductor companies went into global markets. However, with technological developments, especially from memory chips, companies such as Samsung among others propelled onto the world map. It took only a short time for South Korea to become a substantial player in the international arena of semiconductors, concentrating particularly on producing high-quality memory chips for the international market.

Research and development continued, especially during

the first decade of 2000, by South Korean companies. The country was renowned for its breakthroughs in semiconductor design and processes of manufacture. South Korea developed into a specialty in the manufacture of memory chips and particularly, DRAM and NAND flash with a great contribution to the global semiconductor market.

By the 2010's, South Korea continued to dominate the global semiconductor market. Companies like Samsung and SK hynix were dominant players in the memory chip market with unequaled technological edges and manufacturing capacity. Consequently, these companies contributed greatly to the country's exports which drove its economic growth.¹

Nevertheless, this industry had encountered many problems. The South Korean semiconductor manufacturers had to overcome the market cyclicalities, intense global competition, and geopolitical tensions. However, these challenges prompted resiliency and adaptability. To survive in this complex world and be able to maintain a strong foothold and survive in this world, the companies diversified their product portfolios, invested heavily in sophisticated technologies, and created strategic alliances with various other organizations.

Today, South Korea is still a significant power in the semiconductor industry. Attention has moved towards cutting-edge technology like Artificial Intelligence, 5G, and the IoT. South Korea continues to lead as ongoing research, innovation, and global cooperation are critical to its success in this field.

3. Growth and success of TEMC

3.1 The introduction of TEMC

TEMC was founded in January 2015 and its vision is based on connectivity through technology, innovating new ideas and jumping forward to a better future.²

It produces specialty gases for semiconductor and display production and medical gases. One of TEMC's missions is the aim of domestic production of these special gases to improve national self-sufficiency and technological development.

TEMC has set itself apart in the industry with a highly

specialized workforce of 97 people. The company registered sales revenue of 3,466.5 billion Won in 2022³ which has helped it gain some considerable competitive edge over its domestic peers. Therefore, it remains a significant challenge for TEMC in the upcoming parts of the report to provide justification for this exceptional rate of growth in the past year.

TEMC 2022 Sales

COLLECT DATA UNTIL DECEMBER 2022

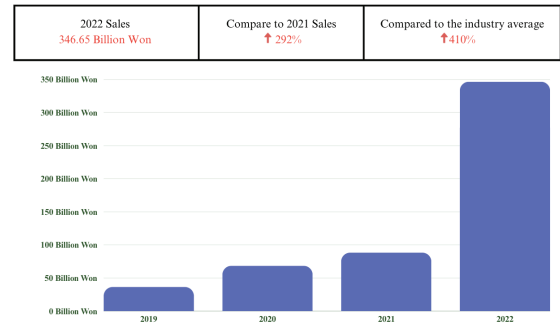


Figure 1. TEMC 2022 Sales Number

Despite being a medium-sized enterprise in South Korea, TEMC has demonstrated remarkable performance in recent years. This is attributed to its collaborations with leading companies in the Korean semiconductor sector, such as SK Hynix, POSCO, and the Samsung Group. Within the short span of a decade, TEMC has achieved outstanding results, both financially and competitively within the industry.

1.2 TEMC success in 2022

TEMC is a company specializing in the production of rare and specialty gases used in semiconductor processing. Since the third quarter of 2023, TEMC has been supplying its products to Samsung Electronics. The successful supply to Samsung Electronics by TEMC, a member of SK Hynix's second-generation technology innovation company, is expected to accelerate the localization of semiconductor specialty gas production.

Following the surge in neon gas prices after the Russia-Ukraine war, there has been a growing demand for locally produced gases. With TEMC successfully achieving the localization of neon gas production, Samsung Electronics has also started receiving TEMC's products since the third quarter.

TEMC produces various specialty gases, including excimer laser gases, xenon (Xe), krypton (Kr), CF series for etching processes, carbon monoxide (CO), carbonyl

¹ Mushkudiani, D. (2000). THE KOREAN SEMICONDUCTOR INDUSTRY: HISTORICAL OVERVIEW AND PROSPECTS FOR FUTURE DEVELOPMENT. <https://archives.kdischool.ac.kr/bitstream/11125/29891/1/The%20Korean%20semiconductor%20industry.pdf>

² History. (2023). TEMC-History. http://temc.co.kr/en/sub/sub01_03.php

³ TEMC. (2023). JOBKOREA. <https://www.jobkorea.co.kr/company/45275661>

sulfide (COS), and mixed gases for deposition processes. The company manufactures a variety of specialty gas products, including phosphine (B2H6). In 2018, TEMC was selected as the second technology innovation enterprise by SK Hynix and was listed as a key partner.

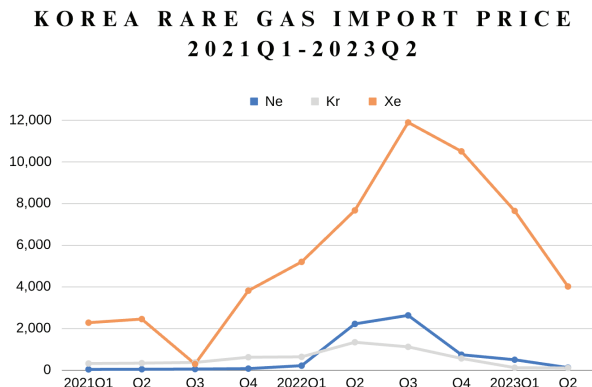


Figure 2. Korea Rare Gas Import Price (from 2021Q1 to 2023Q2)

I.3 The future of TEMC

Semiconductor-specialized gas production company TEMC is exploring new avenues as it navigates through changing market dynamics. Last year, explosive growth in sales related to rare gases was observed during special events related to geopolitical tensions. However, with the conclusion of these events, an inevitable decline in profits looms, prompting the company to focus on diversifying its business structure. As of now, the specific direction of this new business venture remains undetermined.

According to the Financial Supervisory Service's electronic disclosure system on the 20th, TEMC's cash and cash equivalents for the first quarter of this year amounted to KRW 119 billion, marking a growth of 217.5% compared to the end of the previous year. Aside from raising KRW 50.4 billion through its listing on the KOSDAQ earlier this year, the significant price increase in semiconductor specialty gases such as neon (Ne), xenon (Xe), and krypton (Kr) last year contributed to a substantial growth in revenue. However, the profit margin resulted in operational cash of only KRW 5.72 billion, significantly lower than the revenue due to substantial expenses.

While the surge in cash and cash equivalents has contributed to the stabilization of TEMC's relevant financial indicators, the unavoidable decline in profits this year is attributed to the stabilization of rare natural gas prices. The company is actively adjusting its strategies to navigate these shifts in the market landscape.

4. Analysis of the competitive status of TEMC

A.1 Competitive status of the Industry and Company

According to statistics from Job Korea, TEMC ranks eighth in the same industry field in the chemical and energy sector in South Korea. While it may not match the financial strength of conglomerates like Samsung, the substantial operating profit achieved by TEMC in 2022 has granted the company more influence in this sector.

In 2023, TEMC officially initiated efforts for 100% domestic production of neon gas. Simultaneously, the company plans to separate the helium gas generated as an additional byproduct during the operational processes. The recently completed factory has an annual production capacity of approximately 22,000 Nm³ (standard cubic meters) of high-purity neon gas, expected to meet about 16% of domestic demand. This strategic move has significantly bolstered TEMC's competitiveness in the realm of rare gases for the semiconductor industry. This not only strengthens the company's position in the semiconductor industry but also reflects its proactive efforts towards achieving domestic production and enhancing the added value of its products.

A.2 Technological and Organizational Capability

The successful localization of neon gas production and the separation of additional helium gas as a byproduct underscore TEMC's technological prowess. This not only enhances its competitive edge but also positions the company as a technologically adept player in the semiconductor gas market.

TEMC organizational capabilities include managing the operations, strategic initiatives, and partnerships relating issues with the semiconductor industry. This organizational dexterity and networking ability is demonstrated by the fact that it works together with some giant stakeholders like, SK Hynix, POSCO and the Samsung group etc.

The listing of TEMC in KOSDAQ is another indication of its organizational knowledge in penetrating into economic markets for growth. High amount of cash and cash equivalent reflects the solid financial position of the company, which provides positive outcomes for its financial stability.

Nevertheless, as TEMC moves into diversification and explores other businesses, organizational capability has to keep pace with the change process in order to maintain stability and continual expansion. TEMC can make more advancements in its organizational capabilities by focusing on strategic planning, developing talents and communicating properly.

A.3 Market and Financial status

In the competitive semiconductor industry, TEMC stands out through key partnerships with industry leaders like SK Hynix and Samsung. These collaborations not only solidify TEMC's market presence but also position it as a reliable supplier within the semiconductor sector. The recent move to achieve 100% domestic production of neon gas showcases TEMC's commitment to sustainability and market self-sufficiency.

While currently meeting 16% of domestic demand, there's room for growth. Strategic market penetration could further enhance TEMC's share, creating opportunities for expansion.

TEMC's financial indicators demonstrate a robust position. Revenue growth, evident in increased cash reserves (KRW 119 billion), is attributed to the surge in semiconductor gas prices. The strategic listing on the KOSDAQ not only provided capital but also enhanced financial flexibility and credibility.

Profitability is notable, but challenges arise from fluctuating rare gas prices. Effective cash flow management, reflected in increased cash reserves, ensures operational sustainability and supports strategic initiatives.

Condensed Income Statement

(Unit: KRW million)

Category	2020	2021	2022
Sales	68,484	88,323	346,654
Gross Profit	11,960	17,597	65,488
Operating profit	8,812	12,367	52,041
Non-operating revenue	1,136	1,713	8,980
Non-operating expenses	2,339	1,847	8,854
Net income	6,493	10,386	41,356

Figure 3. TEMC Income Statement (from 2020 to 2022)

A.4 Key capability analysis: VRIO analysis

TEMC's success is not only attributed to international circumstances but also stems from the company's inherent strengths. The following VRIO analysis will delve deeper into the factors contributing to the success of the company.

Value:

1. Production of Semiconductor Special Gases: TEMC's core business involves the production of special gases crucial for the semiconductor manufacturing process, providing value to its customers.

2. Localization Efforts: TEMC actively promotes the localization of special gases, ensuring a stable supply and meeting the demands of the local market.

Rare:

1. Industry Partnerships: TEMC has established strategic partnerships with major semiconductor companies such as SK Hynix, POSCO, and Samsung, which is uncommon in the industry, adding uniqueness to its position.

2. Neon Gas Localization: TEMC's efforts in localizing neon gas contribute to its uniqueness in the rare gas sector.

Imitability:

1. Technological Innovation: TEMC consistently engages in technological innovation, developing process technologies for high-purity gases that are challenging to imitate quickly.

2. Supply Chain Integration: TEMC has established a comprehensive supply chain, including raw material procurement, production, and delivery, making it difficult for competitors to replicate.

3. Patent Protection: The chemical manufacturing processes in the chemical industry are highly intricate and challenging. Besides benefiting from legal protection through patents, attempting to replicate all manufacturing processes is nearly impossible.

Organization:

1. Talent and Expertise: The company needs a highly specialized team with expertise in semiconductor processes and special gases.

5. Prospect of the company and recommendations

5.1 Prospect of the company

TEMC exhibits promising prospects in the dynamic landscape of the semiconductor special gases industry. The company stands to benefit from the escalating global demand for semiconductor products, driven by advancements in 5G, IoT, and artificial intelligence.

A key factor contributing to TEMC's positive outlook is its commitment to the localization of special gases. Notably, the achievement of 100% domestic production of neon gas positions the company strategically within the Korean semiconductor market, ensuring a reliable supply chain and enhancing competitiveness.

Strategic partnerships with major industry players, including SK Hynix, POSCO, and Samsung, further amplify TEMC's growth potential. These collaborations not only provide a robust network but also open avenues for future innovations and market access.

TEMC's continuous focus on technological innovation, coupled with potential patent protections, establishes barriers to entry for competitors. The complexity of their manufacturing processes adds an extra layer of security to their market position.

The company's notable financial stability, exemplified by substantial sales revenue in 2022, provides a solid foundation for future endeavors. This financial strength enhances TEMC's resilience in navigating market fluctuations and pursuing strategic initiatives.

Moreover, TEMC has demonstrated adaptability in responding to changing international and industry dynamics. This adaptability reflects the company's strategic acumen and positions it well to address evolving market demands.

TEMC's future success appears promising, supported by a combination of strong market demand, localization efforts, strategic partnerships, technological prowess, financial stability, and adaptability. Continued emphasis on innovation, sustainability, and strategic collaborations is likely to propel TEMC's sustained growth in the semiconductor special gases sector.

5.2 Strategic Recommendations

1. Diversification of Product Portfolio:

TEMC should consider diversifying its product portfolio to include a broader range of special gases or explore related segments within the semiconductor industry. This diversification can enhance revenue streams and reduce dependency on specific products.

2. Global Expansion and Market Penetration:

Explore opportunities for global expansion by entering new markets or strengthening existing footholds. This may involve establishing partnerships or collaborations with international semiconductor companies, allowing TEMC to tap into emerging markets.

3. Investment in Research and Development:

Allocate resources for continuous research and development to stay at the forefront of technological advancements. Investing in innovative technologies and processes will not only improve competitiveness but also contribute to the sustainability of TEMC's market position.

4. Sustainability Initiatives:

Embrace sustainability initiatives in the production processes and supply chain. The semiconductor industry is increasingly focusing on environmentally friendly practices, and TEMC can differentiate itself by adopting

green technologies and emphasizing environmental responsibility.

5. Strategic Partnerships and Alliances:

Strengthen existing partnerships and explore new alliances within the semiconductor ecosystem. Collaborating with industry leaders, research institutions, or complementary businesses can open doors to shared resources, knowledge exchange, and potential synergies.

6. Talent Development and Retention:

Invest in talent development programs to nurture a skilled workforce. Attracting and retaining top talent in areas such as research, engineering, and technology will be crucial for sustaining TEMC's competitive edge.

7. Continuous Monitoring of Geopolitical Risks:

Given the geopolitical sensitivity of the semiconductor industry, TEMC should continuously monitor and assess geopolitical risks. This includes staying informed about international trade dynamics, regulatory changes, and potential disruptions that could impact the supply chain.

8. Customer Relationship Management:

Enhance customer relationship management by understanding the evolving needs of semiconductor manufacturers. Regular communication, feedback mechanisms, and tailored solutions can strengthen TEMC's position as a preferred supplier in the industry.

9. Digital Transformation:

Embrace digital technologies to enhance operational efficiency and customer interactions. This may involve implementing advanced analytics, automation, and digital platforms to streamline processes and provide better customer experiences.

5. Conclusion and Learning from the Case

TEMC, specializing in the production of rare and specialty gases for semiconductor processes, has emerged prominently in the South Korean semiconductor industry through close collaborations and exceptional product quality. Established in 2015, the company swiftly gained a favorable position in the industry by partnering with leading enterprises in the South Korean semiconductor sector.

Acknowledged as the heart of the information age, the semiconductor industry witnessed TEMC's successful localization by manufacturing and selling essential gases required in semiconductor production processes. The company's product range encompasses various gases crucial for semiconductor manufacturing, providing vital support for the development of the South Korean semiconductor industry.

The significant sales figures achieved in 2022, along with

the successful domestication of raw materials like neon gas, have laid a robust foundation for TEMC's future development. Engaging in events such as the South Korean Semiconductor Expo and actively participating in rare gas trade further fueled my curiosity and interest in TEMC and the broader industry. Through the Korean Business Field Project, I aim to gain deeper insights into the industry's evolution and future prospects.

In the TEMC Analysis Report, we delved into the company's history and current status within the South Korean semiconductor industry. By analyzing its competitive status, technological and organizational capabilities, market and financial standing, we identified key success factors. The report concludes with strategic recommendations for the company's future development, summarizing the enlightenments derived from this case analysis.

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The Distinction and Balance of Exploration and Exploitation on Innovation Performance

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Abstract

In this paper, we examined the distinction between exploration, exploitation, and the beneficial effects of their balance. It is suggested that exploration and exploitation affect a firm's different dimensions of innovation performance and there is an inverted U-shaped relationship between exploration-exploitation continuum and performance. Longitudinal data on 281 Taiwanese firms in the IT sector was collected to test the hypotheses.

The findings support predictions. Exploration is the stronger predictor of innovation quality while exploitation is better in explaining innovation quantity. By testing an inverted U-shaped relationship between exploration-exploitation continuum and innovation performance, the finding of this study confirmed the existence of the optimal equilibrium level between exploration and exploitation. Managerial implications and future research directions are discussed.

Keywords

Exploration, Exploitation, Innovation performance

1. INTRODUCTION

In today's business environment, as competition intensifies and the pace of change accelerates, firms are forced to renew themselves by building skills and capabilities effectively and efficiently. "The basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, to devote enough energy to exploration to ensure its future viability." (Levinthal & March, 1993, p. 105) The terms "exploration" and "exploitation" are capture firm's strategic actions and behaviors to create new knowledge or modify existing knowledge. As the distinction and resource-competing tension between exploration and exploitation are well-known in literature, the need for an appropriate balance between the two has been highlighted (e.g., March, 1991; He & Wong, 2004; Gupta, Smith & Shalley, 2006; Voss, Sirdeshmukh & Voss, 2008; Uotila, Maula, Keil & Zahra, 2009). How can a firm learn through exploration and exploitation to establish its technology capabilities? What difference are these capacities? And how does the balance level between exploration and exploitation affect a firm's capability building?

Prior research has suggested that exploration and exploitation activities create different capabilities for organizational knowledge production (Özsomer & Gençtürk, 2003; He & Wong, 2004). In pursuit of innovation quality, exploration is a process by which

organizations create variety in experience through experimentation, trialing, and free association (Marengo, 1993). In contrast, exploitation in pursuit of innovation efficiency is a process by which organizations create reliability in experience through refinement, production, and focused attention (Levinthal & March, 1993). These two types of learning require substantially different structures, processes, strategies, capabilities, and cultures to pursue (He & Wong, 2004) and may have different impacts on how much and what kind of knowledge is created. Although previous research has highlighted the importance of exploration and exploitation on organizational performance (e.g., March, 1991; He & Wong, 2004; Özsomer & Gençtürk, 2003; Jansen, Van Den Bosch & Volberda, 2006; Haas, 2006), there is little evidence on exploring the black box between exploration, exploitation and innovation performance.

Moreover, although the necessity of achieving a balance between exploration and exploitation has been highlighted in the literature (e.g., March, 1991; He & Wong, 2004; Gupta et al., 2006), studies that examine the challenges associated with a choice between exploration and exploitation are scarce (Gupta et al., 2006). Recent research by He & Wong (2004) found firms that had both exploitative and explorative innovation strategies had higher growth rates than other firms and the relative imbalance between exploration and exploitation is

negatively related to sales growth rates. Their finding implies that the relationship between the exploration-exploitation continuum and firm performance exhibits an inverted U shape. Therefore, our question is: Does this inverted U-shaped relationship of the exploration-exploitation continuum consistently hold in terms of innovation quality and efficiency?

In this study, we attempt to focus on the process between strategy-capability linkage rather than the strategy-performance linkage. We also examined the relative exploration-exploitation balance and its effect on innovation performance. Based on a sample of 281 Taiwanese information technology firms, we find that exploration is a better predictor of innovation quality while exploitation is better in creating innovation quantity. Moreover, the relationship between exploration-exploitation balance and innovation performance are inverted U shape. The rest of the paper is set out as follows. Section 2 considers the previous literature and sets out the hypotheses of this study. Section 3 deals with the methodology for the study. Section 4 presents the results of the empirical study in achieving the goals set out above. Discussion and conclusions are provided in Section 5.

2. THEORY AND HYPOTHESES

Exploration and Innovation Performance

Exploration, which is characterized by ‘experimentation with new alternatives’ (March, 1991: 85), is a process of learning by which organizations create variety in experience through generate discovery of new opportunities. The scope of innovative search may be broadened, the structure is organic and loosely coupled, and the diversity in knowledge is desirable (Brown & Eisenhardt 1998; Lewin, Long & Carroll, 1999; Ancona, Goodman & Lawrence, 2001; He & Wong, 2004; Özsomer & Gençtürk, 2003).

Exploratory innovations are radical innovations that are discovered through basic research, invention, risk-taking, and building new capabilities. Explorative learning depends more on the research part in R&D than the development part, such activities require new knowledge or departure from existing knowledge (Benner & Tushman 2003, Levinthal & March, 1993; McGrath, 2001; Jansen et al., 2006). Compared to exploitation, knowledge created by exploration is new, unsettled knowledge with potentially high but uncertain returns (Özsomer & Gençtürk, 2003) that have the potential to further develop into new technologies. The potentially valuable knowledge created by exploration has consequently been exploited to win a technology race in a new niche or to gain a competitive advantage by being the first to develop new, hitherto unproven, technologies (Beckman, 2006). Therefore, exploration which brings ground-breaking advancement enhances the value and quality of a firm’s knowledge resource, hence contributing to building

technology capability effectively. This suggests,

Hypothesis 1: Exploration is more strongly associated with innovation quality than is exploitation.

Exploitation and Innovation Performance

Exploitation is characterized by ‘the refinement and extension of existing competencies, technologies and paradigms’ (March, 1991: 85) which creates reliability in experience through advancement, routinization, production, and implementation of knowledge (Holmqvist, 2004). The scope of innovative search may be reduced, the systems are more mechanistic and tightly coupled, and the knowledge base necessitates conformity. Exploitative innovations are incremental innovations that build on existing knowledge and reinforce existing skills, processes, and structures (Abernathy & Clark 1985, Benner & Tushman, 2002; Levinthal & March 1993, Lewin et al. 1999; Jansen et al., 2006). Exploitative learning depends more on the development part in R&D than the research part, such activities need to focus activities on certain domains (Holmqvist, 2003) and require efficiency and consistent implementation (Beckman, 2006). Compared to exploration, knowledge created by exploitation is incremental, enhanced knowledge with moderate but certain, immediate returns (Schulz, 2001; Özsomer & Gençtürk, 2003). The benefits of exploitation have been demonstrated by learning-curve effects (Özsomer & Gençtürk, 2003). Refinement of existing knowledge and learning from experience reduce transaction costs and thereby expedite decision-making, implementation, and control (Cyert & March, 1963). Organizations could easily benefit from efficient innovation by pursuing exploitation. Thus, the following hypothesis was posited:

Hypothesis 2: Exploitation is more strongly associated with innovation quantity than exploration.

The balance between Exploration and Exploitation

It is commonly stressed in organizational learning literature that ‘maintaining an appropriate balance between exploration and exploitation is critical for firm survival and prosperity’ (March 1991: 71). The need for a balance between exploration and exploitation has been crystallized by scholars’ conceptualization of the ambidextrous organization. That is, to balance exploration and exploitation by maintaining a set of organizational activities, each of which contributes to a particular type of corporate renewal in the exploration-exploitation continuum (Tushman & O’Reilly, 1996; He & Wong, 2003). Recently, evidence on organizational ambidexterity indicates that firms capable of both exploring and exploiting do better than firms rooted in either one (Gibson & Birkinshaw, 2004; Katila & Ahuja, 2002; Tushman & O’Reilly, 1996; Uotila, Maula, Keil & Zahra, 2009). However, although both exploration

and exploitation are essential for organizations, striking this balance is inherently difficult. Since exploration and exploitation not only compete for scarce resources but also exhibit stark differences, firms need to manage actively the tension between the strong path dependence of exploitation and the vulnerability of exploration for long-term survival.

Firms emphasize exploitation benefits quickly, since the certainty, speed, proximity, and clarity of feedback. However, an excessive focus on exploitation results in organizational myopia and competency traps (He & Wong, 2004). What may be effective activities in the short term may turn out to be highly ineffective in the long run. Exploitative learning is a directed search emphasizing limiting variety, that may decrease variation in organizational routines and impair the capability for exploratory learning (Levinthal & March, 1993). Companies could easily find themselves trapped in pursuing operational efficiency in an outdated area at the expense of overall innovation quality. On the other hand, as the returns from exploration are 'systematically less certain, more remote in time, and organizationally more distant from the locus of action and adaptation' (March, 1991: 73), organizations that emphasize exploration at the expense of exploitation are likely to suffer the costs of experimentation without gaining its benefits. As a result, both excessive exploration and exploitation harm organizations' long-term success, there might be an appropriate balance exists between exploration and exploitation. Considering the above reasoning, the following hypothesis is developed.

Hypothesis 3: The relationships between the exploration-exploitation continuum and innovation quality and efficiency are inverted U-shape.

3. METHOD

3.1. Data collection and sample

The empirical sample consisted of 281 Taiwanese firms, all engaged in the information technology industry, listed on the Taiwan Stock Exchange. Sampling from these publicly traded firms ensures that all the firms observed met the same reporting standards required by the authorities and had periodically been audited by independent third parties (Sher & Yang, 2005). Our study period was eight years from 2013 to 2020.

To compile our sample, we collected corporate information and patent information. The patenting data were then matched with corporate financial data on the firms. Corporate information regarding the control variables, R&D intensity, past performance, industry profitability, and environmental turbulence, were collected from the database of the Securities and Futures Commission (SFC), Ministry of Finance, Taiwan. Patent information of the selected firms regarding independent variable, exploration, exploitation and E/E ratio, dependent

variable, innovation quality, and efficiency, were collected from the U.S. Patent and Trademark Office (USPTO).

We used U.S. patent information of the selected Taiwanese IT firms for three reasons: first, foreign firms, with and without operations in the United States, usually patent in the U.S. system because the United States represents the largest single market in the world for IT products, and therefore, foreign firms often seek to protect their intellectual property rights with U.S. patents. Secondly, the IT sector in Taiwan is famous as a global IT hardware producer, and most of its product's exported to the U.S. Thirdly, the United States Patent and Trademark Office has a comprehensive database of U.S. patents that is publicly available and this USPTO database has been widely used in the technology management literature (Gittelman & Kogut, 2003; Jaffe & Lerner, 2001). Therefore, USPTO patent information is appropriate for exploring the innovative behaviors and outcomes of Taiwanese information technology firms.

3.2. Measures

Dependent variables

Innovation quality. Researchers recommend using citation rates to gain insights into the importance of the patents (Jaffe, Fogarty & Banks, 1998; Mogege, 1991) as a high citation rate indicates the value of the original patent for the follow-up developments of the innovations (Miller, 2004; Decarolis & Deeds, 1999; Harhoff, Narin & Scherer, 1999), thereby adding a quality dimension to patent analysis (Kelley & Rice, 2002). We used the number of citations a firm's patents received each year after their issued date as a proxy of innovation quality.

Innovation quantity. Patent counts have been used to measure innovative output in several previous studies (e.g., Henderson & Cockburn, 1996; Penner-Hann & Shaver, 2005). In this study, we used the patent counts granted to a firm in each year as a proxy of innovation quantity.

Independent variables

Exploration. Exploration using the growth rate of the number of utility patents granted by a firm in a particular year compared to the prior year. This variable reflects whether the firm's explorative R&D activity is growing during the sample years.

Exploitation. Exploitation growth uses the growth rate of the number of design patents granted by a firm in a particular year compared to the prior year. This variable captures whether the firm's exploitative R&D activity is growing during the sample years.

Exploration-to-exploitation ratio (E/E ratio). This variable was calculated as the number of utility patents divided by the number of design patents, we attempt to capture the relative tendency toward exploration and exploitation choice. The more a firm engages in exploration than exploitation, the higher the ratio; conversely, the more a firm engages in exploitation than exploration, the lower

the ratio.

Control variables. To empirically test the relationship between innovation strategy and consequence innovation performance, we control several firm-level and industry-level variables known to affect our dependent and independent variables. Two firm-level control variables, R&D intensity, and past performance were included. The variable *R&D intensity*, as measured by firm-level expenditure on R&D divided by sales each year, is very often considered a proxy for the intensity of investment in innovation. The R&D intensity of the firm is expected to have a positive effect on innovations and patenting activities. Moreover, the link between a firm's past level of profitability and innovation activities has also been considered. We included the variable *Past performance* by employed return on assets, defined as net income over total assets of a firm each year. It is a commonly used financial measure of organizational performance.

In addition to the firm-level control variables described above, we also controlled for some industry-level factors that might impact either invention activities or patent output. 281 firms in our sample were categorized into 45 industries in the IT sector according to the 3-digit SIC code of Taiwan. *Industry profitability* controls the overall performance of the firm's primary industry. This variable is calculated as the stock return of the specific industry in each year, based on Delios and Beamish (1999). Moreover, the variable *Environmental turbulence*, as measured by a sales growth rate of the specific industry in each year, was also included in our models to control the rate of environmental change in an industry.

3.3. Models and estimation

Because our dependent variables were the number of patent issues to a firm each year and the number of citations a firm's patent received each year after its issued date, we turned to count data models for estimation (Greene, 2000), and negative binomial regression was used to test the hypotheses. The use of such methods is common in studies of patent count and patent citation (e.g., Graves & Langowitz, 1993; Henderson & Cockburn, 1996; Pennerhann & Shaver, 2005; Miller, Fern & Cardinal, 2007; Hoetker & Agarwal, 2007). The analysis was conducted using fixed-effects and random-effects (Hausman, Hall & Griliches, 1984) negative binomial models via the XTNBREG procedure in STATA. Because the fixed-effects and random-effects models yielded almost identical estimates, only estimates from the random-effects models were reported.

Specifying the proper lag structure for the effects of the independent variables on the dependent variables is one of the most important issues in panel data analysis (O'Brien, 2003). Researchers have evidence that a year lag is appropriate in innovation-performance models (O'Brien, 2003; Lu & Beamish, 2004; Wadhwa & Kotha, 2006). To facilitate causal inference, we lagged all the independent

variables by one year. The proper interpretation of our model is that a change in an independent variable at time $t-1$ will be associated with a change in a dependent variable at time t .

4. RESULTS

Table 1 presents means, standard deviations, and correlations for all measured variables in this study. Table 2 displays the results of negative binomial regression for combinations of the independent variables with innovation quality and efficiency as dependent variables. Model 1 and Model 5 in Table 2 are the base models that include only the control variables. The results for the control variables were virtually identical in Models 1 and 5, and most had the expected effect. Most of the control variables had negative significant influences on innovation quality and efficiency, except for R&D intensity.

Hypothesis 1 predicts that explorative R&D will have a stronger positive effect on innovation quality than exploitative R&D. Take Models 2 and 3, exploration was a stronger predictor of innovation quality ($\beta=0.473$, $p<.001$) than was exploitation ($\beta=0.314$, $p<.001$). Thus, Hypothesis 1 is confirmed. Hypothesis 2 predicts that exploitation is more strongly associated with innovation quantity than exploration. The results in Model 6 and Model 7 show that exploitation was a stronger predictor of innovation quantity ($\beta=0.226$, $p<.001$) than exploration ($\beta=0.128$, $p<.001$), thus hypothesis 2 was supported. We further tested the differences in beta coefficients between exploration and exploitation in their predictive relationships with innovation quality and efficiency (Cohen, Cohen, Aiken, & West, 2003, p.640) and found that the differences were significant for innovation quality as well as innovation quantity.

Hypothesis 3 predicts that there exists an optimal level between exploration and exploitation that leads to the best level of innovation quality and efficiency. We built the test of the inverted-U relationship by adding the linear term and its squared term of exploration-to-exploitation ratio (E/E ratio) in the models. For innovation quality, as shown in Model 4, the coefficient for the E/E ratio is positive and significant ($p<0.05$) while its squared term is negative and significant ($p<0.05$). Similarly, for innovation quantity, Model 8 shows the same result at the $p<0.05$ level. The evidence supports Hypothesis 3.

5. DISCUSSION AND CONCLUSIONS

The purpose of this study was to develop our understanding of the effect of two learning type—exploration and exploitation—and their relative balance on innovation performance. A panel data of 2248 cases was collected to test the hypotheses. Overall, the findings of this study support the idea that exploration and exploitation contribute to the building of different capabilities, and there is an appropriate level of balancing choice between

exploration and exploitation investment.

The findings of this study contribute to the learning theories by explaining the linkage between exploration, exploitation, and a firm's innovation capabilities. While many studies have identified exploration and exploitation as distinct activities that are both vital for long-term success (e.g., March, 1991; He & Wong, 2004; Holmqvist, 2003), little effort has been devoted to specifying the different consequences of these two different learning strategies. We contribute to learning literature by having compared the degree to which relationships between innovation strategy (exploration and exploitation) and innovation quality and efficiency. As exploration is more helpful in building innovation quality while exploitation is better in pursuit of efficiency, firms can prioritize their resources for technological innovation according to their current situation.

Regarding the "balance" debate, we found an inverted-U-shaped relationship between innovation strategy (exploration and exploitation) and innovation performance. While the beneficial effect of balancing exploration and exploitation has been hypothesized in the literature (e.g., March, 1991), there have been few studies providing direct empirical evidence, especially continuously. Our finding provides a better understanding of the trade-off and choice of how firms can efficiently and effectively establish their capacities in the innovation process. Therefore, firms should understand that the exploration and exploitation strategy should be carefully defined in the appropriate middle approach to achieve better innovation outcomes. However, although our findings suggest the need for firms to manage the tension between exploration and exploitation, yet, we still know too little about the mechanisms for achieving such a balance as well as the dynamics of the balance. Future research can study further to examine how the optimal balance between exploration and exploitation may be contingent on internal and external context factors.

In summary, our results shed some light on the effect of exploration, and exploitation on innovation but also leave some limitations for the consideration of further research. First, we derived our empirical results from a sample of technology-based firms in the IT sector, thus raising concern about the external generalizability to other sectors and industries. Future research is therefore suggested to empirically test the validity of the framework and hypothesis in other high-tech industries. Secondly, patent counts and patent citations are both proxy measures of innovation performance. Therefore, the findings of this study must be used cautiously. Future research can include other sources, such as survey data, of capabilities measures to supplement the objective measures.

Table 1 - Descriptive Statistics and Correlation Matrix

	Mean	s.d.	Minimun	Maxi-mun	1	2	3	4	5	6	7	8
1. Innovation quality	32.96	221.68	0	4560.00								
2. Innovation quantity	5.81	36.51	0	629.00	0.86 **							
3. Exploration	9.31	62.13	-2	1851.38	0.67 **	0.43 **						
4. Exploitation	5.20	36.80	-2	1029.41	0.69 **	0.69 **	0.16 **					
5. E/E ratio	0.06	0.67	0	18.93	0.00	0.00	0.03	0.01				
6. R&D intensity	14.38	2.98	0	106.86	0.00	0.00	0.00	0.00	0.00			
7. Past performance	9.14	12.01	-119.88	82.28	-0.00	-0.00	-0.02	0.01	-0.03	-0.07 **		
8. Industry profitability	19.99	65.47	-87.70	700.00	-0.01	-0.01	-0.02	-0.00	0.02	-0.00	0.18 **	
9. Environmental turbulence	53.21	91.81	-94.00	968.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	-0.05 *	0.02

Number of observations = 2248, *P<0.05, **P<0.01

Table 2 - Results of Negative Binomial Random-Effects Models ^a

Variable	Innovation quality				Innovation quantity			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	-1.045 ***	-0.999 ***	-0.979 ***	-0.947 ***	0.169	0.263 *	0.265 **	0.292 **
R&D intensity	0.548	0.787	0.611	0.623	0.457	0.593	0.482	0.479
Past performance	-0.012 **	-0.010 **	-0.011 **	-0.144 ***	-0.014 ***	-0.011 **	-0.012 **	-0.014 ***
Industry profitability	-0.003 ***	-0.002 **	-0.002 **	-0.003 ***	-0.003 ***	-0.002 **	-0.002 **	-0.003 ***
Environmental turbulence	-0.002 ***	-0.002 **	-0.002 **	-0.002 **	-0.002 ***	-0.002 ***	-0.002 ***	-0.002 ***
Exploration ^b		0.473 ***				0.128 ***		
Exploitation ^b			0.314 ***				0.226 ***	
E/E ratio ^b				27.561 *				25.233 *
E/E ratio square ^b				-1.57 *				-1.569 *
Log likelihood	-3790.51	-3545.94	-3565.36	-3272.78	-2515.13	-2351.10	-2354.56	-1986.99
Wald Chi-Square	58.10 ***	210.98 ***	104.24 ***	58.11 ***	76.09 ***	122.79 ***	93.94 ***	18.12 **

^a *P<.05, **P<.01, ***P<.001. Unstandardized regression coefficients are shown.

^b The coefficient for variables Exploration, Exploitation, E/E ratio and E/E ratio square were multiplied by 10² for reporting in this table.

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The Impact of Collaboration Capabilities on the Supply Chain Performance: The Perspective of Resource Orchestration Theory

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Abstract

The COVID-19 pandemic caused significant disruptions to global operations and supply chains. How firms coordinate efforts to collectively compete as supply chains is a key concern of supply chain management scholars and practitioners. Supply chain competences, such as relational competence and information technology (IT) competence, have been recognized as critical factors to promote supply chain collaboration capability for obtaining supply chain performance. Whereas prior researches focused on the positive results of collaboration capability for supply chain performance, little empirical research has studied on its facilitators, leaving the gap this study seeks to fill. We draw on resource orchestration theory (ROT) to develop our research model. According to this theory, a firm can exploit the full potential of its resources and capabilities only when these are deployed in a complementary manner. In this paper, we intend to extend the stream of research in Supply Chain Management (SCM) by systematically identifying the antecedents and consequences of supply chain collaboration capability between supply chain partners. The theoretical contributions and managerial implications of the study are discussed.

Keywords

Resource Orchestration Theory, Relation Competence, IT competence, Collaboration Capability, Supply Chain Performance.

1. Introduction

The ongoing COVID-19 pandemic has been causing serious impacts not only to the management of companies worldwide but also to the supply chains they belong to, due to the decrease in demand from companies. Furthermore, the advancement of globalization and information communication technology (ICT) has intensified the competition among supply chains. These environmental changes pose complex and challenging problems not just for individual companies, but for the entire supply chain (Queiroz et al., 2022). To respond to these global environmental changes, it is crucial for the companies participating in the supply chain to develop the ability and capacity to discover opportunities and crises, overcome them, and continuously monitor environmental changes to enhance supply chain competitive advantage, all based on strategic supply chain orientation (Tajeddini et al., 2024).

To strengthen the competitiveness of the supply chain, activities that harmoniously allocate and combine the various resources and capabilities held by the supply chain participating companies are needed so that synergy

can emerge through the integration of related resources (Adams et al., 2014). To explain such social phenomena and theories, a new theoretical approach and extension are required from research mainly conducted on resource-based theory and dynamic capability theory. For this, this study intends to approach the issue from the perspective of resource orchestration theory (ROT) (Sirmon et al., 2007, 2011; Liu et al., 2016; Asiaei et al., 2021).

Resource orchestration theory (ROT) is an extension theory of the resource-based theory, which theoretically emphasizes the relationship between operating activities related to the investment and allocation of resources at the corporate level and corporate performance (Sirmon et al., 2011; Wong et al., 2018). Looking at the existing preceding studies related to supply chain management, the resource-based view (RBV) emphasizes the excellence of corporate resources and capabilities, but has limitations in explaining the methods of combining and allocating resources to achieve performance (Bianchi et al., 2014; Kim and Jung, 2018). Resource orchestration theory is suitable for clarifying the structural relationship between relationship capabilities among supply chain participating

companies, supply chain capabilities, and supply chain performance (Liu et al., 2016).

Therefore, this study aims to propose an integrated approach from the perspective of efficient investment and allocation activities of resources in the resource orchestration theory, and the activities to link resources to performance in the dynamic capability theory (DCT). This is done to strengthen the long-term competitive advantage of the supply chain against changes in the global business environment. Specifically, this study intends to examine the influence of supply chain relationship capabilities and IT capabilities on supply chain collaboration capabilities, and the impact of collaboration capabilities on supply chain performance, by presenting a research model and conducting empirical research. The results of this study will provide theoretical and practical implications in a strategic dimension by illuminating the relationship between supply chain capabilities, ability, and performance, thereby enhancing the competitive advantage of the supply chain.

2. Theoretical development and hypotheses

2.1 Resource orchestration theory

To enhance the competitiveness of the supply chain and improve supply chain performance, it's important that participating companies appropriately allocate and harmoniously structure their resources and capabilities according to the situation. In other words, the ability to manage, allocate, and coordinate the resources held by companies participating in the supply chain can influence the improvement of supply chain performance. Resource orchestration theory (ROT) is an extension of the resource-based view (RBV) and is closely related to the dynamic capability theory (DCT), which concerns the integration, creation, and rearrangement of resources (Sirmon et al., 2007; Teece et al., 2007).

The resource-based view (RBV) posits that the value, rarity, inimitability, and non-substitutability of a company's resources influence its sustained competitive advantage. The dynamic capability theory (DCT) refers to a company's ability to integrate, build, and reconfigure internal and external capabilities to respond to rapidly changing environmental changes. However, while the RBV suggests that resources and capabilities are the source of competitive advantage, it has limitations in explaining how companies can develop these resources and capabilities (Queiroz et al., 2022). The ROT focuses on how a company can structure its resources and efficiently allocate them to enhance performance (Sirmon et al., 2007, 2011; Wong et al., 2018; Tajeddini et al., 2024).

From a supply chain perspective, companies have firm-specific assets, and resources are heterogeneously distributed, so many factors need consideration when integrating the supply chain. That is, coordinating,

allocating, and harmoniously structuring the assets, resources, and capabilities held by participating companies can enhance supply chain capability. This provides important insights for forming a competitive supply chain ecosystem and improving performance. Resource orchestration theory is very useful for understanding the ability to arrange and utilize the resources and functions held by companies participating in the supply chain (Malik et al., 2021). According to the ROT, it's not the individual capabilities of a company that are important, but rather how each capability is interdependently aligned and structured. This provides a theoretical basis for understanding the arrangement of resources and functions, such as supply chain relational competence and IT competence, and the structural relationship with collaboration capability, in enhancing supply chain performance.

2.2 Relational competence

To ensure the smooth operation and enhancement of supply chain competitiveness, relying solely on the competitiveness of individual companies is insufficient. To overcome this challenge, resources and capabilities of companies participating in the supply chain must be shared and strategically deployed according to necessary circumstances. Moreover, supply chain relational competence is crucial for creating a synergistic effect across the entire supply chain and maintaining and strengthening competitive advantages over competitors (Mofokeng and Chinomona, 2019).

Effective supply chain management requires the strategic construction of the supply chain, taking into account trade-offs (Kang et al., 2022). That is, it's vital for companies participating in the supply chain to have a supply chain orientation (Min and Mentzer, 2004), share a vision and purpose, and have an integrated supply chain strategy (Patterson et al., 2003). Sharing and utilizing information, as well as forming a consensus, are also crucial to enhancing performance (Paulraj et al., 2008). Zhu et al. (2020) classified the components of e-business in supply chain operations into technical and relational factors. They also clarified the structural impact relationship between e-Business operation capabilities and competitive performance.

If relational competence in a supply chain is established, it can curb the opportunistic behaviors of individual companies and enhance collaborative capabilities among participating companies. If value sharing with long-term orientation among the participating companies is continuously strengthened, it will positively impact supply chain performance. Based on these discussions, this study intends to propose the following hypotheses.

H1a. Supply chain relational competence will have a positive effect on collaboration capability.

H1b. Supply chain relational competence will have a positive effect on supply chain performance.

2.3 IT competence

Recently, the collapse of supply chains and increased uncertainty have been having a serious impact on supply chains as a whole. For effective and efficient supply chain management, it's important to manage various elements such as the flow of goods, services, information, and funds that occur in the supply chain, in conjunction with participating companies. Information technology is a crucial technical resource for managing, integrating, and operating not only one's own company resources but also those of participating companies in the supply chain. It can also enhance the visibility of the supply chain (Lee et al., 2021; Kumar et al., 2024).

From the resource-based view (RBV) perspective, IT competence is the ability to arrange and manage information technology-related resources, representing a company's ability to assemble, integrate, and build information technology resources to meet business requirements and seize business opportunities (Wade and Hulland, 2004). Initial studies related to IT competence were conducted from a departmental perspective, but they are now expanding to a company-wide level (Tippins and Shohi, 2003). Particularly in terms of supply chain management, IT competence needs to expand from the company level to the supply chain level. For example, Tippins and Shohi (2003) proposed information technology competence as information technology objects, operations, and knowledge. Wu et al. (2006) constituted information technology competence as advanced information technology and information technology linkage, while Rai et al. (2006) composed information technology integration capability as data consistency and application integration between functions. Liu et al. (2016) conceptualized IT competence as flexible IT infrastructure, IT homogenization, and managerial IT knowledge from a resource orchestration theory perspective.

In this way, IT competence in the supply chain can serve as a tool for exploring and utilizing information by interconnecting each function within and outside the supply chain. It also holds significant business value as a means to promote inter-company process integration and collaborative activities. Based on these discussions, this study intends to propose the following hypotheses:

H2a. Supply chain IT competence will have a positive effect on collaboration capability.

H2b. Supply chain IT competence will have a positive effect on supply chain performance.

2.4 Collaboration capability

Generally, in organizational research, there's a distinction between competency and capability. Competency refers to the core resources a company possesses, while capability refers to behavioral elements such as the operation and utilization of resources (Kang and Moon, 2014). Wu et al. (2006) proposed information exchange, coordination, activity integration, and supply chain responsiveness as abilities for coordinating and utilizing resources from a resource-based view (RBV) perspective. Kim and Lee (2010) classified collaboration into systems collaboration and strategic collaboration, elucidating the relationship between supply chain responsiveness and market performance. Systems collaboration involves developing and maintaining a communication system for demand forecasting and planning among supply chain partners. Strategic collaboration entails jointly executing business strategies and activities, such as demand forecasting and planning for long-term success with supply chain partners. Allred et al. (2011) proposed dynamic supply chain capability as a source of supply chain competitive advantage from a dynamic capability perspective, clarifying the relationship between customer orientation, supplier orientation, productivity, and satisfaction. The dynamic capability theory (DCT) emphasizes a pragmatic approach where companies on the supply chain can seek opportunities through collaboration. Firstly, "dynamic" refers to the ability to quickly alter a company's resource base in response to a changing environment. Secondly, "capabilities" refer to a company's ability to integrate, build, and reconfigure internal and external competencies (Teece et al., 2007).

Supply chain collaboration is the ability to share and utilize resources (such as informatization, personnel, and technology) of participating companies to create synergy effects for competitive advantage. In other words, collaborative capability is crucial for efficient supply chain operations, simple transaction processing, creative problem-solving, continuous improvement, and growth (Adams et al., 2014). This study aims to conceptualize supply chain collaborative capability from a perspective of integrating, creating, and rearranging the competencies within and outside the companies participating in the supply chain to respond to rapidly changing and uncertain supply chain environments. We believe that if collaborative capability is excellent, it will significantly influence the enhancement of supply chain competitiveness. Based on this, we have set the following hypotheses:

H3. Supply chain collaborative capability will have a positive effect on supply chain performance.

2.5 Research model

The resource orchestration theory is particularly useful for understanding the development and arrangement of resources and capabilities. This study aims to elucidate

how companies participating in the supply chain can efficiently allocate various resources they invest in and hold, in order to maximize their effects and enhance supply chain performance (Sirmon et al., 2007, 2011; Tajeddini et al., 2024). Accordingly, this study constructs independent variables from a competency perspective, which include supply chain relational competence and IT competence, and it frames collaborative capability as a mediating variable from a capability perspective. Furthermore, it identifies supply chain performance as a dependent variable to clarify the structural relationships between these variables (Adams et al., 2014; Allred et al., 2011; Cao and Zhang, 2011; Kim and Lee, 2010; Liu et al., 2016; We et al., 2006). The research model proposed in this study is shown in Figure 1.

3. Research methodology

3.1 Instrument construction

This study has restructured the operational definitions and survey questions to fit the purpose and characteristics of the study, referencing previous studies related to supply chain management. The operational definitions for the research variables are shown in Table 1.

Table 1 Constructs and definitions

Constructs	Definition	Reference
Relational Competence (RC)	Relational competence is a promise or agreement to do something in the future in supply chain relationships	Adams et al.(2014)
IT Competence (ITC)	IT competence of a company refers to its ability to effectively utilize information technology to achieve business goals	Liu et al. (2016)
Collaboration Capability (CC)	Collaboration capability is essential capabilities to align the interests of different partner firms with those of the entire supply chain	Kim and Lee(2010)
SC Performance (SCP)	Supply chain performance is conceptualized as the operational performances for the entire supply chain	Cao and Zhang (2011)

3.2 Data collection

The survey was conducted primarily targeting the managers responsible for supply chain departments within manufacturing companies participating in the supply chain. As the research subjects were manufacturing companies in South Korea, we adhered to the principle of retrieving one set of responses per company for data collection. A total of 122 surveys were collected and selected for analysis.

This study used SPSS 26.0 for basic statistical data analysis, and SmartPLS 3.0 for the analysis of the Partial Least Squares-Structural Equation Model (PLS-SEM). PLS-SEM is commonly used in MIS studies (Ringle et al., 2012). Among the responding companies, manufacturers in the electrical/electronics sector constituted the largest proportion at 39.3%. Companies with revenues between 10 and 50 billion won (KRW) represented the largest distribution at 30.3%. Moreover, it was confirmed that the most common company size was those with over 300 employees, accounting for 42.0%.

3.3 The measurement model

This study analyzed variance-based PLS-SEM through SmartPLS 3.0 software for the assessment of the measurement and structural model. We utilized Cronbach's alpha, composite reliability, factor loadings, average variance extracted (AVE), correlation coefficients, and the square root of AVE. The statistical analysis results for the measurement items are shown in Table 2. The factor loadings for the research variables ranged from 0.786 to 0.931, with all measurement items exceeding 0.7 cut off value. Additionally, Cronbach's alpha and composite reliability were found to be 0.818~0.862 and 0.891~0.913 respectively, exceeding the general criterion of 0.7 (Hair et al., 2014).

Next, to evaluate discriminant validity, the square root of the AVE values was compared with the correlation coefficients between the concepts. Generally, if the square root of the AVE value is greater than the correlation coefficient of each latent variable, it is considered that discriminant validity has been secured. As shown in Table 3, the analysis results confirm that the square root of the AVE values (0.841~0.876) exceeds the values of the correlation coefficients (0.415~0.573), ensuring discriminant validity. As such, the analysis results of the measurement model as shown in Table 2 and Table 3 confirm that both reliability and validity have been secured.

Table 2 Validity and reliabilities

Constructs		Item loadings	Cronbach's alpha	Composite Reliability	AVE
Relational Competence	RC1	0.844	0.848	0.908	0.767
	RC2	0.880			
	RC3	0.903			
IT Competence	ITC1	0.798	0.818	0.891	0.732
	ITC2	0.884			
	ITC3	0.882			
Collaboration Capability	SCC1	0.836	0.857	0.913	0.779
	SCC2	0.931			
	SCC3	0.878			
SC Performance	SCP1	0.786	0.862	0.906	0.708
	SCP2	0.847			
	SCP3	0.893			
	SCP4	0.835			

Table 3 Discriminant validity

Constructs	RC	ITC	CC	SCP
Relational Competence	0.876			
IT Competence	0.415	0.856		
Collaboration Capability	0.573	0.500	0.883	
SC Performance	0.462	0.467	0.530	0.841

Notes. Square root of AVE is shown on the major diagonal (bold)

3.4 The structural model and hypothesis testing

This study verified hypotheses based on a structural model, considering supply chain performance as the dependent variable and examining the influences of supply chain relational competence and IT competence on collaborative capability from the perspective of resource orchestration theory (ROT). The validation of the structural model is measured by the size of the path coefficient, statistical significance, and the explained (R^2) of the final dependent variable. Figure 4 shows the analysis results of the proposed structural model in this study, and Table 4 summarizes the detailed verification results for the proposed models (Model 1, Model 2, Model 3).

First, supply chain relational competence was found to have a significant positive (+) impact on collaborative capability ($b=0.441$, $t=5.666$, $p<0.01$) and supply chain performance ($b=0.191$, $t=2.008$, $p<0.05$). Therefore, Hypotheses H1a and H1b were accepted. Second, IT competence was found to have a significant positive (+) impact on collaborative capability ($b=0.317$, $t=4.075$, $p<0.01$) and supply chain performance ($b=0.237$, $t=2.421$, $p<0.05$). Therefore, Hypotheses H2a and H2b were accepted. Third, supply chain collaborative capability was found to have a significant positive (+) impact on supply chain performance ($b=0.302$, $t=2.784$, $p<0.01$). Therefore, Hypothesis H3 was accepted. Finally, the R^2 value for collaborative capability and supply chain performance was shown to be 41.1% (0.411) and 35.9% (0.359), respectively.

Notes. * $p<0.05$; ** $p<0.01$

Figure 2 Results of path analysis (Model 1)

Notes. * $p<0.05$; ** $p<0.01$

Figure 3 Results of path analysis (Model 2)

Notes. * $p<0.05$; ** $p<0.01$

Figure 4

Results of path analysis (Model3)

Additionally, a comparative analysis of Models 1 to 3 was conducted to identify the model with the highest explained (R^2). As shown in Table 4, Model 1 (Direct model) analyzed whether supply chain relational competence, IT competence, and collaborative capability directly influence supply chain performance. IT competence (0.332, $p < 0.01$) was found to have the greatest impact on supply chain performance. Also, collaborative capability (0.290, $p < 0.01$) was found to have a statistically significant impact on supply chain performance.

The analysis results of Model 2 (Full mediation model) indicated that both supply chain relational competence (0.519, $p < 0.01$) and IT competence (0.229, $p < 0.05$) have a statistically significant impact on collaborative capability. Furthermore, collaborative capability (0.465, $p < 0.01$) was found to have a statistically significant impact on supply chain performance. Model 3 (Hypothesized model) produced results as depicted in Figure 4. The R^2 value of the proposed Models 1 (Direct model), 2 (Full mediation model), and 3 (Hypothesized model) was confirmed to be highest in Model 3 at 0.359 (35.9%), followed by Model 1 (0.313) and Model 2 (0.216). Comparing the R^2 value of the three models through the data analysis, the role of independent variables in relational competency and IT competency seems appropriate, and the role of mediating variable in collaboration capability seems appropriate.

<Table 4> Results of the SEM estimation

Paths		Model1	Model2	Model3
Relational Competence	→ Collaboration Capability	-	0.519**	0.441**
IT Competence	→ Collaboration Capability	-	0.229*	0.317**
Collaboration Capability	→ Supply Chain Performance	0.290**	0.465**	0.302**
Relational Competence	→ Supply Chain Performance	0.061	-	0.191*
IT Competence	→ Supply Chain Performance	0.332**	-	0.237*
Variance explained(R^2) SC Performance		0.313	0.216	0.359
** t-value significant at $p < 0.01$				
* t-value significant at $p < 0.05$				

4. Discussion and conclusions

With the advancement of globalization and information and communication technology, the importance of global supply chain management is being emphasized beyond the competitiveness of companies, to competitiveness among supply chains and even among nations. As the world economy becomes globalized, the expansion and integration of supply chains in time and space can provide new opportunities for businesses, but it also exposes them to various risks. The risk to supply chains has been further exposed by the recent spread of COVID-19, which is having a negative impact on the world economy (Queiroz et al., 2022; Lee et al., 2021).

This study constructed a structural relationship of competence-ability-performance from the perspective of resource orchestration theory to strengthen supply chain competitiveness and improve performance (Sirmon et al., 2007, 2011; Asiaei et al., 2021; Tajeddini et al., 2024). We analyzed the relationships between supply chain relational competence, IT competence, collaborative capability, and supply chain performance. The results of the analysis are as follows. First, supply chain relational competence was found to have a significant positive impact on collaborative capability and supply chain performance (Paulraj et al., 2008; Zhu et al., 2020), particularly having a greater impact on collaborative capability. Second, IT competence had a significant positive impact on collaborative capability and supply chain performance (Liu et al., 2016; Lee et al., 2021; Kumar et al., 2024), and it was statistically verified that it has a greater impact on collaborative capability. Lastly, collaborative capability was found to have a significant positive relationship with supply chain performance, confirming consistency with prior research (Allred et al., 2011). Lastly, we analyzed the explanatory power of Model 1 (direct model), Model 2 (full mediation model), and Model 3 (hypothesized model). The proposed research model (Model 3) in this study was obtained and R^2 value of 0.359.

Based on these research results, the theoretical and practical implications are as follows. From a theoretical perspective, first, this study extends prior research on the impact relationship between corporate competence and ability based on resource-based view (RBV), by proposing a structural relationship between supply chain competence, supply chain ability, and supply chain performance from the perspective of resource orchestration theory and integrating dynamic capability theory (DCT). Second, based on the proposed conceptual model, we derived research variables of supply chain relational competence, IT competence, collaborative capability, and supply chain performance, and clarified the relationships between these variables. Third, we validated the explanatory power of the research model by proving the explanatory powers of Models 1, 2, and 3, and proposed the most suitable model, which is considered to have significant

academic implications. However, it can be seen that the roles of independent variables and mediating variable differ according to the composition of the research model. This provides new academic value that it structures a research model for improving supply chain performance based on prior research and increases explanatory power. From a practical perspective, the implications of this study are as follows. First, many companies have experienced supply chain collapses and operational disruptions due to the recent COVID-19 pandemic. Recognizing the importance of redesigning competitive supply chains that can cope with uncertainty and rapid changes in the supply chain is important. At a time when supply chain uncertainty is increasing and competition between supply chains is becoming more competitive, we have statistically verified that improving the collaborative capabilities of supply chain participating companies is more important than anything else for improving supply chain performance. Second, collaborative capability is the ultimate common task of supply chain participating companies, and it is not the result of a single point in time, but is formed in the process of learning and evolving in a bilateral system. To do this, it is necessary to form relationships and invest in supply chain relational competence and IT competence from a long-term perspective. For example, it is necessary to build competitive supply chain management by predicting supply disruptions and various risks based on data analysis and insight using advanced technologies such as artificial intelligence, big data, and the Internet of Things. This is expected to provide practical implications in that it can build a competitive supply chain ecosystem and improve supply chain performance. Lastly, the limitations of this study and suggestions for future research are as follows. First, the subject of this study is manufacturing companies, and there are limitations in that it does not consider product and industry characteristics. Future research is expected to require comparative research on product characteristics and industry groups by industry. Second, the relevance of resource possession and use and collaborative capability of supply chain participating companies may vary depending on environmental characteristics. Future research is expected to require additional research that includes such characteristics.

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Evaluating Conversational AI Systems for Responsible Integration in Education: A Comprehensive Framework

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Abstract

As conversational AI systems such as ChatGPT have become more advanced, researchers are exploring ways to use the min education. However, we need effective ways to evaluate these systems before allowing them to help teach students. This study proposes a detailed framework for testing conversational AI across three important criteria.

Specialized benchmarks that measure skills include giving clear explanations, adapting to context during long dialogues, and maintaining a consistent teaching personality.

Adaptive standards check whether the systems meet the ethical requirements of privacy, fairness, and transparency. These standards are regularly updated to match societal expectations.

Evaluations were conducted from three perspectives: technical accuracy on test data sets, performance during simulations with groups of virtual students, and feedback from real students and teachers using the system.

This framework provides a robust methodology for identifying the strengths and weaknesses of conversational AI before its deployment in schools. It emphasizes assessments tailored to the critical qualities of dialogic intelligence, user-centric metrics capturing real-world impact, and ethical alignment through participatory design. Responsible innovation by AI assistants requires evidence that they can enhance accessible, engaging, and personalized education without disrupting teaching effectiveness or student agency.

Keywords

Language Models, ChatGPT, GPT-3, Evaluation Framework, Benchmarks, Standards, Responsible AI, Bias Mitigation, Ethics, Learning Management System (LMS)

1. Introduction

The emergence of large language models such as GPT-3 and Chat GPT has stimulated extensive research into their potential applications in education. These models have the ability to generate human-like text, answer questions, summarize content, and engage in natural conversations, which makes them promising for creating personalized and adaptive learning experiences. However, as Ahuja [1] highlighted, the integration of AI into education requires addressing challenges related to ethics, privacy, bias, and the critical evaluation of outputs.

Although research on conversational AI in specialized domains, such as medical education, there is a lack of a comprehensive framework for evaluating Chat GPT capabilities in broader educational contexts [2][3]. As Ray (2023) [4] emphasizes, the development of rigorous benchmarking standards for aspect such as coherence, accuracy, relevance, and ethical alignment is

crucial for driving responsible innovation. However, popular benchmarks such as GLUE and Super GLUE primarily focus on technical performance on standardized NLP tasks and overlook the critical nuances required for assessing conversational systems.

To address these limitations, this study proposes the following three-fold objective:

1. Construct specialized benchmarks that reflect key attributes of conversational intelligence, such as contextual adaptation, knowledge recall, and coherent persona.
2. Proposed adaptive standards that incorporate ethical requirements and context-specific user expectations for conversational systems.
3. Developing a multidimensional evaluation framework that assesses both technical prowess and user-centric metrics using comprehensive task-based, real-world, and human evaluation datasets.

This study contributes to the development of more effective and responsible conversational AI systems for educational applications, by pursuing specific objectives. To achieve this goal, this study presents a six-layered evaluation architecture that includes feasibility, SWOT, and adaptability analyses. Furthermore, this paper provides a roadmap to advance benchmarking, standards, and assessment protocols that are tailored for ChatGPT’s unique characteristics as compared to static NLP tasks. The methodology proposed in this paper aims to continuously align evaluation criteria with the evolving challenges around ethics, bias, and human expectations, thereby nurturing the safe and trustworthy integration of AI, such as ChatGPT, within multifaceted learning contexts.

This study commences with an exploration of current benchmarks and standards, highlighting their inadequacies in assessing conversational AI. Subsequently, it presents a proposed evaluation framework comprising specialized benchmarks, adaptive standards, and reinforcement learning. The effectiveness of the framework was subsequently scrutinized through availability analysis, ethical adaptability, and generalizability. Finally, the paper concludes with a discussion of the assumptions, boundary conditions, and future work necessary to ensure that the framework remains pertinent as technologies and applications evolve.

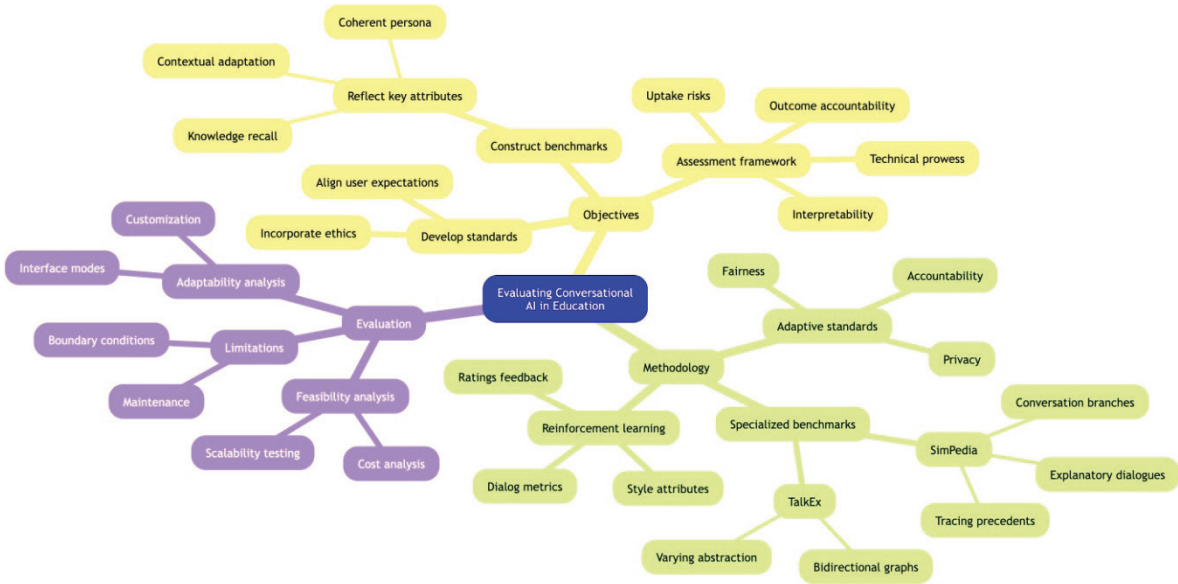


Figure1: Framework for Evaluating Conversational AI in Education

2. Literature Review

The study of large language models has generated significant interest, yet research on their application in education is still in its early stages [1]. Existing studies have investigated the use of conversational AI in limited contexts such as medical education [2][3] and English language learning [5]. However, a comprehensive evaluation framework to assess the capabilities and limitations of ChatGPT-like models in general educational settings is yet to be developed.

Current benchmarks for natural language processing (NLP) primarily focus on technical proficiency in standardized tasks such as translation, summarization, and question answering [6][7]. However, there is a dearth of benchmarks that assess a wide range of critical attributes for conversational AI systems, such as context awareness across long conversations [8], persona consistency [9], ability to handle ambiguity and complexity [10], and bias in generated text [7]. Furthermore, mainstream benchmarks often neglect user-centric metrics, such as perceived coherence, satisfaction, and system misuse risks, which are crucial for evaluating the real-world impact of conversational AI systems.

The importance of ethical considerations, including privacy, transparency, and algorithmic bias, as emphasized by Ahuja [1], has not received sufficient attention in current studies. Moreover, the capacity of systems, such as ChatGPT, to adapt to evolving societal norms and complex user requirements has not been adequately explored. Although various metrics have been proposed for different attributes, such as low perplexity, coherence, and human ratings [11], integrating them into a comprehensive assessment framework would enhance the credibility of the evaluation process.

Advances in the field of benchmarking, standards, and evaluation methodologies specifically designed to address the nuances of conversational AI systems are in their infancy. Existing academic literature has yet to develop comprehensive frameworks for assessing ChatGPT-like models across key parameters of dialogic intelligence, user centricity, ethical alignment, and real-world versatility, which are essential for the reliable integration of these systems into educational settings. This study aimed to bridge these gaps and make a meaningful contribution to the field.

Table1: Review of Literature Evaluating ChatGPT and Conversational AI

Author	Domain/Module	Problem Addressed	Benchmarks Used
Floridi&Chiriatti,2020	Conversational AI	Language generation capabilities	Qualitative analysis
Ahujaetal.,2023	Educational Technologies	Opportunities and challenges	User studies
Wanget al.,2023	NLP	Technical accuracy	Translation/QAdatasets
Ray,2023	Conversational AI	Ethical alignment	Qualitative analysis
Kasnecietal.,2023	AIin Education	Responsible development	User studies
Jietal.,2022	Language Learning	Pedagogical impact	Learning outcomes
Huangetal.,2023	Medical Education	Domain application	Specialized QAdataset
Sobaniaetal.,2023	Text Generation	Output quality	Coherence metrics
Ohmeretal.,2023	Conversational AI	Persona consistency	Human evaluation
Chanetal.,2023	Dialog Systems	Context awareness	Dialog metrics
Heetal.,2023	Fairness in AI	Bias detection	Bias analysis

3. Insights and Considerations for Evaluating Chat GPT

The development of suitable evaluation criteria presents several challenges such as coherence tracking, relevance maintenance, transparency, and responsible constraint handling. To deploy conversational AI systems, such as ChatGPT, in educational contexts, specialized frameworks that go beyond conventional methods are necessary. The unique aspects of conversational AI systems require specialized evaluation protocols, as opposed to the practices commonly used to assess static AI models. The key dimensions must be evaluated before the real-world deployment of these systems. Some of the key dimensions include the following.



Persona Consistency:

The ability to exhibit and maintain a coherent personality is crucial for engaging in natural conversations; however, this is often neglected in the testing of static models. To adequately assess the efficacy of such models, it is necessary to conduct dedicated analyses that focus on the consistency of the personas, opinions, and stances expressed, rather than simply evaluating context-agnostic outputs.

Strengths:

- It provides a means of assessing the uniformity of a tutoring style and pedagogical methods tailored to the learning needs of students.
- It offers a way to measure the capacity to modify feedback strategies for a diverse group of students who require mediation.

Weakness:

- There is a potential for over emphasis on the teaching persona, which could compromise the precision of feedback.
- The process is resource intensive and requires extensive coverage of various student demographics.



Contextual Adaptability

Traditional evaluation methods, which typically employ single-shot queries in isolation, are inadequate for accurately assessing conversational agents' abilities to engage in bidirectional, contextually attuned interactions. It is essential to gauge an agent's capacity for sustained context retention through extended multi-turn exchanges prior to deployment in real-world settings, where seamless discourse flow is paramount.

Strengths:

- Evaluates student-specific response adaptation attuned to gaps
- Coherence tracking ability is vital for logical explanation sequences

Weaknesses:

- Designing cohorts covering multifaceted misconception branches is a challenging task.



Simulation of Naturalness

Static benchmarking using formal corpora alone insufficiently encapsulates the complexity, dialects, vagueness, and realism of free-flowing human conversations that are necessary to avoid dissonance. The use of human-in-the-loop simulations of organic conversations is vital for assessing user comfort.

Strengths:

- Ameliorates student discomfort by facilitating acclimatization
- Adapts responses to optimize motivation and other effectiveness pillars

Weaknesses:

- Computational expense associated with consistent simulations with representative students
- Potential for bias in evaluations during annotation process



Updated Ethical Benchmarks.

The potential for technical testing to disconnect from societal expectations for responsible development is a concern. It is important to evaluate and assess factors such as transparency, fairness, avoidance of exploitation, and unintended consequences regularly. This should involve consultations with a diverse range of stakeholders.

Strengths:

- Encourages openness, which is crucial for ethical treatment of student data
- Integrates diverse educational viewpoints

Weaknesses:

- Assessing the long-term consequences, such as the erosion of opportunities, presents a challenging discrepancy among various perspectives is a complex endeavor.

4. Proposed Evaluation Framework

The proposed architecture consists of six interconnected layers: pedagogical benchmarks, student cohort simulations, multi-turn dialogue coherence tracking, ethical alignment with responsible educational practices, learner-centric evaluations, and iterative engagement optimization protocols. This approach offers a comprehensive methodology for evaluating systems such as ChatGPT across multiple dimensions, such as learning effectiveness, inclusion, trust, and impact on student-teacher experience, prior to real-world deployment.

The framework encourages responsible progress by establishing feedback loops that continuously inform enhancements across aspects of accuracy, relevance, equity, and reliability as perceived by various learning stakeholders. Detailed information about the framework's components and techniques is provided in the subsequent subsections.



Conversational

Intelligence

Benchmarks

The framework for evaluating conversational intelligence in AI-powered educational assistants is enhanced by incorporating specialized benchmarking tasks and datasets that assess crucial aspects of conversational intelligence in the context of multi-turn pedagogical dialogue. These tasks go beyond technical evaluation by examining persona consistency, contextual adaptation, reasoning, and explanation capabilities during iterative question-answering sessions.

For example, SimPedia is a benchmark that includes multi-turn explanatory dialogues on high school science topics with conversation branches based on predicting and resolving student misconceptions. This evaluation measures the ability to sustain a clear tutoring persona, trace precedents to resolve references, and provide logically coherent and relevant elaboration at successive depths tailored to implicit learner cues.

Another benchmark, TalkEx, focuses on the explanatory exchange of concepts between university-level subjects. It features bidirectional dialogue graphs with answers at varying levels of abstraction, branching based on diagnosing gaps, and adapting elucidation accordingly. The associated metrics examine persona consistency, contextual relevance, reasoning clarity, and explanation efficacy over successive dialogue turns.

Specialized benchmarks play a critical role in the framework by providing comprehensive, multifaceted feedback for developing conversational capabilities that align with education-centric user expectations, discourse dynamics, responsibility, and ethical development. By emphasizing core competencies, such as personalization, interpretability, and localized adaptation, these benchmarks offer a rigorous methodology for integrating AI assistants in a manner that enhances teaching and learning processes.



Simulations of Learner Engagement

The framework emphasizes the use of student cohort studies to assess the real-world impact of conversational agents on knowledge gain, motivation, and equitable accessibility. These studies involve simulations that measure metrics, such as comprehension gains, retention over time, perceived cognitive load changes, and equitable access across diverse learner groups during iterative pedagogical interactions.

For example, simulations can be used to create virtual classrooms with student archetypes that exhibit common misconceptions in a subject area. Chatbot interactions spanning easy-to-complex concepts can be used to quantify knowledge gain trajectories using pre- and post-tests, and the success of the chatbot in offloading cognitive load can be measured by tracking the successful explanation rates necessary for escalation to human tutors.

Another protocol evaluated motivation through surveys of self-efficacy, interest, and participation comfort over multiple question-driven sessions. Comparative accessibility was assessed by contrasting impressed metrics

across student archetypes stratified by language proficiency, educational needs, and backgrounds. Overall, human-in-the-loop simulation protocols provide valuable evaluation lenses complementary to static testing, illuminating the strengths and weaknesses when deploying conversational technologies in situations involving sustained learner partnerships.

Insights from these simulations can provide actionable feedback for advancing conversational agents that can effectively team up with young people. By sustaining motivation, comprehension, and inclusion, the framework aims to nurture AI that respects student agency, while expanding learning possibilities.

Tracking Dialogue Effectiveness

This framework aims to evaluate the effectiveness of assistants in educational contexts by tracking the specific qualities of their dialogue. To achieve this, the framework proposes several specialized metrics that quantify the perceived coherence, continuity, relevance, and explanation fidelity during iterative question-answering sessions. These metrics included Long-term Coherence Tracking (LCT), Cumulative Relevance Index (CRI), and Explanation Satisfaction Rating (ESR). LCT traces concepts across multi-turn explanatory sequences using semantic similarity with precedence weighting, whereas CRI gauges tangential deviations by comparing turn embeddings to question phrasings. ESR surveys gather subjective ratings of clarity, completeness, and precision across elucidations. These metrics provide fine-grained, actionable feedback that targets the effectiveness of pillars that directly impact the human experience during assistive conversations. By analyzing discourse dimensions, the framework supplements static testing with insights into maintaining the engagement necessary for impactful educational applications.

Long-term Coherence Tracking(LCT):

The LCT measures the semantic similarity between the current dialogue turn and the previous turns. It uses precedence weighting based on the temporal distance to emphasize more recent continuity. A higher LCT indicates greater continuity in the conversational flow.

$$\text{LCT} = \text{semantic\_similarity}(\text{turn}_t, \text{turn}_{t-k}) \times \text{precedence\_weight}(k) \quad (1)$$

Where:

- turn_t : the current dialogue turn
- turn_{t-k} : the dialogue turn k steps back
- $\text{precedence\_weight}(k)$: assigns weights based on distance

Cumulative Relevance Index(CRI):

CRI quantifies how well the dialogue stays on-topic relative to the original question. This is measured by the aggregate semantic similarity of each turn to the question representation. Higher CRI signals better maintenance of

relevance to the initial inquiry.

$$\text{CRI} = 1 - \sum_i \text{cosine\_distance}(\text{turn\_embedding}_i, \text{question\_embedding}) \quad (2)$$

Where:

- turn_embedding_i : the embedding for dialogue turn i
- $\text{question\_embedding}$: the original question embedding

Explanation Satisfaction Rating(ESR):

ESR provides an aggregate measure of subjective explanation quality based on user ratings. The major dimensions of quality captured are the clarity of the explanation, cost-effectiveness or coverage of the concepts, and precision or exactness of explanations. Each of these can be captured and quantified through user surveys. Appropriate weights allow the configuration of the relative emphasis per quality dimension. A higher ESR indicates a better perceived quality and user satisfaction with the explanations provided during the dialogue.

$$\text{ESR} = \alpha \times \text{clarity\_rating} + \beta \times \text{completeness\_rating} + \gamma \times \text{precision\_rating} \quad (3)$$

Where:

- clarity_rating : Explanation Clarity Score (based on clarity ratings)
- $\text{completeness\_rating}$: Completeness Score (based on completeness ratings)
- precision_rating : Precision Score (based on precision ratings)
- α, β, γ : tunable weights

Ethical Alignment Standards(EAS)

The EAS framework prioritizes responsible integration by adhering to ethical rules and utilizing pedagogical best practices. To accomplish this, the framework establishes flexible criteria that are regularly revised through inclusive procedures including many education participants. These standards include current expectations in areas such as privacy, openness, personalization, fairness, and accountability.

As an illustration, the suggested guidelines require that learning interaction data be stored in an encrypted manner and that protocols be implemented to prevent misuse by means of aggregation and anonymization. The framework also highlights the need for explanation criteria, which necessitate the provision of interpretable audit trails for query responses to maintain transparency. In addition, the methodology addresses algorithmic fairness by reducing biases among different demographic groups, thereby ensuring equal access to services for learners from disadvantaged backgrounds. The requirements also encompass procedures for addressing student-teacher feedback, assuring the presence of human supervision.

The ability to update ethical standards helps increase the acceptance and ongoing relevance of assistive systems. This

fosters trust by maintaining the principles that are of the best interest to the public. The framework uses participatory methods that involve consulting stakeholders to ensure that progress aligns with changing societal expectations. This self-reflective, cooperative approach encourages balance and avoids imposing support methods that are unsuitable for the learning environment.



Learner-Centric Metrics

The suggested paradigm highlights the significance of assessing conversational AI systems in educational settings. In order to achieve this objective, various methods have been devised to assess user happiness, trust, and acceptance. These methods include conducting user studies, administering feedback questionnaires, and observational studies. These methods aim to offer a more detailed comprehension of the system's efficacy by examining responses to subjective inquiries regarding perceived usefulness, satisfaction, trust, and acceptance.

Furthermore, the framework formulates measures to evaluate the efficiency of the system. The Pedagogical Impact Rating (PIR) quantifies the reported improvements in students' motivation, engagement, and comprehension that arise from using the system. The Trust Index (TI) is a statistic that evaluates the overall dependability, data privacy guarantees, and transparency of the system. Furthermore, comparative preference testing was employed to assess the relative performance of various versions of the system, such as voice and text interfaces, by considering their rated efficacy and qualitative feedback.

Incorporating learner-centric criteria is crucial for enhancing the thoroughness and breadth of evaluating conversational AI systems in education. This framework focuses on specific indicators that identify potential obstacles to adoption. It offers practical feedback that can be utilized to enhance the system and optimize its compatibility with young individuals.

$$PIR = \alpha \times MG + \beta \times ER + \gamma \times CG$$

(3)

Where:

MG—Reported motivation gains

ER—Engagement rating

CG—Comprehens

α, β, γ —Weights for each component

$$TI = \delta \times RI + \epsilon \times DP + \zeta \times TR$$

(4)

Where:

RI—Rated reliability index

DP—Data privacy score

TR—Transparency rating

δ, ϵ, ζ —Weights for each component



Iterative Evaluation Protocol

The framework uses active learning and reinforcement techniques to make assistants more conversational, personalized, and effective in delivering content. These techniques are based on the dynamic responses of the learners.



Active learning

Active learning techniques involve interactive questioning to encourage learners to explore topics related to the curriculum. When people participate in co-creative activities, they tap into their natural motivations, making them even more interested and invested in the process. Adaptive questioning protocols help to identify areas where knowledge is lacking and offer suggestions for further learning through additional explanatory materials. Methods such as opt-in annotations are used to acquire labels that can be used to expand personalized question banks, which in turn helps maintain user engagement. In general, active learning helps us adapt to different ways of expressing ourselves, and allows learners to have a say in how they receive help.



Reinforcement Learning

Reinforcement learning techniques are used to adapt to conversational styles. This involves reinforcing coherent, relevant, and logically clear explanations. Feedback signals such as aggregated ratings and dialogue success metrics were used to determine the effectiveness of these explanations. By mapping performance to different levels of style attributes, we can specifically target areas for improvement. This could involve increasing the warmth of a persona to boost motivation or simplify language to enhance comprehension. Bandit-based content ordering is a method that helps determine the best sequence and level of complexity to keep people engaged without overwhelming them mentally. We expand horizontal connections by following learners' interests. Reinforcement learning helps educators to safely try different teaching methods to find the most effective and engaging approaches.

In general, the goal is to encourage users to remain engaged and continuously improve the system to ensure that it remains relevant. This approach helps prevent the system from getting stuck in a limited perspective and considers only one point of view when making updates. By constantly adapting and improving the support that we provide based on the specific needs expressed by individuals, we can ensure that we are always serving the best interests of the public as we move forward.

5. Evaluating Framework Efficacy

Assessing the fitness of conversational AI to enhance teaching learning requires a multifaceted analysis spanning feasibility, adoption, and ethical considerations within school contexts. Evaluating real-world viability warrants the study of scalability for concurrent users, integration with existing tools such as LMSs, and benchmarking across diverse topics.

User acceptance depends on aligning assistants with the styles and needs of students and teachers. Surveys, interviews, and usage analysis inform design choices fostering perceived helpfulness, trust, accessibility, and guiding iteration-matching expectations. Comparisons determine modalities, such as voice vs. text interfaces, that

are better suited to learning scenarios.

Responsible development mandates the preservation of human discretion over curriculum quality and student data privacy, as assistance permeates instructions. Impact is appraised by gaug-Influence on comprehension, motivation, and equitable support accessibility. Oversight procedures combat the risks of student profiling and foster transparency. Convoluting efficacy metrics offers insights to help advance assistants in amplifying learning outcomes without disrupting teaching effectiveness or agency. By emphasizing user centricity, adaptable tools respecting constraints can responsibly expand help availability, benefiting diverse minds Evaluations inform nurturing human-AI symbiosis, improving accessible, personalized, and engaging education.

Feasibility Analysis

Evaluating the feasibility of education necessitates gauging viability across dimensions spanning technical readiness, economic rationale, and integration with institutional operations.

Technical feasibility

Technological feasibility metrics evaluate the readiness of infrastructure and processes to harness benefits while minimizing disruptions. It evaluates the computational requirements for simulation protocols, specialized metrics, and multilayered assessment workflows relative to the available infrastructure. Scalability testing examined the performance of concurrent users across learner cohorts and subjects. Interoperability assessment studies integrate smoothness with existing education tools such as LMSs, student data systems, and administrative software.

Evaluating technical feasibility requires analyzing the computational needs of assessment protocols relative to infrastructure capabilities. Key metrics include:

$$\text{ConcurrencySupport} = \text{Max}(\text{ActiveUsers})$$

(5)

$$\text{Scalability} = \frac{\text{Avg.ResponseLatency}}{\text{IncreasingUsers}}$$

(6)

Concurrency support and simulation lags quantify the load capacities to avoid degraded experiences during scaled evaluations and preparation. A high integration complexity signifies the need for more gradual adoption, allowing smoothing alignments with legacy systems.

Cost Benefit Analysis

Financial justification metrics examine the rationales for institutional commitments by weighing projected improvements in key indicators, such as motivation and personalized support against expenses, such as development, training, and support. Cost scenarios aid optimal targeting of specific learning scenarios forecasted to provide the highest dividends.

Economic feasibility weighs expenses for development and maintenance against projected improvements in metrics, such as

$$\text{ProjectedAdoptionRate} = \frac{\text{Expected Adoption}}{\text{TargetUsers}}$$

Assistance offloading for instructors provides returns on investment quantifying:

(7)

$$\text{Assistance Offload} = \text{Reduction} \left(\frac{\text{Instructor Assistance Time}}{\text{Total Time}} \right) \quad (8)$$

Cost scenarios provide resource commitment rationalization for user groups and use intensities.

Operational Feasibility

Operational preparedness metrics determine areas that require procedural adaptations to accommodate changing roles and reporting needs. New oversight protocols may be needed to preserve transparency, as assistance permeates the instructions. Training and changing management cushions can help prevent abrupt culture shocks.

Analyzing operational feasibility requires investigating policy update needs, alignment with reporting procedures, and gauging workflow reconfigurations through metrics such as

$$\text{WorkflowDisruption} = \text{Changed:Institution:Procedures}$$

(9)

Adaptability Analysis

Education is a highly individualized experience that presents unique challenges and needs at various stages. To accommodate diverse cohorts better; it is essential to incorporate customizable student models, adaptable interface modalities, and multiple explanation modes. Additionally, configurable weightings in composite metrics enable the fine-tuning of evaluations and incentives to drive personalization innovations that align with the articulated needs. In the ever-evolving world of education, it is crucial to have evaluation frameworks that include built-in upgrade pathways to seamlessly integrate emerging advancements without causing disruptions.

Updatable Benchmarks:

As teaching modalities and curriculum content change, new benchmarks are required for reliability. Open participatory design allows the expansion of test case matching developments, such as personalized assessments and smart content. Version control and notification protocols aid in smooth upgrades.

$$\text{Update:Latency} = \text{Time}(\text{New:Version:Release})$$

(10)

A lower latency indicates a more rapid adaptation to the evolving testing needs. As teaching tools and content modernize with technology, reliability necessitates continuously updated benchmarks to evaluate new modalities, such as smart content and personalized assessments. Open participatory design allows the expansion of test-case-matching developments.

Adaptable Standards:

Ethical expectations surrounding learning technologies evolve and mature over time. Participatory amendment pathways must be established to ensure compliance with these standards, considering norms related to equitable accessibility and student data privacy. These pathways must also include provisions for restrictions and consent as risks may arise that necessitate their implementation.

Compliance:Overheads=Resources (Policy:Adaptation)

(11)

Lower overheads imply smoother adaption to changing regulations regarding data privacy, ethical use, etc. Societal expectations of equitable accessibility, transparency, and responsible use mature over time. Updatable policies aligned with emerging concerns foster wider trust and acceptance. Participatory design allows adaptive standards to respect the constraints of learning environments where risks magnify owing to learner vulnerabilities.

Configurable Metrics:

Multifaceted metrics that quantify impact dimensions should modularly reconfigure the relative weightings in composite scores based on contextual priorities. This allows for the tuning of desired outcomes as needs evolve.

Personalization: Latency = Time (Update:

Student:Models)

(12)Lower latency signals responsiveness to evolving learner needs and contexts.

Limitations and Assumptions

While a robust methodology is evaluated through multidimensional protocols, the scope is used to enhance contextual adaptation and reduce evaluative friction before actualizing dividends at scale.

Technological Assimilation

Effective assimilation necessitates calibration of technical interventions in school ecosystems. Factors such as variable LMS landscapes, procurement equitability, onboarding bandwidth, and decentralized control require gradual escalations and balancing evidence gathering with agile implementations to improve fit.

Sociocultural Resonance

Responsible innovation requires understanding learning cultural pain points, co-designing tools resonating with pedagogical styles, and sustaining student-teacher agency. For instance, benchmarking should reward explanatory clarity over terse correctness and incentivize assistants to adopt Socratic approaches to amplify critical thinking.

Global Accessibility:

Equitable progress remains constrained without multilingual, multidialectal, or contextual benchmarking covering representative demographic, geographic, and developmental procurement ranges. Computational constraints necessitate judicious test case prioritization guided by adoption potential and visibility.

Maintenance Sustainability

The framework itself warrants ongoing support for continually expanding standards, upgrading personalized components, and monitoring robustness against gaming. Sustenance through private partnerships risks consumer lock-in, whereas public funding impacts scalability. Hybrid models that balance openness, innovation incentives, and access partnerships merit further exploration.

6. Conclusion

This paper presented a comprehensive evaluation framework comprising specialized benchmarks, adaptive standards alignment, and intelligent assessment techniques for responsible innovation and integration of conversational AI systems, such as ChatGPT, into education.

By critically surveying the limitations of prevailing evaluation practices detached from the nuances of interactive learning scenarios, a multidimensional methodology was proposed that harnesses user-centric simulations, discourse dimension quantifiers, and ethical compliance audits. The feasibility, SWOT analysis, and participatory design principles underpin reliability across core facets spanning technical readiness, adoption risks, and updatability for sustaining relevance during education transformation.

Key contributions include illuminating evaluation gaps for conversational intelligence, outlining real-world performance quantification protocols beyond static testing, and laying innovation pathways that uphold student rights during assimilation of assistive technologies. While the scope remains for enhancing generalization, the framework offers an architecture for accumulating insights guiding responsible progress.

As learning technologies advance, questions about climatization with pedagogical objectives and constraints retain significance in unleashing their potential while minimizing risks. This necessitates continuous collaborative redressal by research communities and stakeholders. The proposed evaluation paradigm signifies the initial steps towards such priority alignments, fostering progress centered on human values of agency, understanding, and upliftment.

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Customer Service Trust and Intention: The Conversational AI Satisfaction View

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Abstract

Nowadays, tasks that are repetitive and boring for humans, or tasks that are too difficult, dangerous, or too delicate and complicated, can be quickly served by robots. Increase productivity through automation, robots, and even a future where robots and humans work together. More and more conversational AI customer service developers are emerging, combining AI and big data to produce conversational AI (CAI), providing 24-hour online customer service for enterprises, providing better service integration, and improving customers' shopping experience. However, improving customers' purchase intentions through CAI is also a significant challenge. Understanding customers' views on CAI can help online CAI customer service developers and e-commerce companies strengthen the content and functions of their CAI. Improve the key factors that can affect customer attitudes and purchase intentions, and provide customers with a complete service experience to increase consumers' purchase intentions. Utilizing the expertise of 157 users, this study adopts a questionnaire survey and statistical analysis. The results show that trust is related to user satisfaction, and use satisfaction influences continued use intention. In theory, trust is an essential factor in the use of CAI. The relationship between cognition and behavior provides customers with good trust. In terms of practical application, improving and strengthening CAI's service quality is necessary to enhance a complete service experience.

Keywords

Conversational AI, satisfaction, trust, chatbot, intent.

Introduction

In human society, repetitive, monotonous, or dangerous fine work can be easily replaced by robots. Conversational artificial intelligence (CAI) can help businesses better understand the relationship between producers and consumers and how to maximize business efficiency [1][2]. The continuous development and application of AI technology have important implications for understanding the factors influencing people's trust level for future technological development and application [3][4]. In the future, it may be a situation where robots and humans work together to improve productivity using automation and robots. Businesses must utilize conversational artificial intelligence better to create value [1][2]. Currently, more and more casual AI customer service developers use AI and big data to develop CAI to provide 24-hour online customer service for enterprises. Businesses can improve customer service, generate leads, and increase sales through conversational artificial intelligence. [5]

[6] identified consumers' perceptions of companies that use service automation as a critical aspect. CAI provides more comprehensive service integration to enhance customers' shopping experience. [5][6] also proposed the role of automation in consumer response in the business environment through fundamental consumer-robot interactions.

CAI can immediately answer common customer inquiries, such as order status or store hours, reducing customer wait times. However, there are issues with standard AI technology, including inaccuracies, weaknesses in logic flow, authenticity/truthfulness, and lack of critical detailed explanations[7]. CAI's human-like similarity and interaction mechanisms affect users' perceptions of CAI features and pleasant quality, affecting user experience [8]. It is essential to design a more effective CAI and provide practical recommendations for improving customer experience [9]. Standing customers' views on CAI can help online casual AI customer service developers

and e-commerce companies strengthen and improve the content and functionality of their CAI, which can impact critical factors of customer attitudes and purchase intent and provide customers with a complete service experience, thereby increasing consumer purchase intent. The application of artificial intelligence CAI in the tourism industry and the impact of CAI's humanized features on customer usage intent [9]. [3][4]. (2021) believe that the humanization of artificial intelligence in the service field affects consumer trust and analyzes factors such as human analogies and intelligence levels. However, most research needs more empirical knowledge to support the impact of CAI interaction design on user experience [8].

This study explores the relationship between service quality, trust, satisfaction, and continued use intentions of CAI in Taiwan. For example, using artificial intelligence tools and robots in the Nigerian market can enhance customer value and experience [10]. Understanding how consumers perceive and interact with service robots and how they affect their attitudes and behaviors toward service automation [5][6]. The human-like characteristics and interaction mechanisms of conversational artificial intelligence can influence users' perceptions of its functions and usage experience, affecting their experience [8]. Using conversational artificial intelligence to purchase goods can increase consumers' intention to use it. Consumers can more effectively inquire about product information and improve processing fluency than employees, increasing their willingness to purchase. However, ethical issues, such as whether robots can replace human work, are also essential and need further exploration [5][6]. Enterprises should improve conversational artificial intelligence to enhance customer satisfaction, reuse intentions, and follow relevant directions and guidelines [11]. The study also explores the influence of CAI characteristics on customer satisfaction and reuse intentions and the moderating effect of pleasure and utilitarian motivation on this relationship [11]. This can further investigate visitors' "service trust" and "satisfaction with the service" of CAI and compare the key factors influencing consumer attitudes and purchase intentions.

Literature Review

Although CAI still cannot perform like humans, it can display personality and humor, giving users an illusion of interaction and attributing human-like functions to non-existent CAI. Service automation is using robots or other automation technologies to provide customer service. Perceived intelligence is the consumer's perception of

the intelligence level of the robot. Anthropomorphism is whether the robot has human-like characteristics and behavior. Trust is the consumer's trust in the company and the robot. Comfort is the consumer's comfort level when interacting with the robot. Attitude is the consumer's overall attitude towards service automation, including preferences and dislikes [5][6].

If companies interact with customers through CAI, it can help improve customer satisfaction and loyalty in service quality. CAI can handle unlimited support requests, which can shorten wait times and increase customer satisfaction. The humanization feature of CAI is defined as the human-like behavior and language displayed by CAI. Customer usage intention is the willingness and tendency of customers to use CAI. Social presence is CAI's behavior that is similar to real human interaction. Emotional information is CAI's dynamic or expressive language [9].

With conversation and interaction mechanisms, CAI can create a social presence and engage users in conversation. Thus, this type of CAI may be more positively perceived. For example, insights into customer attitudes, behavioral intentions, satisfaction, and value toward service robots can be considered [12]. [8] believe that CAI's type of conversation and interaction mechanism will affect users' perception of casual AI features and pleasure quality.

How CAI communicates with customers can significantly impact their perception of it. Factors such as dialogue type, interface type, identity, conversation data, and social presence can all shape users' attitudes and behaviors toward CAI. The application of artificial empathy in AI marketing agents can affect customer experience and enterprise value [13]. Button interactions can enhance CAI's human-like and social presence [8]. CAI's hedonic and utilitarian aspects, such as benefits and values, can influence consumers' views of CAI. The human-like, social presence, practical quality, and hedonic quality of CAI all have a positive relationship with user experience [8]. Integrating artificial empathy can increase customers' trust and satisfaction with AI marketing agents [13].

CAI can automatically support common customer questions, reducing costs without additional human support. [8] provide practical recommendations for improving CAI interaction design to enhance user experience by examining how dialogue type and interaction mechanisms affect users' experiences. However, CAI may be unable to solve complex customer problems and has some limitations. Furthermore, CAI lacks the complexity and empathy of talking to someone in real life. Therefore, it is necessary to address the issues

with CAI in customer service and provide methods and recommendations for improving CAI interaction design [8]. Solutions include improving the efficiency of CAI, enhancing customers' willingness to use it, and their intention to reuse it [11]. Companies can measure the success of their CAI implementation through metrics such as engagement rates, total interactions, new interactions, or KPIs. The features and perceived hedonic quality of CAI can affect user experience [8] By tracking these indicators and KPIs, companies can measure the success of their CAI implementation and make improvements as needed. Therefore, improving CAI service and support is necessary to enhance customer experience and satisfaction [9].

CAI can immediately answer common customer questions, such as order status or store operating hours, reducing customer wait times in queues. However, generated CAI technology may have issues with accuracy, logic flow, truthfulness, and lack of critical detailed explanations[7]. CAI's human-like similarity and interaction mechanism can affect users' perception of CAI features and pleasant quality, thus impacting the user experience [8]. It is essential to provide practical advice on designing more effective CAI and improving customer experience [9]. Enhancing customers' purchase intent through CAI is also a significant challenge. Understanding customers' views on CAI can help online CAI customer service developers and e-commerce companies strengthen and improve their CAI's content and functionality, which can affect critical factors in customer attitude and purchase intent and provide customers with a more comprehensive service experience to increase their purchase intent. The application of artificial intelligence CAI in the tourism industry and the impact of CAI's human-like features on customer usage intent [9]. [3][4] believe that the humanization of artificial intelligence in the service field affects consumer trust and analyzes factors such as human analogy and intelligence. However, most studies lack empirical evidence to support the impact of CAI interaction design on the user experience [8]

H1: Trust inCAI positively relates to continued use intention.

As artificial intelligence becomes more human-like, the customer's tendency to use AI will depend on various factors such as service type, level of automation, quality of AI, and customer preferences. Customer satisfaction has a direct impact on the willingness to reuse CAI. The higher the overall satisfaction with CAI, the greater the desire to use it again [11]. Although AI can provide benefits such as faster turnover and simple answers,

concerns about incorrect information and loss of decision control may make some customers prefer human customer service. Motivational pleasure and utilitarian motivation moderate the relationship between CAI features, customer satisfaction, and reuse intention [11]. For example, when motivational pleasure increases, the relationship between CAI features and customer reuse intention is more closely related [11]. When utilitarian motivation increases, the relationship between CAI features and customer satisfaction and reuse intention is more closely related [11].

H2: Used satisfaction for CAI is a positive mediated relation between Trust inCAI and Continued used intention.

Methods

Utilizing the expertise of 157 users using a survey and statistical analysis. Trust in CAI has five items [14], such as “the system is deceptive,” “I am wary of the system,” “I am confident in the system,” “The system is dependable,” and “I can trust the system.” Used satisfaction for conversational AI has three items [15] such as “I am satisfied with conversational AI,” “I am satisfied with my understanding of conversational AI,” and “I am satisfied to continue with your conversational AI.” The continueduse intention has four items [16] such as “I will continue to use conversational AI in the future,” “I have been using conversational AI in daily life,” “I will use conversational AI as frequently as now,” “I will return to use conversational AI rather than others.”

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Table 1 –Study mode verification results

	Continued used intention		
Trust in CAI	8.64***		2.19
Used satisfaction for CAI		11.55***	10.13***
D-W	1.93	2.17	2.24
R ²	20.6%	28.1%	30.7%
F	27.42***	34.43***	40.62***

Figure 1Research structure.

Results

Baron & Kenny (1986) verified this study's results. See Table 1. Step one is that the independent variable significantly correlates with the strain number. Therefore, the assumption is established that trust in CAI positively and significantly correlates with continued use intention. Step two determines whether the mediation variable substantially correlates with the strain number. Therefore,

used satisfaction for CAI positively and significantly correlates with Continued used intention, and hypothesis 2 is established. Step 3 is that the independent variable correlates significantly with the corresponding mediation variable. Therefore, used satisfaction for CAI will positively affect the relationship between trust in CAI and Continued used intention, and the hypothesis is established.

Discussion

Compared to human customer service, consumers' views of CAI depend on the nature of the task. AI's degree of humanity and intelligence positively impacts consumers when they lack evidence to support it, making them more likely to trust AI that resembles humans [3][4]. CAI is the preferred choice for simple tasks, but human agents are still necessary for more complex tasks that require personal interaction. Consumers are more likely to trust AI products or services with enough control [3][4]. Customer satisfaction positively impacts customers' intention to reuse [5][6].

However, CAI increases customer trust in the company when it becomes more human-like. Contextual factors affect consumers' trust in AI [3][4]. People tend to trust CAI with sensitive information and are willing to accept their suggestions. Consumers are more likely to trust AI when they are familiar and predictable with the results obtained from interacting with it [3][4]. Robots' perceptual intelligence and anthropomorphism will affect their trust and comfort level [5][6].

However, some customers prefer to interact with human agents, so deploying CAI should be cautiously approached to avoid customer frustration and reduced trust. In the business environment, consumers react more negatively to the widespread use of service robots, which could hurt the companies that employ them [5][6]. AI is designed as a tool to reliably perform services rather than simply pursuing humanity and intelligence [3][4].

The application of artificial intelligence in marketing is quite essential [10]. Companies use CAI to improve the customer experience by analyzing customer preferences and providing products or services that are suitable for them. AI technology can improve marketing strategies and customer experiences [10]. By dealing with common customer queries through CAI, the burden on support teams can be reduced, productivity can be increased, and costs can be lowered. Consumer reactions to service automation are influenced by various factors, including the degree of robot intelligence and anthropomorphism

and the way and extent to which the company uses service automation technology [5][6].

CAI can provide personalized experiences for potential customers, interact with customers 24/7, answer their questions, and be cost-effective, simultaneously handling multiple conversations, thereby reducing the need for additional staff. Companies and service providers can better understand consumers' reactions to service automation and provide solutions to improve their responses [5][6]. Therefore, CAI can increase customer engagement and generate tailor-made experiences for potential customers. [11] have researched the relationship between CAI features, customer satisfaction, and reuse intentions. AI technology will face many challenges and marketing limitations [10].

Conclusion

CAI can efficiently and effectively provide quick and valuable responses to customer queries, improve overall customer experience, and increase sales potential. Artificial intelligence technology can improve marketing strategies and customer experience but may face challenges and limitations [10]. For example, considering factors such as security, privacy protection, cost-effectiveness, and customer satisfaction, the features and functions of CAI that best meet Thailand's healthcare institutions' needs can be identified [18]. By using CAI, businesses can reduce the need for human agents and increase efficiency to save company funds. The relationship between the features of CAI, customer satisfaction, and reuse intentions is meaningful [11]. Businesses can also use the customer data and feedback collected through CAI to provide valuable insights to improve products and services and increase sales. By further understanding the user requirements of CAI, companies can optimize CAI design, increase customer satisfaction and reuse intentions [11].

Recommendation

This study has a relatively small sample size and may only represent part of the population. The scope of the study is narrow, only involving the role users play, without an in-depth exploration of the impact of other factors. The research method is mainly a questionnaire survey, which has a particular subjectivity and bias. The explanation of some concepts and theoretical models needs to be more explicit, which may cause difficulties for readers to understand [1][2]. For example, some factors still need to be considered in the differences in the reaction of

some service automation [5][6]. Even the content of in-depth exploration of CAI technology is relatively scarce. This study only explored the impact of CAI features on customer satisfaction and intent to reuse from users' perspectives [11].

In future research directions, the design of CAI will significantly impact the user experience [12]. [9] pointed out that customers with different cultural backgrounds and industries significantly affect the intention to use and satisfaction with CAI. Enterprises can establish more attractive, pleasant, and effective CAI through voice, personality, and visual design to achieve their goals. At the same time [13], [5][6] proposed that improving consumers' reactions to service automation can improve the way and degree of using service automation technology by enhancing the degree of robot and personification. Integrating CAI with other customer service channels can also help provide a seamless experience for users [15]. [9] there are complex interactions between various factors in CAI design, so it is necessary to improve the effectiveness and efficiency of simple AI design.[8] believe that informal AI's dialogue type and interaction mechanism affect the user experience and propose improving CAI's interaction design to enhance the user experience. By identifying goals and channels, using existing systems to use CAI for self-service, integrating with ticketing systems, and providing a consistent experience [16], enterprises can create more efficient and effective customer service experiences [17]. For example, [5][6] explored the impact of service automation on enterprises and service providers and how to maximize the use of service automation technology to improve enterprise efficiency and customer satisfaction. Therefore, continual usage intention of microblogging is also vital [18]. CAI will be more important in considering organizational issues [19].

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Analyzing the Effect of Trust in Reviews on Trust in a Product and a Company: Using the Trust Transfer Theory

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Abstract

The purpose of this study is to investigate the influence of trust in reviews. four characteristics of reviews, namely expertise, enjoyment, recency, and usefulness are set as independent variables, and trust in reviews is set as the mediating variable. Trust in products and trust in companies are set as the dependent variables, and based on the theory of trust transfer, the flow of trust is to be analyzed. The research results showed that the trust in reviews is transferred to trust in a company through trust in a product. From a practical perspective, the importance of reviews was confirmed. Also, it was found that the category or characteristics of a product could potentially influence the formation of trust in reviews.

Keywords

Online-Review, Characteristics of Review, Trust, Trust Transfer Theory

Introduction

Word-of-mouth (WOM) refers to the exchange of opinions regarding specific products or experiences between individuals (Westbrook, 1987). With the advent and advancement of the internet, WOM has transformed into online word-of-mouth (e-WOM), which signifies the communication of product information on the online platform (Gelb & Johnson, 1995). This transformation has brought about changes in consumer behavior. Consumers, when making purchasing decisions, seek online consumer reviews to gather essential information about products (Zhu & Xiaoquan, 2010), and they rely on such reviews as references before making a purchase (Chevalier and Mayzlin, 2006). Technological progress has facilitated the emergence of a new form of product purchasing, wherein consumers assess and share product information online (Avery et al., 1999).

Due to the significance of reviews in influencing consumer purchases, they have become a crucial resource for consumer marketing and corporate activities (Mayzlin et al., 2014; Chevalier & Mayzlin, 2006). Successful consumer marketing strategies utilizing reviews, pioneered by Amazon (New York Times, 2004), have been adopted by various online platforms such as internet retailers and search engine sites (Chen and Zie, 2008;

Lantz, 2019). Unlike recommendation systems managed by companies, reviews are generated based on consumer experiences (Jabr and Zheng, 2014), making them valuable for establishing customer trust in products offered by businesses (Nielsen Online Global Consumer Study, 2009) and potentially influencing product purchases.

The influence of reviews on consumers has been the subject of various studies examining the relationship between reviews and consumers. Research has been conducted from diverse perspectives, such as analyzing the relationship between product evaluations and consumers' purchase intentions and payments (Sridhar & Srinivasan, 2012; Cheung and Thadani, 2012), investigating how reviews assist consumers' purchase decision-making process on specific websites (Mudambi & Schuff, 2010), exploring the effects of reviews on product and consumer characteristics and purchase intentions (Zhu & Xiaoquan, 2010), and studying fake reviews (Luca and Zervas, 2015).

Because consumers' trust in reviews was formed, consumers' purchases were made with reference to reviews. (Li et al., 2006; Quershi et al., 2009). Consumers strive to reduce risks through relationships with trusted third parties (Mayer et al., 1995), and online reviews serve as a means of communication or a source of trust-building

with these third parties. This trust is considered a crucial factor and strategy that can even influence consumers' repurchasing behavior (Flavian et al., 2006; Gefen, 2002). Consequently, the trust formed through reviews is highly important, which is regarded as a manageable aspect from a corporate perspective.

Research on reviews has predominantly focused on whether they impact product or service purchases. Studies on the credibility of reviews have also been actively conducted. However, there is a need for research investigating the process by which trust in reviews transitions. Thus, this study aims to analyze how trust in reviews influences trust in products and companies through a particular flow. In this study, the Trust Transfer Theory (hereafter TTT) is adopted as the background theory to analyze the flow of trust. TTT refers to the cognitive process in which trust in one specific entity can be transferred to other related entities (Stewart, 2003). That is, TTT is a valuable theory for understanding the essence of trust. This theory has been predominantly applied and utilized in e-commerce and mobile commerce contexts (Cheng et al., 2019; Lu et al., 2010). However, the aim of our research is to investigate whether the trust formed through reviews can be transferred to the trust in related products and companies based on the prior studies that demonstrated the transfer of trust between related entities such as companies and their employees (Doney and Cannon, 1997).

In this study, the five key characteristics of reviews, namely expertise, empathy, recency, and usefulness are set as independent variables, while the trust in reviews is set as the mediating variable. The dependent variables are set as trust in products and trust in companies. The research questions for this study are as follows:

Q1: Which factors of reviews influence the formation of trust?

Q2: Does the trust formed through reviews transfer to trust in products and companies?

Theoretical Background

Characteristics of reviews

As the importance of online reviews has increased, various forms of review platforms have emerged. Yelp.com is a platform where users can share reviews of various restaurants, while STEAM has grown as a platform for consumers to write reviews about games they have played. These online reviews, also known as Electronic Word of Mouth (e-WOM), differ from traditional face-to-face communication in that they occur on the internet, where consumers share information and experiences about products (Schindler & Bickart, 2002). The e-WOM differs from traditional word-of-mouth in terms of speed,

convenience, and the number of people reached (Sun et al., 2006; Cantallos & Salvi, 2014).

The significance of online reviews lies in the fact that these are not information conveyed by companies but rather information generated and transmitted directly by consumers who have used the product or service. As a result, other consumers perceive such information to be highly trustworthy and relevant (Bickart, 2002; Harrison-Walker, 2001). In other words, online reviews serve as a channel for consumers to obtain objective information when they cannot directly examine the product (Dabholkar, 2006).

Online reviews have more purpose than merely disseminating information. They can also provide enjoyment in the process of information exploration for consumers (Mathwick & Ridgon, 2004) and facilitate extended engagement on review platforms (Kumar & Benbasat, 2006). According to a survey conducted in Korea in 2017, 87 percent of consumers check reviews when making online purchases and approve of the reviews' significance and necessity. (TrendMonitor, 2017). Previous research results suggest that online reviews play various roles. From a business perspective, reviews also hold significant importance due to their substantial impact on various aspects of corporate activities. They play a crucial role in formulating detailed marketing strategies, enhancing customer interactions and loyalty, and facilitating communication with the target market (Cantallos & Salvi, 2014). Therefore, reviews are significant in the realm of corporate activities. The unique online environment accentuates the importance of online reviews (Elliott, 2002).

Online reviews can generally be categorized into positive and negative reviews (Sparks & Browning, 2011). Positive reviews share favorable experiences and recommendations with potential consumers, while negative reviews discourage potential consumers from making purchases based on unfavorable experiences (Hu et al., 2009; Litwin et al., 2008; Mauri & Minazzi, 2013). Some studies have shown that information contained in negative reviews is perceived as more valuable and helpful to potential consumers due to its rarity and unpredictability (Yin, Bond & Zhang, 2014). Therefore, review management is essential in business (Lee & Yang, 2015) because reviews can impact not only product or company image but trust (Mauri & Minazzi, 2013). Online reviews have evolved beyond being a form of word-of-mouth and can influence both product and company trust.

Trust Transfer Theory (TTT)

Trust has been extensively studied and discussed in various academic fields, including management, as one of the fundamental factors influencing human interactions (Gambetta, 1988; Rousseau et al., 1998; Oh and Cho, 2016). It is defined as a psychological state that

involves accepting risks based on positive expectations or behaviors, and as a belief that others will not engage in malicious actions (Eddleston et al., 2012; Dyer, 2012; Robinson, 1996).

Trust tends to shift from well-known targets to unfamiliar ones (Uzzi, 1996), and in the online context, this characteristic of trust can even facilitate purchase decisions (Quelch & Klein, 1996). This process of trust transfer, based on persuasion theory, can influence consumer behavior in online marketing (Funkhouser, 1984; Milliman & Fugate, 1988; Stewart, 2003). Due to these traits of trust, trust transfer is considered an important and long-term issue in online marketing (Keen, 1997). Trust transfer can be observed in both online and offline contexts. For example, higher trust in courier services can lead to increased trust in the online sites where orders are placed, which can influence customer satisfaction through the online word-of-mouth effect (Sirdeshmukh et al., 2002). The formation of trust in the online context is attributed to the existence of multiple communities where evaluations are conducted (Bakos & Dellarocas, 2002).

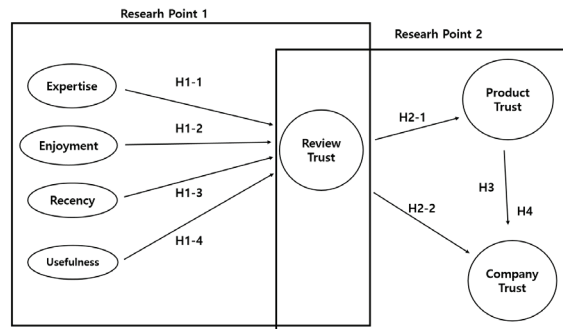
Research on trust transfer in the online context has been conducted in various topics. The earlier studies focused on inter-organizational trust transfer through web pages of two online platforms (Stewart, 2003), and dominated online purchases (Fang et al., 2014). Previous studies have explored diverse topics, including the impact of reviewer characteristics on consumers' positive behavioral intentions (Xu, 2014), the formation of trust relationships between platforms (McKnight et al., 1998), and the trust formation and transfer processes in shared accommodation platform companies (Gutiérrez et al., 2017). Several studies have demonstrated the essential and significant nature of trust formation and transfer in the process of online transactions transitioning to offline products and services, concerning consumers' perceptions of products and companies (Ert et al., 2016; Zamani et al., 2019). Trust, which is an effective and indispensable factor in enhancing long-term relationships between businesses and consumers (Agag & El-Masry, 2016), plays a crucial role.

In this study, we utilize the trust transfer theory to investigate the process by which trust in reviews transfers to trust in products and companies. We set reviews as the starting point for trust formation and measured the trust in reviews through their characteristics. Using that, this study elucidates the aforementioned trust transfer process.

Research Methodology

To answer the research questions of this study, the analysis was conducted using the research model. The independent variables are set as the expertise, enjoyment, timeliness, and usefulness of the review to explore their impact on the formation of review trust. Also, product and corporate trust are set as mediating and dependent

variables, respectively, to investigate whether the trust in reviews is transferred. Research Point 1 is a point to find the answer to research question 1, and Research Point 2 is an analysis path to explore the process of trust transfer in reviews, which is one of the core questions of this study. In this study, the analysis was conducted using the SPSS 21 and Amos 21 programs. The study participants consisted of Chinese consumers who had recently made purchases based on reviews. The survey was distributed and collected both online and offline. The questionnaire was structured with a Likert 5-point scale (1 for 'Not at all' ~ 5 for 'Very much so').



<Figure 1. Research Model>

Hypothesis Development

Expertise in Reviews

Expertise refers to the ability of an information provider to objectively evaluate the characteristics or performance of a product (McGuire, 1968). In the past, expertise was measured using factors such as specialized knowledge, experience, and qualifications related to the information source (Ohanian, 1990). However, in recent online review research, reviewer expertise has been analyzed by measuring factors such as the number of followers, rankings, and social status within a specific site (Yin et al., 2014; Cheng & Ho, 2015; Craciun & Moore, 2019).

If there are characteristics within online reviews that indicate reviewer expertise, consumers can easily recognize and find more useful reviews (Mackiewicz, 2010). Moreover, as these characteristics increase, reviewers can gain more trust from consumers (Banerjee et al., 2017; Willemsen et al., 2011). Indeed, reviewer expertise has been found to directly influence the trust in reviews (Willemsen et al., 2011).

In this study, expertise is defined based on McGuire's (1968) definition as the ability of experienced consumers to provide valid evaluations of product characteristics or performance. Building on prior research, we hypothesize the following relationship between reviewer expertise and trust in reviews:

H1-1: Reviewer expertise will be positively associated with trust in reviews.

Enjoyment in Reviews

Enjoyment can be defined as a pleasurable characteristic that meets the information satisfaction needs of users on the Internet (Hwang, 2010). Enjoyment itself is an immediate experience felt by consumers and is also defined as high satisfaction (Webster and Martocchio, 1992). Enjoyment is mainly dealt with as an important variable among the characteristics of information that online reviews have (Haley, 1996; Elliot, 2002; Shindler and Bickart, 2002). In previous studies, the enjoyment of reviews was shown to affect the trust of the information provided by the review (Eom, 2013). That is, the trust in the information in the review means that the consumer trusts the review, and it can be seen that there is a causal relationship.

In this study, the enjoyment of the review was defined as a pleasurable characteristic that meets the information satisfaction needs (Hwang, 2010). The hypothesis setting to see the relationship between the enjoyment of the review and the trust of the review is as follows.

H1-2: Enjoyment in review will be positively associated with trust in reviews.

Recency in Reviews

Considering the fundamental purpose of websites as information dissemination platforms, the presence of up-to-date and high-quality information can lead to positive user attitudes toward websites (DeLone & McLean, 1992; Tandon et al., 2020). The recency of information provided online is one of the crucial indicators for consumers to judge whether it is useful (Madu, 2002). In fact, consumers tend to assess businesses based on the recency of reviews rather than their quantity, with reviews older than three months being considered irrelevant to product-related information (BrightLocal, 2019).

When making decisions, consumers tend to focus more on the most recent information than outdated information (Xie et al., 2016). In other words, through reviews containing the latest information, consumers make purchase decisions for products (Wulff et al., 2015). The location of links within a website has been found to be a significant factor influencing consumers' clicking behavior, with links placed at the top of a page being more likely to be clicked by users (Murphy et al., 2006; Ansari & Mela, 2003). Therefore, the most recent reviews can instill the trust in consumers and influence their purchase decisions for products or services.

In this study, the recency of reviews is defined as the most recent experiences written by consumers that are associated with the post-date of the review (Tandon et al., 2020; Xie et al., 2016). Based on this, the following hypothesis is formulated:

H1-3: Recency in review will be positively associated with trust in reviews.

Usefulness in Review

Review usefulness refers to the perception of consumers that online reviews written by others will be beneficial and helpful to them (Schuckert et al., 2015). The usefulness of reviews is largely influenced by the characteristics of both the product and the review itself (Mudambi & Schuff, 2010). Factors such as the review's rating and length can have an impact, and the usefulness may vary depending on whether the product is an experiential or search good (Liu & Park, 2015).

The significance of review usefulness lies in its role as a criterion for potential consumers to judge the quality of reviews, ultimately influencing their behaviors (Filieri et al., 2018; Li et al., 2019; Salehan & Kim, 2016; Zhao et al., 2019). Some researchers argue that review usefulness represents the most efficient characteristic among a plethora of review information, enabling consumers to save time and effort (Filieri et al., 2018). In other words, higher review usefulness can induce product purchases or certain behaviors, and this process can be interpreted as part of the trust-building process.

In this study, review usefulness is defined as the perception that reviews are beneficial and helpful to consumers (Schuckert et al., 2015). Based on previous research, the following hypothesis is formulated:

H1-4: Usefulness in review will be positively associated with trust in reviews.

Trust in Reviews and Trust in a Product and a Company

Trust in reviews on online platforms is of great importance as consumers base their product and service purchases on these reviews, even though they do not represent direct transactions between providers and buyers (Cheung et al., 2012). Considering that the trust in online reviews is influenced by the reviewers and objectivity, rather than by the platform or content type (Banerjee et al., 2017), it can be explained that online reviews with higher consumer involvement are more trustworthy compared to less involved reviews (Reyes-Menende et al., 2019). In other words, trusting reviews (Oliveira et al., 2017) imply that they play a significant role in consumer decision-making for product and service purchases (Shan, 2016).

In this study, we consider trust in online reviews as an important factor and hypothesize that it will mediate the relationship between the characteristics of reviews and reliability in products and companies. The hypotheses are as follows:

H2-1: Trust in reviews will be positively associated with trust in a product.

H2-2: Trust in reviews will be positively associated with trust in a company.

H3: Trust in a product will be positively associated with trust in a company

H4: Trust in a product will mediate the relationship between trust in reviews and trust in a company.

<Table 1. Measurement Items and Quotation>

Variable		Item	Quotation
Expertise	Exp1	The information provided by the online reviews on the product purchase site was professional..	Ohanian(1990), Kim (2008), Yoon (2019)
	Exp2	The information provided by the online reviews on the product purchase site was special.	
	Exp3	The information provided by the online reviews on the product purchase site contained professional explanations necessary for purchase.	
	Exp4	The information provided by the online reviews on the product purchase site included many technical terms about the product.	
Enjoyment	Enj1	The content of the reviews on the product purchase site was interesting.	Davis et Al (1992), De Wulf & Rangarajan (2006)
	Enj2	The review information on the product purchase site provided an interesting experience.	
	Enj3	The review information on the product purchase site made me happy.	
Recency	Rec1	The review information on the product purchase site is continuously updated.	Mckinny et al. (2002), DeLone & McLean(2003),
	Rec2	The review information on the product purchase site contains the latest information about the product and the company.	
	Rec3	The reviews on the product purchase site provide information about the latest trends related to the product.	
	Rec4	The reviews on the product purchase site quickly provide appropriate information according to user requirements.	
Usefulness	Use1	The review information on the product purchase site is worth reading.	Schindler & Bickart(2002), Kim et al(2010), Yi, S.(2012)
	Use2	The reviews on the product purchase site accurately provide information about the value of the product.	
	Use3	The review information on the product purchase site is beneficial.	
	Use4	The review information on the product purchase site helps to understand the product or service.	
Trust in Review	Rtrust1	I trust the reviews provided by the product purchase site.	Filieri & McLeay(2013)
	Rtrust2	The reviews provided by the product purchase site are truthful.	
	Rtrust3	I have faith in the reviews provided by the product purchase site..	
	Rtrust4	The reviews provided by the product purchase site are helpful to me.	
Trust in Product	Ptrust1	The product mentioned in the review possesses fairness.	Kim (2018), Kim (2014), Kang (2015), Han (2015)
	Ptrust2	I gain trust as I get to know the product mentioned in the review well.	
	Ptrust3	The quality of the product mentioned in the review is trustworthy.	
	Ptrust4	I have confidence in the product mentioned in the review.	
Trust in Company	Ctrust1	I believe that the company mentioned in the review is an honest company.	Ko (2012), Park (2011), Kim & Cho (2011), Kim & Kwon (2011)
	Ctrust2	The products and services of the company mentioned in the review can be trusted.	
	Ctrust3	The company mentioned in the review is keeping a promise with the customer.	
	Ctrust4	The company mentioned in the review can be trusted socially.	

Research Results

Demographic Characteristics

A total of 302 respondents participated in this study. Among the respondents, 81 were male and 221 were female, with a majority of female participants. In terms of age distribution, the largest group consisted of individuals aged 20 to 25, 164 respondents, while there were also 74 respondents aged 40 above. A significant portion of the participants had made purchases of household goods and food products, with the primary platform used being Taobao. Detailed demographic characteristics are presented in Table 2.

<Table 2. Demographic Characteristics of Survey Respondents >

Category		Frequency	%
Gender	Male	81	26.8
	Female	221	73.2
Age	20 - 25	164	54.3
	26 - 30	44	14.6
	31 - 35	16	5.3
	36 - 40	4	1.3
	Over 40	74	24.5
Education	Graduated High School	44	14.6
	Enrollment in University	60	19.9
	Graduated University	91	30.1
	Enrollment in Graduated University	76	25.2
	Graduated from Graduate School	31	10.3
Category in Product	Food	60	19.9
	Electronics	37	12.3
	Cosmetics	44	14.6
	Household Goods	123	40.7
	Etc	38	12.6
Purchased Site	Coupang	32	10.6
	Naver	3	1.0
	Taobao	213	70.5
	Pinduoduo	30	9.9
	SSG / Kurly / Olive Young	4	1.3
	Etc	20	6.6

Results

Before the research analysis, it was found that there was a gender difference among the respondents, and it was checked whether there was a difference according to gender. A t-test analysis was conducted by dividing the gender into two groups. The analysis results showed that there was no difference according to gender in the remaining variables except for corporate trust (Table 3).

<Table 3. T-test Analysis Results According to Gender >

Variable	Gender	N	Mean / S.D.	t-value	P
Expertise	Male	81	3.28 / .90	-.443	.658
	Female	221	3.32 / .74		
Enjoyment	Male	81	3.58 / .75	.011	.991
	Female	221	.358 / .74		
Recency	Male	81	3.50 / .76	-1.937	.054
	Female	221	3.68 / .67		
Usefulness	Male	81	3.79 / .79	-1.017	.310
	Female	221	3.89 / .69		
Trust in Review	Male	81	3.22 / .81	-1.208	.228
	Female	221	3.34 / .73		
Trust in Product	Male	81	3.32 / .82	-1.565	.119
	Female	221	3.47 / .70		
Trust in Company	Male	81	3.25 / .81	-2.634	.009**
	Female	221	3.51 / .72		
**p < .01					

Correlation, Mean and Standard Deviation Result

The correlation analysis among variables along with the mean and standard deviation analysis are as follows. For the means, values ranged from 3.3045 to 3.8598, while for the standard deviations, values ranged from 0.7014 to 0.7913. The correlation analysis revealed significant correlations among all included variables, with a notable strong correlation observed between product trust and company trust variables (Table 4).

<Table 4. Correlation, Mean and Standard Deviation Result>

Variable	M	SD	Exp	Enj	Rec	Use	Review	Product	Company
Exp	3.3091	0.7913	1						
Enj	3.5795	0.7412	.471**	1					
Rec	3.6316	0.7014	.546**	.631**	1				
Use	3.8598	0.7208	.438**	.633**	.667**	1			
Review	3.3046	0.7544	.565**	.602**	.595**	.605**	1		
Product	3.4272	0.7362	.566**	.608**	.656**	.585**	.760**	1	
Company	3.4404	0.7555	.569**	.538**	.643**	.566**	.749**	.852**	1

**p < .01

Exploratory Factor Analysis and Reliability Result

The results of the exploratory factor analysis are presented in Table 5 and 6. To facilitate factor analysis, the variables were distinguished and analyzed twice. The four independent variables showed a total of 13 items (excluding Exp2 and Use2, which fell below the standard) that were suitable for raising the standard. The trust in reviews and the trust in products and companies were analyzed for a total of 11 items (excluding Ptruſt4, which fell below the standard).

<Table 5. Exploratory Factor Analysis and Reliability Result (Independent Variables)>

Variable	Item					Cronbach α	Explained Total Variance (%)
		1	2	3	4		
Expertise	exp1	.739				.817	74.631
	exp3	.831					
	exp4	.829					
Enjoyment	eny1		.828			.816	
	enj2		.688				
	enj3		.720				
Recency	rec1			.598		.845	
	rec2			.757			
	rec3			.787			
	rec4			.709			
Usefulness	use1				.709	.862	
	use3				.855		
	use4				.794		

Kaiser-Mayer-Olkin: .923,

Battlett's chi-squared: 2060.567, df: 120, sig: .000

<Table 6. Exploratory Factor Analysis and Reliability Result (Dependent and Mediating Variables)>

Variable	Item				Cronbach α	Explained Total Variance (%)
		1	2	3		
Trust in Review	rtuſt1	.768			.900	81.478
	rtuſt2	.825				
	rtuſt3	.798				
Trust in Product	ptruſt1		.746		.909	
	ptruſt2		.791			
	ptruſt3		.653			
	ptruſt4		.590			
Trust in Com- pany	ctruſt1			.717	.927	
	ctruſt2			.760		
	ctruſt3			.775		
	ctruſt4			.780		

Exploratory Factor Analysis and Reliability Result

A confirmatory factor analysis was conducted using the AMOS program based on the results of the exploratory factor analysis. Absolute fit indices and incremental fit indices, among others, were used to evaluate the model's fit. The construct reliability and the average variance extracted (AVE) values were derived to measure internal consistency. The results of the model fit are as follows: CMIN: 496.864, DF: 231, p: .000, CMIN/DF: 2.151, RMR: .030, RMSEA: .062, GFI: .876, PGFI: .674, NFI: .915, IFI: .953, TLI: .943, CFI: .952. Overall, values that meet the criteria were derived, and there appeared to be no major problems with the model fit for the research. The construct reliability (> 0.7) and AVE values (> 0.5) showed that all values meet the criteria (Table 7).

<Table 7. Confirmatory Factor Analysis Results >

Variable	Item	Non-Standardization Coefficient / Standardization Coefficient	C.R.	p-value	AVE	Construct Reliability
Expertise	exp1	1.000 / 0.788	-		0.6369	0.8399
	exp3	1.080 / 0.798	13.257	***		
	exp4	1.041 / 0.737	12.368	***		
Enjoyment	enj1	1.000 / 0.687	-		0.6686	0.8573
	enj2	1.258 / 0.851	12.589	***		
	enj3	1.175 / 0.778	11.825	***		
Recency	rec1	1.000 / 0.675	-		0.6616	0.8861
	rec2	1.261 / 0.812	12.261	***		
	rec3	1.109 / 0.748	11.449	***		
	rec4	1.208 / 0.810	12.236	***		
Usefulness	use1	1.000 / 0.806	-		0.7624	0.9085
	use3	0.974 / 0.803	15.110	***		
	use4	1.010 / 0.864	16.409	***		
Trust in Review	rtust1	1.000 / 0.859	-		0.8149	0.9296
	rtust2	1.041 / 0.868	19.413	***		
	rtust3	1.054 / 0.871	19.516	***		
Trust in Product	ptrust1	1.000 / 0.846	-		0.7856	0.9361
	ptrust2	0.981 / 0.812	17.414	***		
	ptrust3	1.074 / 0.867	19.418	***		
	ptrust4	1.074 / 0.867	19.050	***		
Trust in Company	ctrust1	1.000 / 0.827	-		0.8233	0.9490
	ctrust2	0.997 / 0.870	18.990	***		
	ctrust3	1.031 / 0.900	19.978	***		
	ctrust4	1.060 / 0.900	19.986	***		

Hypothesis Testing Results

The results of the hypothesis tests H1-1~H1-4, H2-1~H2-2, H3 are as follows. The result of verifying the impact of the expertise of online reviews on review trust showed that the path coefficient (Estimate) was .327 ($t=4.389$, $p<0.01$), which was significant. As the expertise increases, users' trust in online reviews increases, and among the three variables, expertise had the greatest impact on the formation of review trust. The result of verifying the impact of the enjoyment of online reviews on online review trust showed that the path coefficient (Estimate) was .350 ($t=3.092$, $p<0.05$), which was significant. It can be interpreted that if consumers feel that the content of the review is enjoyable for themselves, positive emotions influence the formation of review trust. The result of verifying the impact of the timeliness of online reviews on review trust showed that the path coefficient (Estimate) was .090 ($t=.702$, $p>0.05$), which was not significant, so the hypothesis was rejected. The result of verifying the impact of the usefulness of online reviews on review trust showed that the path coefficient was .229 ($t\text{-value}=2.316$, $p<0.05$), which was significant. In other words, it was analyzed that if one judges that the content of the review they have checked can be usefully utilized for themselves, trust in the review is formed.

Hypothesis H2-1, which states that online review trust has a positive impact on product trust, showed that the path coefficient was .566 ($t\text{-value}=7.655$, $p\text{-value}<0.01$), which was significant. Considering the environment where reviews are frequently used as reference materials before purchasing a product, this is an analysis result that can confirm the importance of reviews. Hypothesis H2-2, which states that product trust has a positive impact on corporate trust, showed that the path coefficient was .825 ($t\text{-value}=8.462$, $p<0.01$), which was significant. In other words, it can be confirmed that trusting a product translates into trust in the company that manufactures or provides the product. However, the result of verifying the impact of review trust on corporate trust showed that the path coefficient was .146 ($t\text{-value}=1.760$, $p>0.05$), which was not significant. The detailed results of the hypothesis tests are as follows (Table 8).

<Table 8. Analysis Results of Hypothesis (H1-1 ~ H1-4, H2-1 ~ H2-2, H3) >

Path Analysis	Estimate	S.E.	C.R.	P	Result	
Rtrust <- Exp	.327	.074	4.389	.000**	H1-1	Accepted
Rtrust <- Enj	.350	.113	3.092	.002**	H1-2	Accepted
Rtrust <- Rec	.090	.128	.702	.483	H1-3	Rejected
Rtrust <- Use	.229	.099	2.316	.021**	H1-4	Accepted
Ptrust <- Rtrust	.566	.074	7.655	.000**	H2-1	Accepted
Ctrust <- Rtrust	.146	.083	1.760	.078	H2-2	Rejected
Ctrust <- Ptrust	.825	.097	8.462	.000**	H3	Accepted

The bootstrap method was used to verify the mediation effect (Bootstrap = 1,000 / Percentile Confidence Intervals = 95 / Bias-corrected Confidence Intervals = 95 set), and the significance of the mediation effect is determined by checking whether '0' is included in the given confidence interval (Lee, 2014). If '0' is not included in the confidence interval, it is considered significant at the $p < .05$ (or .01) level (Lee, 2014). The results of the mediation effect hypothesis (H4) are as follows (Table 9).

<Table 9. Analysis Results of Hypothesis (H4) >

Path Analysis (Total Effects)						Estimate	S. E.	95% CI		P	Results
								Lower	Upper		
H4	Ctrust	<-	Ptrust	<-	Rtrust	.596	.101	.422	.826	.002	Accepted

Path Analysis (Direct Effects)						Estimate	S. E.	95% CI		P	Results
								Lower	Upper		
H4	Ctrust	<-	Ptrust	<-	Rtrust	.142	.116	-.130	.340	.213	-

Path Analysis (Indirect Effects)						Estimate	S. E.	95% CI		P	Results
								Lower	Upper		
H4	Ctrust	<-	Ptrust	<-	Rtrust	.454	.124	.290	.768	.002	-

Conclusion

This study aimed to examine the factors influencing trust in reviews, trust in a product and trust in a company, based on the characteristics of online reviews, targeting Chinese consumers who have experienced products online. Also, using the Trust Transfer Theory (TTT), we verified the relationship between trust in review, trust in a product, and trust in a company. The main results of this study are as follows.

First, among the characteristics of online reviews, expertise, enjoyment, and usefulness had a positive impact on trust in review. It was found that if professional terms and knowledge are included in reviews, or if potential consumers feel joy while reading reviews, consumers form trust in reviews. Also, if they judge that the review contains information necessary for purchasing a product or service, consumers are also likely to trust the review. However, recency did not affect trust in review. This result is contrary to many previous studies, and it was found that respondents who responded to the survey value the content more than the time the review was written. Considering that the product that the respondent mainly purchased is daily necessities or food, it is judged that the category of the product to be purchased has affected the result. In other words, categories with less product change and high purchase frequency are likely to be less affected by the time of writing than products that change over a certain period of time, such as electronic devices and clothes.

Second, looking at the relationship between trust in reviews and trust in a product and a company, it was found that trust in review has a positive impact on trust in product and trust in product has a positive impact on trust in a company. The result that the trust in reviews affects trust in a product is consistent with the research results of standard previous studies, and in the research of Zhang & Fu (2019), it was found that trust formed online in the game market has a significant impact on consumer trust formation for major sellers. In the research of Belanche et al., (2014), it was found that user trust in public administration formed offline plays an important role in promoting trust in electronic services. Similarly, the result that trust in a product affects trust in a company is also the same as previous research. In the research of Sirdeshmukh et al (2002), it was found that as trust in courier service increases, trust in the online site where orders are made increases,

which is consistent with the research result of this study that trust in a product affects trust in a company. The result of this study showed that trust in review did not directly affect trust in a company, but it had a full-mediation effect through trust in a product. This confirmed statistically the phenomenon that online trust in reviews is transferred to trust in a company through trust in a product. It was confirmed that the trust formed in online reviews is transferred to trust in a product. Therefore, from a corporate perspective, because online reviews affect the company, a strategic approach is needed to enhance the trust in reviews that consumers feel.

Implication and Limitation

This study has the following practical implications for companies selling products and services using online reviews. As shown in the research results, when online reviews on online shopping platforms are professionally described, funnily expressed, and include the latest information with real-time characteristics, consumers can ultimately increase their trust in the company mentioned in the review. The transfer of trust was statistically confirmed to ultimately affect the trust of the company. These results suggest that companies need to manage online reviews and explain their importance. Therefore, companies need to develop and provide products in the direction consumers want by understanding consumer reactions through online reviews, not only the quality and diversity of products. Especially, online reviews with enjoyment have a strong impact on corporate trust, so companies should pay more attention to how to satisfy this characteristic and manage it well.

The limitations and future research of this study are as follows. First, this study confirmed the significance of how the trust of online reviews is transferred using quantitative methodology. Due to the limitations of the methodology, it did not analyze how and why trust is transferred, but future research on this question is expected to be needed. Also, the recency of online reviews, a characteristic of online reviews, did not affect review trust but did affect product trust. No specific analysis has been made on how this influence crosses layers, and a more in-depth analysis of this is needed. Second, the respondents who participated in this study showed a concentration phenomenon in specific genders, ages, and product categories. For the generalization of the results, it is judged that analysis of various genders, ages, and product categories reflecting the limitations of this study is needed. In this study, most of the respondents were women, so a t-test was conducted, but if it is considered that gender can still affect the response results, future research reflecting this limitation is needed. Therefore, in future research, it is necessary to balance gender by participating in similar responses for men and women, analyze separately according to gender, and compare differences. Also, this study did not

classify age and the category of purchased goods, but if future research reflecting this area is conducted for the generalization of the results of this study, meaningful results are expected to be derived.

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Using the DEMATEL Method to Exploring The Key Factors of Using the Interactive Intelligent Health Promotion Equipment

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Abstract

This study explores the considerations and key factors of the public in using interactive intelligent health promotion equipment. The DEMATEL method is employed to understand the correlation and relative importance among various decision criteria, serving as a foundation for future promotion of interactive intelligent health promotion equipment. This aims to enhance the willingness for recreational sports, improve physical fitness, and reduce healthcare resources. The study identifies eight main factors: economic traits, personality traits, communication behavior, relative advantage, compatibility, complexity, observability, social support, and peer relationships. The direct and indirect impact of each factor is analyzed, along with the calculation of key indicators for each factor. The results indicate that, for individuals with exercise habits, personality traits and the relative advantage of the product are crucial factors influencing whether they use interactive intelligent health promotion equipment. Within personality traits, comfort is identified as the most influential criterion, leaning towards impacting other criteria. In the relative advantage criterion, personalization is identified as the most influential sub-criterion, leaning towards impacting other criteria..

Keywords

DEMATEL, Interactive Intelligent Health Promotion Equipment, Key Factors

Introduction

The global sports technology market has a total size of approximately \$872 billion, with wearable devices, high-intensity interval training, group training programs, weight training, personal trainers, sports medicine, weight management, elderly exercise, health management, and professional coaching courses becoming trends in the fitness industry [1]. Especially since the end of 2019, the world has been facing the COVID-19 pandemic, affecting outdoor activities and leisure sports centers globally for nearly three years. Approximately 30,000 campus and corporate sports competitions, routine professional baseball games, international competitions, major sports events, and over 7,000 sports businesses in our country have been affected by domestic and international epidemic control decisions [2]. The pandemic has fundamentally changed people's lifestyles, with home exercise and fitness becoming a new trend in daily life. Interactive intelligent health promotion equipment, with its unrestricted operation in terms of time and space, as well as being unaffected by weather and venue limitations, has seen a significant increase in people's willingness to engage in sports[3].

It can serve as a tool to promote recreational exercise at home. The application of high-tech motion sensors and wireless transmission systems in interactive intelligent health promotion equipment realizes virtual reality and human-computer interaction modes, achieving both fitness and entertainment effects [4]. This demonstrates the developmental potential of using interactive intelligent sensor gaming equipment in addressing issues related to promoting public health. Whether interactive intelligent health promotion equipment can be successfully applied in the field of sports depends on user acceptance. This study aims to explore the criteria and key factors that influence the public's use of interactive intelligent health promotion equipment, serving as insights into the continued use of such equipment for sports activities and the intention to seek a healthier lifestyle in the future.

Literature Review

Decision-Making Models

In the context of business activities, making correct

decisions is crucial, as decisions made without adequate knowledge and methods may lead to a decrease in business performance and an inability to maximize profits [5]. For consumers, the plethora of choices in the market for sports and fitness products, coupled with the inundation of information from the internet, advertisements, news, etc., increases the complexity of decision-making [6]. Thus, understanding consumer needs is a crucial step in addressing consumer issues, as consumers seek to solve life problems through the purchase of goods or services [7]. Before people decide to purchase or use a new product or service, they go through five stages: Awareness, Interest, Evaluation, Trial, and Adoption, collectively known as the AIETA model. This model signifies that individuals become aware of a product or service, develop an interest, evaluate it based on relevant attributes and criteria, try it out, and, if satisfied, become users [8].

Multi-Criteria Decision-Making

Decision criteria are essential factors considered in decision-making. Consumers, when evaluating decisions, are influenced by individual differences and the environment, leading them to use different evaluative criteria in consumer decision-making [7]. The complex world, multiple standards, data complexity, and the environment make decision problems challenging. Therefore, adopting decision-making techniques and methods is crucial. Multi-Criteria Decision-Making (MCDM) possesses excellent evaluation capabilities, integrating objective survey data and expert subjective judgment in complex environments. Through small-sample expert interviews, MCDM can provide effective information to help decision-makers formulate optimal strategies [9]. MCDM has been widely applied to various evaluation and selection problems, assisting in solving decision problems like classification, ranking, and selection [10]. Its scientific and standardized decision-making process has been widely recognized, offering advantages such as problem identification and understanding, quantitative data collection, analysis using appropriate scientific models, constructing alternative solutions, serving as the basis for objective decision-making, and providing references for decision-makers [5].

DEMATEL Analysis Method

The Decision Making Trial and Evaluation Laboratory (DEMATEL) is a multi-criteria decision analysis method widely used to structure complex problems and analyze the complex relationships between various management issues [11]. DEMATEL can concretize decision problems, its primary feature being the elucidation of relationships between dimensions and factors. Through analyzing the results, effective relationships between key factors/dimensions can be obtained to help decision-

makers identify feasible solutions [12]. DEMATEL uses graphical representation to illustrate the cause-and-effect relationships among criteria in the problem. This visual representation helps identify the core of the decision problem, understand the impact and correlation between each criterion, and establish a systemic model structure. The method's computational basis relies on matrix correlation mathematical theory, quantifying the interdependence relationships and degrees between criteria, effectively simplifying decision problems [13]. From the structured model of DEMATEL, decision-makers can categorize evaluation criteria into dispatching factors (factors influencing other factors) and receiving factors (factors being influenced). Further insights into the strength of relationships between factors can be gained, assisting decision-makers in formulating strategies based on the results [11]. DEMATEL has been confirmed by numerous studies to be effective in solving complex cause-and-effect structure problems. Due to the increasing complexity of the social environment, more scholars are involved in related research, widely applying DEMATEL in various fields to analyze and evaluate multi-criteria decision problems.

Research Method

Research Design

This study employs a quantitative questionnaire survey to collect data. The questionnaire for the first stage of DEMATEL is designed based on factors influencing consumers' pre-decision knowledge and persuasion stages in Rogers' [14] Innovation Diffusion Model. Additionally, it incorporates Holak's [15] New Product Adoption Model, with "Consumer Characteristics," "Product Innovation Traits," and "Environmental Variables" as the main framework.

The first stage DEMATEL questionnaire structure is divided into two major parts: socio-economic background and decision factors. The first part covers respondent demographics, including gender, age, education level, occupation, weekly fixed exercise frequency, and monthly average spending on sports-related expenses. The second part assesses the decision-making factors related to the use of interactive intelligent health promotion equipment. It includes variables such as economic traits, personality traits, communication behavior, relative advantage, compatibility, complexity, observability, social support, and peer relationships. There are a total of 36 questions across eight variables, as shown in Table 1. The questionnaire utilizes a paired comparison scale design following the DEMATEL approach and a scoring scale based on Shieh et al.'s [16] research, categorizing the degree of influence between criteria into four levels: 0 - No influence, 1 - Low influence, 2 - Medium influence, and 3 - High influence. Positive and negative signs represent the direction of influence.

Study Participants

This study targets individuals with fixed exercise or fitness habits who have experienced or purchased home fitness equipment. The questionnaire was distributed online, and the instructions provided definitions and examples of the terms used in the decision criteria to help respondents understand the questionnaire format and purpose. A total of 80 questionnaires were distributed for the DEMATEL study, with 12 invalid responses excluded, resulting in 68 valid responses and an 85% response rate.

Descriptive Statistics Analysis is applied to encode and organize the collected data, utilizing the EXCEL software for data analysis. Frequency distribution and percentage analysis are conducted for the sample distribution of personal background data to obtain the mean and standard deviation for each research variable.

Table 1: Framework and Questionnaire Content

Dimension	Criteria	Subcriteria	References
Consumer Characteristics	Economic Traits	1. Money cost	Bettman[17]
		2. Time cost	
		3. Information gathering cost	
		4. Physical effort cost	
		5. Psychological effort cost	
	Personality Traits	6. Optimism	Parasuraman[18]
		7. Innovativeness	
		8. Comfort	
		9. Safety	
	Communication Behavior	10. Advertising content	Park, Joworski and MachInnis[19]; Hsieh and Yu[20]
		11. Social word-of-mouth	
		12. Trial experience	
		13. Product website	
		14. Endorsements	
Product Innovation Traits	Relative Advantage	15. Brand	Hoffer and Alexander[21]; Liu et al.[22]; Lee et al.[23]
		16. Convenience	
		17. Personalization	
		18. Interactivity	
		19. Variety of choices	
	Compatibility	20. System compatibility	Hoffer and Alexander[21]; Liu et al.[22]; Lee et al.[23]
		21. Habits	
		22. Application scope	
		23. Sensor operation	
	Complexity	24. Installation steps	Lee et al.[23]
		25. Operation interface	
		26. Operating rules	
		27. Goal difficulty	
	Observability	28. Functional communication	Liao and Shiu[24]
		29. Usage effects	
		30. Product performance	
		31. Entertainment	
		32. Health management tools	
Environmental Variables	Social Support and Peer Relationships	33. Support from family and friends	Schiffman and Kanuk[25]
		34. Evaluation by family and friends	
		35. Actual use by family and friends	
		36. Social activities with family and friends	

Calculation of DEMATEL Analysis

The following explains the calculation method of the Decision Making Trial and Evaluation Laboratory (DEMATEL) method. DEMATEL, through the mutual relationships between pairs of criteria, observes the degree of influence among them. The underlying calculation method is based on matrix correlation mathematical theory, used to calculate the cause-and-effect relationships and structural strength between different criteria. This effectively simplifies the complexity of the real social environment, providing improvement directions for criteria with causal relationships or interdependencies. Ultimately, it identifies effective key criteria for improving or resolving related issues. The calculation steps are as follows [16]:

(1) Establishing pair-wise comparison scale

Based on the results of the literature review, pair-wise comparison questionnaires for the main decision criteria and their sub-criteria are designed for DEMATEL. The questionnaire begins by explaining the terminology and providing examples for each decision criterion to help respondents understand the questionnaire's filling method and purpose. The main content involves the pairwise comparison of the interactions between main and sub-criteria.

(2) Establishing direct-relation matrix

Using the arithmetic mean to integrate expert opinions to determine the mutual influence between criteria, a direct-relation matrix is established based on this result. Assuming there are n evaluation criteria, a direct-relation matrix A of dimensions $n \times n$ is obtained as per Formula (1), where a_{ij} represents the degree to which criterion i influences criterion j , resulting in the direct-relation matrix A .

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

(3) Calculating Normalized Direct-Relation Matrix

The direct-relation matrix is normalized by multiplying matrix A by s , resulting in the normalized matrix X , as shown in Formulas (2) and (3):

$$X = s \times A \quad (2)$$

$$s = \frac{1}{\max_{1 \leq i \leq n} \sum_j a_{ij}} \quad (3)$$

(4) Attaining the Total-Relationship Matrix

After obtaining the normalized direct-relation matrix X , the total-relationship matrix T is obtained using Formula

(4), where I is the identity matrix.

$$T = X(I - X)^{-1} \quad (4)$$

(5) Calculating Prominence and Relation

t_{ij} represents an element in the total-relationship matrix T . Formula (5) is used to sum the elements in the rows of the total-relationship matrix to obtain D_i , and Formula (6) is used to sum the elements in the columns to obtain R_j .

$$D = D_i = \sum_{j=1}^n t_{ij} \quad \text{for } i=1, 2, \dots, n$$

(5)

$$R_j = R_j = \sum_{i=1}^n t_{ij} \quad \text{for } j=1, 2, \dots, n \quad (6)$$

Where D_i represents the total sum of elements for which element i is the cause, including both direct and indirect influences, and R_j represents the total sum of elements for which element j is the result. When $i = j$, the sum of the row and column ($D_i + R_j$) represents the total extent to which element i influences and is influenced, known as prominence. On the other hand, the difference between the column and row ($D_i - R_j$) is used to classify the criteria into cause group or effect group. If the result of ($D_i - R_j$) for a particular element is positive, it belongs to the cause group. Conversely, if the result is negative, the element belongs to the effect group.

(6) Establishing Causal Diagram

Using $D+R$ as the horizontal axis and $D-R$ as the vertical axis, mark the coordinates with the obtained ($D_i + R_j$) and ($D_i - R_j$). To emphasize significant causal relationships, values in the total-relationship matrix (T) are deleted if they are smaller than the arithmetic mean, serving as a threshold value. Elements greater than the threshold value are selected to draw the causal diagram, as shown in Figure 1. Drawing the causal diagram simplifies complex causal relationships graphically, assisting decision-makers in selecting appropriate decision solutions based on criteria classification.

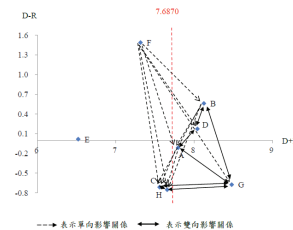


Figure 1. The DEMATEL Map (Machado et al., [26])

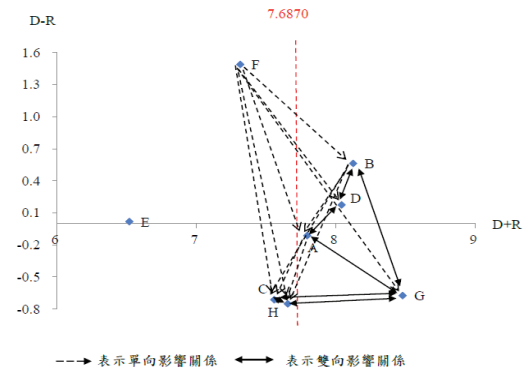
Research Results

Description of Background Variables

The effective sample of this study's questionnaire includes 68 individuals with exercise habits. The personal background variables of the sample are categorized into six items: gender, age, education level, occupation, the number of fixed exercise sessions per week, and the monthly average expenditure on exercise-related expenses. The analysis results are as follows: There are 52 females (76.47%) and 16 males (23.53%). The age is predominantly concentrated in the 31-40 age group, with the highest ratio of 32 individuals, accounting for 47.06%. The next highest is the 21-30 age group, with 24 individuals, accounting for 35.29%. The occupation is mostly in the military or public service, with 16 individuals, accounting for 47.06%, followed by 16 individuals in the manufacturing industry, accounting for 23.53%. The education level is mostly at the university level, with 36 individuals, accounting for 52.94%, followed by 28 individuals with postgraduate education or above, accounting for 41.18%. The number of fixed exercise sessions per week is highest in the 1-2 times category, with 32 individuals, accounting for 52.94%, followed by 3-4 times, with 28 individuals, accounting for 41.18%. The monthly average expenditure on exercise-related expenses is highest in the category of 500 yuan or less, with 24 individuals, accounting for 35.29%, followed by 1000-1999 yuan, with 12 individuals, accounting for 17.65%.

Description of Background Variables

To explore the causal relationships among the decision factors for using interactive smart health promotion equipment, the opinions on the mutual influence relationships among the eight main criteria were analyzed based on the DEMATEL calculation steps. The results of the total relationship matrix analysis for the eight main criteria are shown in Table 2. The threshold value was calculated by taking the arithmetic average of all the relationship values in the total relationship matrix, and it is 0.4804. By setting the threshold value, relationships with lower influence levels among criteria were omitted. Only relationships significantly affecting the decision problem were retained. The mutual influence relationships among the eight main criteria are organized in Figure 2. From the analysis results, it is evident that personality traits and relative advantages are core factors, compatibility and complexity are driving factors, communication behavior and social support with peer relationships are independent factors, and economic traits and observability are influenced factors.



Unidirectional influence relationship ;

Bidirectional influence relationship

Figure 2. Causal Relationship Chart of the Eight Major Criteria

Results of Sub-Criteria Analysis

Each of the eight sub-criteria underwent a total-relationship matrix analysis, and relationships with lower impact among the criteria were omitted based on the threshold value to focus only on significant influences on decision-making. The mutual influence relationships for each sub-criterion are illustrated in Figures 3 to 10. The results were used to identify causal relationships among the factors of each sub-criterion, and the importance and classification of sub-criteria are presented in Table 3.

From the analysis results, in the Economic Traits sub-criterion, the threshold value was determined to be 2.0650, with an average $D+R$ value of 20.6498. Money cost and information collection cost were identified as factors inclined to influence other criteria, while time cost, physical effort cost, and psychological effort cost were factors inclined to be influenced by other factors. In terms of importance, physical effort cost was identified as the most crucial sub-criterion, followed by time cost, psychological effort cost, and money cost, with information collection cost being the least important item. In the Personality Traits sub-criterion, the threshold value was determined to be 9.7093, with an average $D+R$ value of 77.6743. Comfort and safety were identified as factors inclined to influence other criteria, while optimism and innovation were factors inclined to be influenced by other factors. In terms of importance, comfort was identified as the most crucial sub-criterion, followed by optimism and safety, with innovation being the least important item.

In the Communication Behavior sub-criterion, the threshold value was determined to be 1.9698, with an average $D+R$ value of 19.6980. Advertising content, product website, and endorser were identified as factors inclined to influence other criteria, while social word of mouth and trial experience were factors inclined to be influenced by other factors. In terms of importance, advertising content was identified as the most crucial sub-

criterion, followed by social word of mouth, endorser, and trial experience, with the product website being the least important item.

In the Relative Advantages sub-criterion, the threshold value was determined to be 2.2960, with an average $D+R$ value of 22.9600. Brand, convenience, and personalization were identified as factors inclined to influence other criteria, while interactivity and diversity of choice were factors inclined to be influenced by other factors. In terms of importance, personalization was identified as the most crucial sub-criterion, followed by diversity of choice, convenience, and interactivity, with the brand being the least important item.

In the Compatibility sub-criterion, the threshold value was determined to be 3.8337, with an average $D+R$ value of 30.6697. System compatibility and habit were identified as factors inclined to influence other criteria, while application scope and sensorial operation were factors inclined to be influenced by other factors. In terms of importance, system compatibility was identified as the most crucial sub-criterion, followed by habit and sensorial operation, with application scope being the least important item.

In the Complexity sub-criterion, the threshold value was determined to be 3.3873, with an average $D+R$ value of 27.0986. Installation steps and operational rules were identified as factors inclined to influence other criteria, while operational interface and goal difficulty were factors inclined to be influenced by other factors. In terms of importance, operational interface was identified as the most crucial sub-criterion, followed by operational rules and installation steps, with goal difficulty being the least important item.

Table 2. Total Impact Relationship Matrix of Eight Main Criteria

criteria	A	B	C	D	E	F	G	H
A.Economic Traits	0.3904	0.4772	0.5192*	0.5267*	0.4189	0.3721	0.5817*	0.5558*
B.Personality Traits	0.5787*	0.4304	0.6123*	0.5668*	0.4590	0.4221	0.6553*	0.6198*
C.Communication Behavior	0.4403	0.4632	0.3709	0.4700	0.3591	0.3003	0.5166*	0.5032*
D.Relative Advantage	0.5537*	0.5090*	0.5764*	0.4185	0.4612	0.4092	0.6144*	0.5670*
E.Compatibility	0.4448	0.4085	0.4316	0.4439	0.2732	0.3502	0.4753	0.4416
F.Complexity	0.5594*	0.5479*	0.5852*	0.5596*	0.4803	0.4485	0.6299*	0.5917*
G.Observability	0.5357*	0.4925*	0.5304*	0.5075*	0.4341	0.2809	0.5764*	0.5464*
H.Social Support and Peer Relationships	0.4509	0.4526	0.5094*	0.4403	0.3650	0.3293	0.5279*	0.3777

***Reached the threshold value of 0.4804**

In the Observability sub-criterion, the threshold value was determined to be 2.0088, with an average $D+R$ value of 20.884. User effectiveness, product performance, and health management tools were identified as factors inclined to influence other criteria, while functional communicativity and entertainment were factors inclined to be influenced by other factors. In terms of importance, user effectiveness was identified as the most crucial sub-criterion, followed by product performance, health management tools, and functional communicativity, with entertainment being the least important item.

In the Social Support and Peer Relationships sub-criterion, the threshold value was determined to be 6.8543, with an average $D+R$ value of 54.8345. Friend and family support and actual usage by friends and family were identified as factors inclined to influence other criteria, while friend and family evaluations and social activities with friends and family were factors inclined to be influenced by other factors. In terms of importance, actual usage by friends and family was identified as the most crucial sub-criterion, followed by friend and family support and social activities with friends and family, with friend and family evaluations being the least important item.

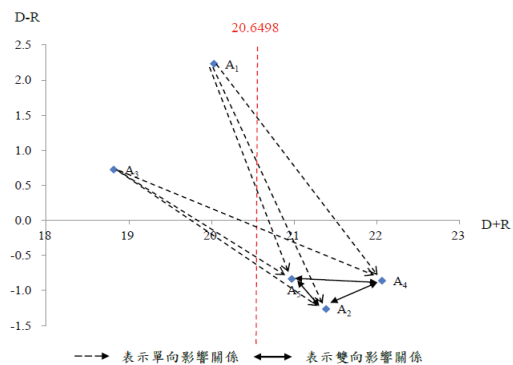


Figure 3. Causal Diagram of the Economic Traits Sub-criteria

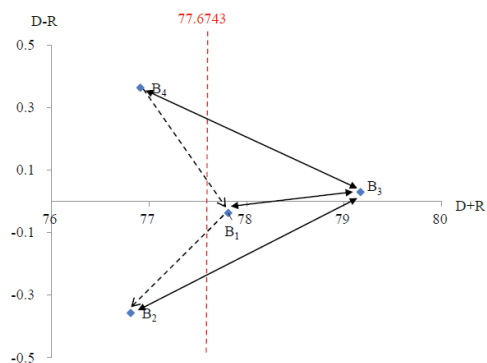


Figure 4. Causal Diagram of the Personality Traits Sub-criteria

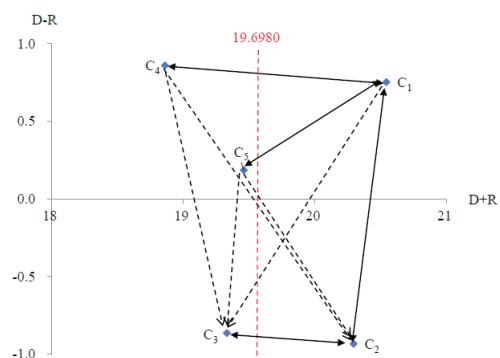


Figure 5. Causal Diagram of the Communication Behavior Sub-criteria

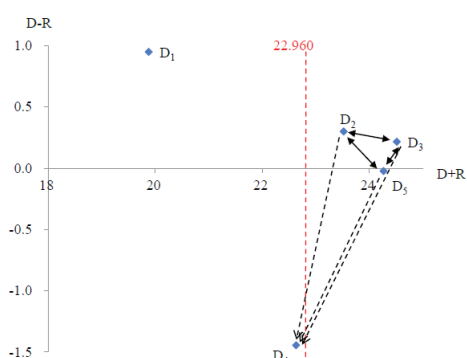


Figure 6. Causal Diagram of the Relative Advantage Sub-criteria

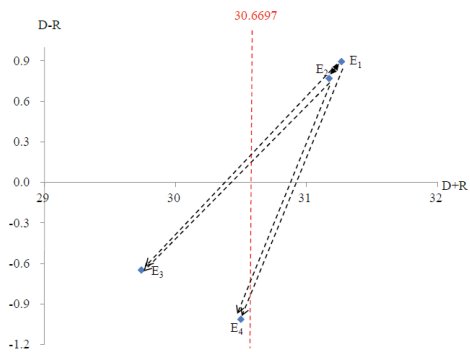


Figure 7. Causal Diagram of the Compatibility Sub-criteria

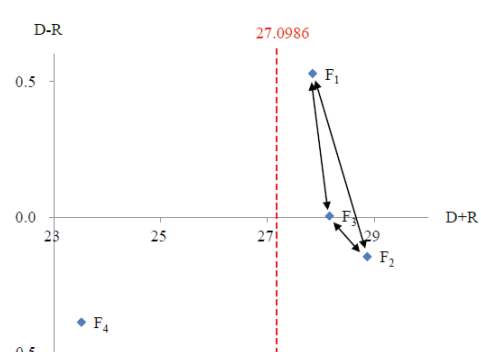


Figure 8. Causal Diagram of the Complexity Sub-criteria

Conclusion

In recent years, newly developed interactive smart health promotion equipment, integrating internet functionality and interactive displays, allows individuals to experience fitness programs at home in real-time. This study aims to explore the considerations and key factors influencing the use of interactive smart health promotion equipment by the public. Through the DEMATEL method, the study seeks to understand the interrelationships and relative importance of various decision criteria. This information serves as a foundation for future promotions of interactive smart health promotion equipment, enhancing the willingness for leisure sports, improving physical fitness, and reducing healthcare resource utilization.

The DEMATEL research results reveal that, for individuals with exercise habits, personality traits and relative advantages are the primary core factors. Compatibility and complexity act as driving factors, while economic traits and observability are influenced factors. Communication behavior and social support with peer relationships are identified as independent factors. This indicates that an individual's personality traits and the product's relative advantages are crucial factors influencing the use of interactive smart health promotion equipment. Past research has also shown that personality traits are stable characteristics less affected by time and environment, and individuals with innovative traits are more likely to adopt new technological products[27]. On the other hand, when individuals perceive higher relative advantages of innovative products, it increases their willingness to use the product [28]. Within the personality traits criteria, comfort is the most influential factor, emphasizing the importance of ensuring that the equipment provides a comfortable experience for individuals with exercise needs.

Economic costs and personality traits were found to be key considerations for consumers in adopting interactive smart health promotion equipment, with time costs and comfort being crucial sub-criteria. Therefore, businesses should emphasize the ease of use and effectiveness of using such equipment, alleviating consumers' concerns about spending additional time or effort to understand the equipment or achieve fitness goals. Additionally, companies can highlight the comfort of the equipment and the anticipated positive effects after use, addressing concerns about the effectiveness of home exercise. Previous research has confirmed the effectiveness of interactive smart health promotion equipment in various rehabilitation and health promotion fields, making consumer acceptance a key factor. Businesses should understand the critical considerations of users and provide corresponding planning to ensure that individuals interested in home exercise can achieve effective fitness results.

Facing the increasing trend of aging populations and the rise in the prevalence of chronic diseases related to lifestyle,

there is a need for more attention and improvement in non-communicable diseases and age-related degenerative diseases. Interactive smart health promotion equipment operates without time and space limitations, unaffected by weather and venue restrictions, and can be used individually. It can serve as a tool to promote leisure sports at home for people, addressing the limitations of time and resources. Given limited resources, service providers of interactive smart health promotion equipment should strategically invest in improving their strengths in decision factors that consumers genuinely care about. Therefore, this study, through the DEMATEL method, contributes to understanding the needs of the public in using interactive smart health promotion equipment. Relevant stakeholders can utilize the interrelationships and relative importance of various decision criteria to formulate effective promotional strategies and apply the results to enhance service provision and competitiveness.

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A Review Paper on Artificial Intelligence in Service Industries

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Abstract

Artificial intelligence(AI) is changing the provision of services. The objective of this study is to review existing literature addressing AI adoption and related issues in service industries and propose avenues for future research in this domain.

Keywords

Artificial intelligence, Literature review, Service industry

Introduction

AI is a digital technology that plays a pivotal role not only in transforming business, production systems, and operations management but also in business process management (Mariani and Borghi, 2022). AI is associated with the ability of machines to understand and use human language and then continue to work on their own (Rust and Huang, 2014). Modern AI is applied in many spheres of public life for various purposes such as reasoning, knowledge, learning, communication, perception, planning, etc. (Hill, Ford & Farreras, 2015; Barra, 2013; Bollier, 2017). Various aspects of our daily lives, such as home automation, healthcare facilities, hotels, and restaurants, have been streamlined by AI-based robots. Virtual bots enable self-service in customer interactions (Fluss, 2017), big data AI applications replace portfolio managers (Javelosa, 2017), and social robots like Pepper take on roles traditionally held by human greeters in customer-facing services (Choudhury, 2016). These advancements have led some to assert that we are in the midst of the fourth industrial revolution, where technology blurs the boundaries between the digital, biological, and physical domains (Schwab, 2017).

In service industries, AI has been acknowledged as a primary driver for the digital transformation of service operations (Mariani and Borghi, 2022). Particularly, AI, especially in the form of mechanical robots, enables service firms to increasingly automate their business and production processes, striving for enhanced efficiency. Service robots are used for commercial purposes by companies (cleaning robots for public places, delivery robots in offices or hospitals, fire-fighting robots, rehabilitation robots, and surgery robots in hospitals

(Ivanov, Webster & Berezina, 2017:).

Unlike manufacturing industries, where the product is manufactured, the outcome of a service production process is co-created by both the service producer and the service customer (Grönroos and Voima, 2013). However, empirical studies have thus far overlooked the impact of AI on service operations. Consequently, the main objective of this study is to review existing literature addressing AI adoption and related issues in service industries and propose avenues for future research in this domain.

Methods

This paper conducts an advanced search of Google Scholar, with two conjoint queries in the title, abstract, and keywords: (1) the terms 'AI' OR 'artificial intelligence'; (2) the terms 'services firms' OR 'service industry' OR 'service industries' OR 'service sector'.

Literature Review

In this study, "service AI" is defined as the configuration of technology to provide value in the internal and external service environments through flexible adaptation enabled by sensing, learning, decision-making, and actions (Bok et al., 2020). As a revolutionary technology for service innovation, AI can make decisions and take actions independently, provide better contact and interaction with customers, and is based on technologies, such as cognitive computing and machine learning (Kuo et al., 2017; Murphy et al., 2017; Tung & Au, 2018). AI has been widely adopted in service industries such as the hospitality industry (Lv et al., 2022; Lukanova and Ilieva,

2019), human resource analytics (Berhil et al., 2020), and healthcare (Mun et al., 2021).

AI provides auspicious opportunities to contribute to individuals' well-being, the success and innovativeness of organizations, and societies' prosperity and advancement (Thiebes et al. 2020). Accordingly, in this review study, we employ a framework of macro-, meso-, and micro-level to discuss issues with future potential regarding AI applications in service industries.

The Macro-level issues on using artificial intelligence in the service industry.

The Macro-level issues aim to investigate how AI can improve or damage human society. The development of AI is being studied from two main angles. The economic research focuses on how AI affects jobs, whereas the service and technology literature emphasizes the benefits of using AI technology.

Economic and social issues.

The impact of AI on human labor and jobs is primarily examined in the literature on strategic management, economics, science, and practitioners. The increasing use of AI in service-related industries has sparked worries about how it will affect employment levels and the caliber of jobs (Acemoglu & Restrepo, 2018).

AI may cause job displacement in some industries and professions, but it can also generate new employment opportunities in service innovation and AI-related sectors (Arntz et al., 2017). Examples of these impacts include the use of deep learning to detect skin cancer more accurately than dermatologists (Ešteva et al., 2017; Leachman and Merlino, 2017); the augmentation effects of AI on knowledge workers (Davenport and Kirby, 2015); digital technologies as the driving force of work and life (Brynjolfsson and McAfee, 2016); the rise in automation-related low-skill service jobs in the U.S. labor market (Autor and Dorn, 2013); and the AI-enabled workplace redefinition (Chui, Manyika, and Miremadi, 2015).

Chui, Manyika, and Miremadi (2015) discovered that a sizable portion of the work done by people in high-paying positions like senior managers, portfolio managers, and doctors can be automated with the use of modern technology.

However, AI will have a harder time replacing services that require a higher level of human interaction or touch (Giebelhausen et al. 2014). To lessen the negative effects on labor markets, employers and policymakers must address the difficulties associated with skill retraining and workforce transfer (Frey & Osborne, 2017).

Technology issues.

AI is undoubtedly one of the most actively debated technologies. The applications of intelligent technology (Colby, Mithas, and Parasuraman 2016; Marinova et al. 2017; Rafaeli et al. 2017), services made possible by

diverse technologies (Huang and Rust 2013), and service technologies (Kunz et al. 2018) are frequently the subjects of the service literature.

One area of growing interest in the application of AI for online retail is the area of AI-based chatbots. These chatbots have been introduced as digital assistants in online retail environments to enhance customer experience and fulfill expectations through real-time interactions (Cheng et al., 2021).

According to the literature, technological advancements should have expected effects, such as a rise in the use of self-service technologies (Meuter et al., 2000), an increase in optimal productivity (Rust and Huang, 2012), and the expansion of the service sector (Rust and Huang, 2014).

Ethical issues.

The thoughtful application of AI to the service sector poses questions about data security, privacy, and moral usage of client information. The development of AI has enabled the collection, storage, and processing of information on an unprecedented scale (Mazurek and Małagocka, 2019), thereby making it extremely easy to identify, analyze, and use personal data at low cost without the consent of others (Mazurek and Małagocka, 2019). Thus, privacy leakage from interaction with AI technologies has become another topic of consumer concern. Establishing strong data governance frameworks, guaranteeing openness in AI algorithms, and giving ethical considerations priority are imperative for organizations to cultivate consumer trust. (Chen & Li, 2020; Kim & Park, 2019)

The Meso-level issues on using artificial intelligence in the service industry.

The Meso-level issues look at how AI improves the industrial or organizational performance of service companies.

AI changes market structure.

Market structure and business competitiveness are affected by AI integration, which changes the competitive environment in the service sector and affects firm dynamics and market concentration (Cockburn et al., 2018). Big businesses may benefit from competitive advantages in terms of efficiency and innovation if they have the financial means to invest in AI technologies (Bughin et al., 2018). But thanks to cloud-based solutions and AI-as-a-service models, small and medium-sized businesses (SMEs) can also access sophisticated capabilities by adopting AI (Manyika et al., 2017).

AI increases productivity and efficiency.

According to Brynjolfsson and McAfee (2014), AI-driven automation and optimization have the potential to greatly increase productivity in the service industry. According to studies, AI-enabled tools and systems can increase service delivery efficiency, decrease operating costs,

and streamline workflows (Autor & Salomons, 2018). However, depending on variables like organizational capacity and technological readiness, the amount of productivity increases may differ throughout industries and businesses (Brynjolfsson et al., 2019).

AI-driven tools for automation and optimization can help service businesses cut expenses, optimize resource allocation, and expedite internal procedures. Supply chain management systems with AI capabilities, proactive maintenance programs, and clever scheduling algorithms are a few examples. (Smith et al., 2021; Johnson & Wang, 2020).

AI enhances client relationships.

Personalized and proactive client experiences can be provided by service firms using chatbots, virtual assistants, recommendation systems, and sentiment analysis tools thanks to artificial intelligence. Organizations may anticipate client demands, rapidly fix difficulties, and cultivate loyalty by utilizing AI-driven insights. (Brown & Lee, 2019; Garcia et al., 2020)

Strategic thinking in using AI

In the service management field, scholars have paid closer attention to the way mechanical AI in the form of service robots is increasingly adopted by service firms (Huang and Rust 2018, 2021). However, not every task in service operation is suitable for mechanical AI. All types of AI—mechanical, cognitive, and emotional—can offer special advantages for customer engagement. Scholars have started to examine the effect of task characteristics on AI acceptance; they have a consensus on suggesting mapping different AI technologies to meet different service offering needs. The challenge for service managers is to design their service system in which appropriate AI technology is used.

Mechanical AI should do most normal, repetitive, and mechanical jobs. The nature of these kinds of activities is simpler in the manufacturing industry. There are differences in this kind of task for services: Certain tasks, like cash withdrawals from ATMs, are as mechanical as they come from manufacturing (Meuter et al., 2000). On the other hand, certain tasks are routine and straightforward but call for additional context or variations, such as waiting service at restaurant tables, which is difficult for mechanical AI to accomplish.

Greater use of thinking AI should be made of service offerings that are more utilitarian in nature. Customers who use utilitarian services mostly receive instrumental, functional, and non-sensory benefits (Huang 2003, 2005). They are ideally suited for thinking AI and might be regarded as high-tech. For instance, thinking AI can be used for financial analysis (like IBM Watson) and cloud data services (like Amazon). On the other hand, hedonistic services ought to make greater use of feeling AI. Hedonistic services primarily offer customers sensory

advantages including enjoyment, playfulness, and fun (Huang 2003, 2005). They could gain from sensing AI and be seen as high-touch. Computer games, for instance, can use emotion-detection AI to put players in a state of flow.

The micro-level issues on using artificial intelligence in the service industry.

The Micro-level issues look at how AI can be accepted by humans, i.e., the customers and employees.

Customer acceptance of AI

To date, researchers have focused on issues of AI adoption, emphasizing customer acceptance and satisfaction evaluation (Murphy et al., 2017). Some studies have addressed this question by extending Davis's (1989) technology acceptance model to consider consumers' acceptance of AI from the perspective of perceived usefulness and perceived ease of use.

In terms of consumer attitudes, studies have focused on consumer satisfaction (Chung et al., 2020), loyalty (Følstad et al., 2018), and intention to continue using AI-aided services (Ashfaq et al., 2020). The management of customer experience focuses on operations and processes orientated to the needs of the individual customers. In addition, previous studies have focused on how humans and computers interact. These studies suggest that the need for human interaction can negatively influence user satisfaction with using AI (Peng et al., 2022).

Employee acceptance of AI

Employee acceptance of AI is highly influenced by how relevant they believe it to be to their duties and responsibilities. Employee adoption and workflow integration of AI is more likely when they believe it is directly related to their jobs and goals (Rogers, 2003).

One important issue influencing employee acceptance of AI technologies is trust. For workers to feel at ease integrating AI technologies into their work processes, they must have faith in the technologies' dependability, correctness, and moral application (Mayer et al., 1995).

Perceived usefulness is the degree to which workers think AI technologies will improve their productivity and performance at work is known as perceived usefulness. Workers are more likely to embrace AI if they believe it will help them complete activities more quickly, make better decisions, and be more productive (Davis, 1989).

On the other hand, perceived usability is the degree to which employees believe AI systems are simple to use and comprehend is known as perceived ease of use. Higher levels of perceived ease of use lead to greater employee acceptance; this can be achieved by an intuitive design, a user-friendly interface, and clear instructions (Venkatesh et al., 2003).

Another important factor in encouraging employee acceptance of AI is organizational support. A favourable

organizational climate for AI adoption is facilitated by management support systems, communication, and adequate training (Venkatesh et al., 2003).

Conclusion

Artificial intelligence (AI) is revolutionizing the service sector at a quick pace, providing previously unheard-of chances for productivity, creativity, and client happiness. The role of AI in the service industry has been reviewed in this review paper, with an emphasis on the technology's uses, advantages, difficulties, and effects on workers. As the analysis progressed, it became clear that artificial intelligence (AI) has the potential to completely transform the service sector in a number of different areas, including healthcare, banking, production, service delivery, data privacy, hospitality, and customer service/communications. Chatbots, predictive analytics, and personalized suggestions are a few examples of AI-driven solutions that have been shown to be successful in improving operational efficiency and providing better customer experiences.

However, resolving a number of significant issues is necessary before AI can be successfully incorporated into the service sector. These include worries about employee acceptability, ethical issues, data protection, and regulatory compliance. Furthermore, the possibility of workforce retraining and job displacement makes it imperative that AI efforts be carefully planned and strategically executed. Notwithstanding these difficulties, there is no denying the advantages of integrating AI in the service sector. Organizations can obtain important insights from data analytics, optimize resource allocation, and streamline processes by utilizing AI technologies. Furthermore, by enhancing their abilities, automating repetitive jobs, and facilitating more strategic decision-making, AI has the ability to empower workers.

To sum up, the integration of AI in the service sector is a revolutionary development that will have a significant impact on companies, workers, and the community at large. Organizations must place a high priority on ethical issues, make training and development investments for their staff, and promote a collaborative and innovative culture if they hope to fully reap the benefits of AI. Organizations must embrace this technology revolution while being aware of its possible hazards and problems as AI develops and permeates every element of the service sectors. They may establish themselves as industry leaders in the digital economy and provide long-term value to their stakeholders and clients by doing this.

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"Share or Sell" Exploring Knowledge Monetization Business Models through Trust Transfer Theory

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Abstract

This study delves into Knowledge Monetization, an evolving economic model wherein knowledge is transformed into goods/services and marketed through social media platforms. In the era of self-media, influencers have become pivotal in the social economy. Anchored in the Trust Transfer Theory, our research aims to scrutinize factors shaping users' inclination to purchase goods or services from knowledge-based influencers on social media. Employing a questionnaire survey, we analyze the trust dynamics between users and influencer brands, probing for potential trust transfer to sales targets. Our study strives to unravel the intricacies influencing users' purchasing intentions concerning extended influencer brands. By exploring the impact of influencer characteristics, consistency, perceived value, and satisfaction on trust, we aim to provide valuable insights for online platform operators and future researchers, contributing to a nuanced understanding of the dynamics surrounding online knowledge monetization.

Building upon the Trust Transfer Theory, this study explores the trust relationship between influencer brands and sales targets and further investigates its impact on users' purchasing intentions. The research primarily investigates the influence of influencer characteristics, consistency, perceived value, and satisfaction on trust, as well as their subsequent relationship with purchasing intentions, drawing from relevant literature to establish the framework for this study.

Keywords

Influencer Economy, Knowledge Monetization, Trust Transfer, Purchasing Intentions, Social Platform Marketin

I. Introduction

1.1 Research Background and Motivation

The widespread use of the internet has brought about significant changes in our lives. Social media has become an essential presence in everyone's life. With the rise of self-media, many individuals share their lives and present professional content through social media. Gradually accumulating popularity, they become "internet celebrities" or "influencers."

According to the 2020 Digital Data in Taiwan, 91.8% of the internet users in Taiwan are engaged with social media. Additionally, an increasing number of users rely on information from social media for their purchasing

decisions. In response to the growing influence of social media on users, many businesses have shifted their online commercial activities from e-commerce platforms to social media, giving rise to the phenomenon of "social commerce." Internet celebrities have become an important marketing strategy.

The business model of monetizing knowledge is developed based on the concepts of the Sharing Economy and Collaborative Consumption. Previous research on the Sharing Economy and Collaborative Consumption mainly focused on tangible assets. In the literature related to knowledge sharing, the emphasis has been primarily on knowledge providers. Therefore, this study takes the perspective of knowledge seekers and explores the

motivations influencing users' willingness to pay for knowledge goods/services.

Drawing on the Trust Transfer Theory, the research investigates the trust relationship between internet celebrity brands and their target audience and further explores its impact on users' purchasing intentions.

1.2 Research Objectives

Building upon the aforementioned background and motivation, it becomes evident that the internet celebrity economy has gradually evolved into a new business model. After gaining users' trust through the free sharing of knowledge content, these influencers further introduce paid online courses on their platforms. The key questions this study aims to investigate are whether such a business model can gain user acceptance and whether user trust will be weakened or strengthened by the introduction of paid services.

Hence, the research objectives can be summarized into the following three aspects:

1. Understand the trust relationship between users and internet celebrity brands.
2. Examine the trust transfer relationship between trust in internet celebrity brands and sales targets:
3. Explore factors influencing users' purchase intentions through the extended impact of internet celebrity brands:

By addressing these objectives, this research seeks to contribute to a deeper understanding of the emerging dynamics within the internet celebrity economy and its impact on user behavior, trust, and purchasing intentions.

II. Literature Review

This study investigates how the "Internet Celebrity Economy," "Monetization of Knowledge," "Trust Transfer," and "Satisfaction" impact users' "Purchase Intentions." The goal is to establish research hypotheses and explore the connections between these factors. The chapter begins with a succinct review of existing literature on the Internet Celebrity Economy, Monetization of Knowledge, Trust Transfer, Consistency, Satisfaction, and Purchase Intentions.

2.1 Trust Transfer Theory

Trust is a voluntary act of transferring resources or control of resources to another person. Palmatier et al. (2008) define trust as having confidence in the reliability and honesty of a transaction partner. Sources of trust include procedural trust, personality trust, and institutional trust. Trust transfer can be achieved through two processes: cognitive and communicative.

Trust Transfer in the Era of Internet Celebrities: In Gefen's (2000) study on blog marketing, trust plays a significant role. Given that internet celebrities serve as an extension of bloggers, trust is also crucial for fans and internet celebrities. Ganesan (1994) defines trust as the willingness

to rely on a transaction partner perceived as trustworthy, viewing trust as a belief, sentiment, or expectation towards a transaction partner. In an age of information overload, where users face a plethora of brand choices, reducing risk becomes crucial. Trust transfer occurs when an individual trusts something, leading to trust in the associated target.

The trust transfer theory acknowledges two types of trust transfer: intra-channel trust transfer and inter-channel trust transfer. Intra-channel trust transfer refers to the trust level of one entity (e.g., location or institution) transferring within the same channel to another affiliated entity. On the other hand, inter-channel trust transfer involves transferring the trust level from one channel to another.

2.2 External Influencing Factors

2.2.1 Internet Celebrity Traits

With the rapid development of social media, internet celebrities on platforms like YouTube garner hundreds of thousands or even millions of followers, wielding significant influence. Brands leverage this influence for product promotion. This section explores the traits of internet celebrities and how they present information about endorsed products, examining their potential impact on users' purchase intentions. The study specifically investigates interactivity, professionalism and popularity. (a) Interactivity: Compared to traditional media, internet users have higher interactive needs and actively choose information (Ruggiero, 2000), aligning with the concept of active audiences (Song et al., 2004; Shie, Annie, 2022). On YouTube, users can interact by commenting below subscribed videos, following YouTubers on Instagram, and engaging through comments or live streams. Increased interactivity allows fans to feel closer to YouTubers, enhancing their likability and loyalty.

(b) Professionalism: Professionalism refers to an individual's level of knowledge and skills in a specific field. In the context of the credibility source model, professionalism reflects an endorser's expertise in the endorsed product or brand (Erdogan, 1999). The degree of professionalism depends on the target audience's perception (Hovland et al., 1953; Ohanian, 1990). Even if internet celebrities may not be true experts, their endorsement messages become more attractive if the information source is deemed effective, leading to a positive attitude or higher purchase intention (Bergkvist et al., 2016; Ohanian, 1990; Magnini et al., 2008; Lee, Mei-Hsien, 2022). Professional endorsers instill trust in users, influencing their willingness to purchase the endorsed product.

(c) Popularity: Popularity refers to the degree of being well-known, dependent on exposure, reputation, and familiarity with the public. Artists and celebrities, due to high societal exposure, tend to have higher popularity. YouTube influencers, similarly, gain popularity based on subscriber count.

In conclusion, this section delves into the external factors of internet celebrity traits, specifically exploring how interactivity, professionalism, and popularity influence users' purchase intentions.

2.2.2 Consistency

Generally, consistency refers to the alignment between the specific traits of the endorser and the characteristics of the endorsed product (Erdogan, 1999; Kamins and Gupta, 1994). This section explores how the compatibility of internet celebrities and endorsed products influences users' purchase intentions. For instance, if a fitness-oriented internet celebrity endorses a protein powder, the consistency between the celebrity's traits and the product increases users' trust, consequently boosting their willingness to purchase. Multiple studies confirm that higher consistency between the endorser's traits, type, and the endorsed product enhances users' brand attitudes and purchase intentions (Till and Busler, 2000; Saldanha et al., 2018). The degree of consistency between the internet celebrity and the endorsed product is considered a key indicator of the success of celebrity endorsements (Kim and Kim, 2021; Janssen et al., 2022).

(a) Brand Trust: Brand trust is defined as the perceived predictability of brand behavior, expressing users' confidence in the brand's ability to fulfill their expected functions. (Kabadayi, E. T., & Alan, A.) (2012). Brand trust and brand affect: Their strategic importance on brand loyalty. *Journal of Global Strategic Management*, 11(6), 81-88. Since users identify with the ideology of the enterprise and have high expectations for brand goods or services, the brand will be able to meet their future needs. Thus, brand trust is an expected feature used by people to assess transactions and determine whether they are ready to take the risk of purchasing goods or services.

(b) Trust in Marketing: Trust in marketing can be established through the buy-sell relationship process of brand enterprises' goods and employees' services. It is viewed as a vital key factor in the success of a transaction. Brand trust means that users accumulate a trust relationship with the brand over a long period when shopping for goods and experiencing the shopping process. Chaudhuri and Holbrook(2001) Chaudhuri, A., & Holbrook, M. B. (2001). The chain of effects from brand trust and brand affect to brand performance: The role of brand loyalty. *Journal of Marketing*, 65(2), 81–93. argue that users will actively trust and rely on a brand they perceive as trustworthy and reliable, forming brand trust. This trust can reduce users' feelings of insecurity because users know the brand is trustworthy, reliable, and honest, representing the psychological variables of users' trust in the brand. Positive actions like a willingness to purchase arise when one party trusts the other.

2.2.3 Brand Trust

Becerra and Badrinarayanan (2013)

P. Becerra, E. and Badrinarayanan, V. (2013), "The influence of brand trust and brand identification on brand evangelism", *Journal of Product & Brand Management*, Vol. 22 No. 5/6, pp. 371-383 propose that when users perceive a brand as trustworthy and reliable, they will rely on that brand, forming brand trust. Chaudhuri and Holbrook (2001) also mention that brand trust is built on users' satisfaction with the quality of brand goods when shopping, exceeding users' expectations, which may increase their desire to shop.

Curran et.al(1998) Curran, J. M., Rosen, D. E., & Surprenant, C. (1998, May). The development of trust: an alternative conceptualization. In *Proceedings of the European Marketing Association Conference* (pp. 111-130). highlight another characteristic of brand trust, stating that brand trust develops over time. This aligns with Garbarino and Johnson's(1999) Garbarino, E., & Johnson, M. S. (1999). The different roles of satisfaction, trust, and commitment in customer relationships. *Journal of marketing*, 63(2), 70-87. summary of brand trust based on users' knowledge and experience. As users' experience and perception of the brand increase, trust in the brand gradually accumulates.

In summary, this section explores the concept of consistency, focusing on the alignment between internet celebrity traits and endorsed products. It also discusses the importance of brand trust in influencing users' behaviors, emphasizing its role as a cornerstone in customer relationships.

2.2.3 Social Media Marketing

With the widespread use of the internet and the increasing trend of users consuming on social media platforms, the pace of social media dissemination has accelerated. According to Mohammadian and Mohammadreza (2012), utilizing social media platforms as a marketing method not only helps build customer relationships but also enhances brand reputation and promotes the brand effectively. Social media shortens the distance between companies and users, creating better and more direct communication and interaction methods.

Social media marketing is defined as using social media platforms to connect with different users to enhance company image and brand awareness. It is considered user-friendly, cost-effective, and has high promotional effectiveness (Trottier D, 2011). Internet celebrities (also known as influencers) on social media platforms are considered opinion leaders for users, influencing users based on the content and information they disseminate. They are regarded as opinion leaders with credibility, expertise, and authenticity (De Veirman et al., 2017). Users use their content and information as reference

points. Expert Marketing: Marketing activities on social media make it convenient for users to obtain product information. The expertise in marketing increases reliability and purchase intentions. Many professionals in various industries have started managing social media, sharing professional knowledge on fan pages, and not for personal gain (Moustakas et al, 2020). Moustakas, E., Lamba, N., Mahmoud, D., & Ranganathan, C. (2020, June). Blurring lines between fiction and reality: Perspectives of experts on marketing effectiveness of virtual influencers. In 2020 International Conference on Cyber Security and Protection of Digital Services (Cyber Security) (pp. 1-6). IEEE.

Based on the above, social media marketing not only shortens the distance between companies and users but also allows for a quicker understanding of customer thoughts and suggestions, providing meaningful and meaningful products for users.

2.3 Intrinsic Influencing Factors

2.3.1 Perceived Value

Successful sellers must emphasize the value they can provide, adopting a "value-based strategy" that enhances the buyer's perception of the value of the product or service. This involves increasing the buyer's perception of the quality (or benefits) and relative selling price to enhance the perceived value of the purchase (Grewal et al., 1998). Zeithaml's (1998) perception theory states that a user's perceived value depends on the relative relationship between the "expected benefits of purchasing the product" and the "costs incurred to purchase the product. Woodruff (1997) defines perceived value as the user's perceived preferences and evaluations of the results generated from product attributes, performance, and facilitation or hindrance of customer goal achievement.

(a) Instrumental Value (Utilitarian): Instrumental value refers to the degree to which a product/service provides expected utility. It implies functionality, tool functionality, and practicality (Wongkitrungrueng and Assarut, 2020). It integrates more levels of attitudes, evaluating the attributes of efficiency, task-oriented, and economic orientation of the product or service. Instrumental value evaluates rational and task-oriented consumer behavior (Batra and Ahtola, 1991) or functional benefits and expenditures (Overby and Lee, 2003). It includes cognitive aspects of attitudes, economic "value for money" (Zeithaml, 1988), and judgments of convenience and time-saving (Jarvenpaa and Todd, 1997; Teo, 2001).

(b) Hedonic Value (Entertainment): Hedonic value refers to the subjective and spontaneous reflection results of an individual. It is self-directed and belongs to the personal emotional results of the user. Babin et al. (1994) and Zhao Yanwei and Wang Chongyu (2017) consider Hedonic Value as the value component of entertainment and

emotion that a product (service) possesses. In contrast to instrumental value, hedonic value depends on the ability of the product to provide emotional experiences or pleasures, rather than its ability to solve problems or achieve specific goals (Cao and Xie, 2007; Zheng Anchen, 2021). Users who lean towards hedonic value focus more on the pleasure it brings rather than the assistance and functionality the product (service) can provide, measuring its value based on the feelings experienced when using the product (service).

(c) Economic Value: Economic value refers to monetary benefits, allowing users to understand the lower monetary costs brought by their participation. For example, forming the perceived value based on the lower monetary costs of the product or service (Haumann et al., 2015; Zhao Yanwei and Wang Chongyu, 2017). Higher perceived economic value will lead to a higher willingness to purchase (Tsai, 2005). Perceived value is the basis for users to decide whether they are willing to purchase, after evaluating the overall value of the relative service or product obtained in comparison to the consumption cost (Woodruff, 1997; Zeithaml, 1988).

2.3.2 Satisfaction and Purchase Intentions

Customer satisfaction and purchase intentions have consistently been critical topics in consumer behavior research. This variable aims to delve into how user satisfaction with a product or service influences their willingness to make a purchase. (Dash et.al, 2021) Dash, G., Kiefer, K., & Paul, J. (2021). Marketing-to-Millennials: Marketing 4.0, customer satisfaction and purchase intention. *Journal of business research*, 122, 608-620. Satisfaction is considered a subjective evaluation by users of a specific product or service, involving various factors such as quality, price, and service attitude. Research indicates a positive correlation between satisfaction and purchase intentions. (Schiessl et., al 2023) Schiessl, D., Korelo, J., & Dias, H. B. A. (2023). How online shopping experiences shape consumer webrooming behavior. *Marketing Intelligence & Planning*, 41(1), 16-30. When users are satisfied with a product or service, they are more inclined to exhibit a positive attitude towards it, thereby increasing their willingness to make a purchase. Improvements in satisfaction may result from factors such as high product quality, reasonable pricing, and excellent after-sales service. Understanding this complex interplay is crucial for businesses aiming to enhance customer satisfaction and drive purchase intentions.

Azen and Budescu (2003) state that user purchase intention is a necessary process that users must go through before the actual purchase behavior occurs. Spears and Singh (2004) consider purchase intention as a conscious and planned effort by an individual before a purchase, signifying a likelihood of taking action when a positive impression and attitude towards a product or brand are

established. Understanding users' purchase intentions is crucial for businesses and marketers to observe and predict user shopping preferences. It serves as a key indicator for predicting whether users are likely to purchase a particular product or brand.

Addressing factors influencing purchase intentions, Hovland's (1953) communication persuasion model identifies three dimensions affecting communication effectiveness: the information communicator, the information itself, and the information recipient. The information communicator could be influencers like YouTubers, live streamers, or Key Opinion Leaders (KOLs) disseminating product information. The information itself refers to the brand, product information, and the communication channels on social media platforms. The information recipient indicates internal factors within the user.

III. Research Design and Methodology

3.1 Research Framework

The research framework is divided into two main factors: external factors and internal factors. External factors encompass interactivity, consistency, and popularity for analysis, while internal factors include perceived value and satisfaction. Extending from the facets of external and internal factors, trust is examined, followed by the transfer of trust leading to purchase intention.

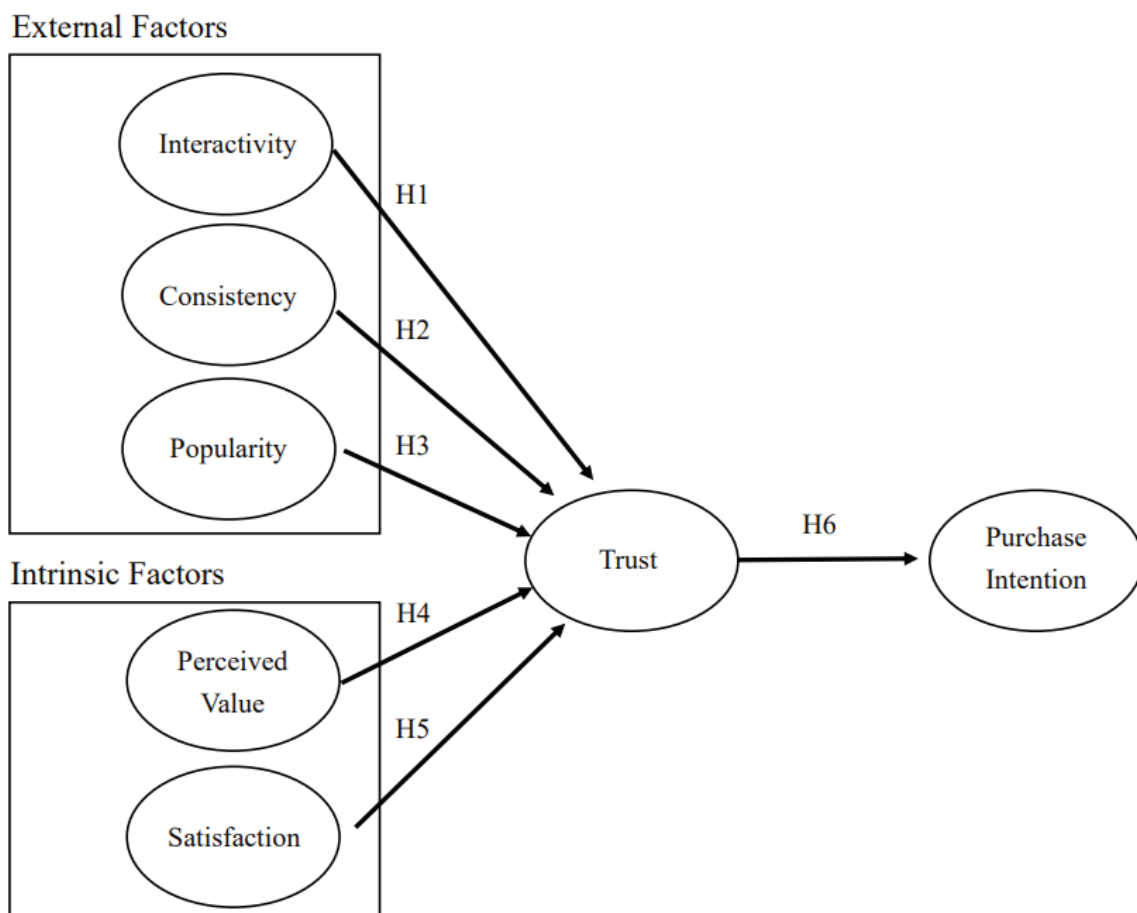


Figure 1 –Research Framework

3.2 Research Hypotheses

Based on the aforementioned research objectives, the following research hypotheses are proposed:

Ruggiero (2000) suggests that compared to traditional media, internet users have higher demands for interactivity and exhibit proactive information-seeking behavior. In the context of YouTube, the increased interactivity between YouTubers and their fans allows fans to connect closely with their daily lives, thereby enhancing user preference and loyalty. This suggests that the augmentation of interactivity can effectively contribute to trust-building. Therefore, the research hypothesis H1 is formulated as follows:

Hypothesis 1 (H1): There is a positive relationship between interactivity and trust.

Erdogan (1999) and Kamins and Gupta (1994) posit that consistency refers to the degree of match between the specific traits of an endorser and the characteristics of the endorsed product. The alignment between Key Opinion Leaders (KOLs) and the recommended product or service influences the trust of social media platform users and subsequently affects their purchase intentions. When the traits of a KOL align with the features of the recommended product or service, users perceive the product or brand more favorably. Simultaneously, the KOL is perceived as a reliable expert, leading to an increase in user trust. Therefore, the research hypothesis H2 is formulated as follows:

Hypothesis 2 (H2): There is a positive relationship between consistency and trust.

Drawing from Tang Yufang's (2020) assertion that an individual's fame is determined by factors such as exposure, reputation, and familiarity to the public, KOLs typically have higher visibility on social media platforms. The higher visibility contributes to their increased popularity, and higher popularity assists in establishing trust among users. The prominence of KOLs reflects broad support and recognition, making users inclined to form positive impressions of well-known KOLs and perceive them as influential and credible. Therefore, the research hypothesis H3 is proposed as follows:

Hypothesis 3 (H3): There is a positive relationship between popularity and trust.

Zeithaml's (1998) theory of perception suggests that user perceived value depends on the relative relationship between the "anticipated benefits of purchasing the product" and the "costs associated with purchasing the product." When the perceived benefits outweigh the perceived costs, the user's perceived value is higher. The components of user perceived value include the benefits obtained from the product and the costs incurred before acquiring the product (Chen Guanyang et al., 2016; Zeng Guanghua, 2020). In other words, when KOLs demonstrate authenticity, expertise, or alignment with the audience's values, users perceive their value, enhancing

trust in them. This trust is built on the resonance between the audience's identification and the KOL. Therefore, the research hypothesis H4 is formulated as follows:

Hypothesis 4 (H4): There is a positive relationship between perceived value and trust transfer.

Satisfaction is considered a subjective evaluation by users of a specific product or service. When users are satisfied with a product or service recommended by a KOL, they are more likely to hold a positive attitude towards that product or service, thereby increasing their purchase intention. Satisfactory experiences strengthen users' trust in the KOL, and they often associate these positive experiences with the KOL, subsequently enhancing loyalty and a greater inclination to accept future recommendations or suggestions. Therefore, the research hypothesis H5 is formulated as follows:

Hypothesis 5 (H5): There is a positive relationship between satisfaction and trust.

In the context of Trust Transfer, trust is described as a voluntary act of transferring resources or control rights to another party. Palmatier et al. suggest that trust involves confidence in the reliability and honesty of a transaction partner. In influencer marketing, trust is also a crucial quality for both fans and influencers. User purchase intention is influenced by subjective attitudes towards a particular brand or product, combined with external factors. When users form positive impressions and attitudes towards a specific brand or product, the likelihood of purchase intention increases. Therefore, when Trust Transfer occurs, and users trust a KOL, holding positive attitudes and impressions, this trust extends to the associated target endorsed by the KOL. Users become more willing to accept products or services recommended by the KOL, thereby increasing their confidence in making a purchase. This leads to an increase in purchase intention. Therefore, the research hypothesis H6 is proposed as follows:

Hypothesis 6 (H6): There is a positive relationship between trust and purchase intention.

3.3 Data Processing and Methods

This study adopts a questionnaire survey method, utilizing SPSS and Amos analysis software as survey tools. The primary research methods are outlined as follows:

Questionnaire Survey Method: Conducted through a unified questionnaire design distributed to selected participants to understand their situations or gather opinions. Data collection is carried out through online surveys. Factor Analysis: Factor Analysis is conducted using correlation coefficients between variables as the analysis basis, estimating factor loadings and inter-factor correlations as outcomes. Factor loadings reflect the importance of factors on Amos is software designed for Structural Equation Modeling (SEM), suitable for covariance structure analysis. SEM combines factor

analysis and path analysis, allowing the analysis of relationships between multiple variables. Amos facilitates model building and analysis through path diagram visualization, and advanced functionalities can be achieved through script language. Amos supports confirmatory factor analysis, multigroup analysis, model evaluation, and modification.

IV. Data Analysis and Results

The analysis is divided into three subsections. Firstly, a descriptive statistical analysis of the survey results will be conducted using SPSS to present the characteristics and distribution of the sample of social media platform users. Secondly, a measurement model analysis will be performed to examine the reliability and validity of the questionnaire. Lastly, discriminant validity analysis will be carried out using Amos software for path analysis and regression analysis to explore the impact of various moderating variables on the research model.

The data collection period for the online questionnaire was from October 21, 2023, to October 31, 2023, distributed across various social media platforms, including Instagram, Facebook groups, Dcard, and Line communities. A lottery incentive was employed to enhance the response rate, resulting in a total of 428 collected questionnaires, with 330 valid responses and an effective response rate of 77.1%

4.1 Measurement Model Analysis

In this subsection, an examination of reliability and validity is conducted on the formal questionnaire results to ensure a smoother subsequent statistical analysis. Reliability refers to the consistency or stability of measurement results. This study utilizes Cronbach's α value to analyze the consistency or correlation between items, ensuring that items measuring the same concept in the questionnaire are consistent. A higher Cronbach's α value indicates higher reliability (Chiu, 2000). Values above 0.9 represent extremely high consistency, indicating a very reliable measuring tool, while values between 0.8 and 0.9 suggest high consistency and reliability.

Validity, on the other hand, refers to the accuracy of measurement, indicating the degree to which a test or other measuring tool accurately measures the desired trait or function. It can be categorized into content validity and construct validity. Content validity reflects the appropriateness of the breadth of content within the measuring tool. As mentioned earlier, the questionnaire in this study is based on relevant domestic and international literature, modified for the characteristics of social media platform users, and validated through guidance from interviewees, teachers, and classmates, along with a preliminary verification through a pilot test. This ensures that the measurement tool in this study has good content validity.

Table 1 Overall results of formal questionnaire item analysis

	Construct	Mean	S.D.	Factor loading	Total score intercorrelation coefficient
Platform Value Cronbach's α value=0.86	PV1	4.09	0.69	0.91	0.74
	PV2	3.97	0.71	0.80	0.78
	PV3	3.93	0.77	0.93	0.70
Interactivity Cronbach's α value=0.81	IT1	3.81	0.82	0.92	0.66
	IT2	3.69	0.88	0.77	0.72
	IT3	3.47	0.95	0.95	0.62
Consistency Cronbach's α value=0.87	PC1	3.81	0.80	0.92	0.71
	PC2	3.85	0.84	0.82	0.77
	PC3	3.92	0.80	0.89	0.75
Popularity Cronbach's α value=0.80	PR1	3.99	0.82	0.91	0.57
	PR2	4.03	0.79	0.87	0.66
	PR3	4.09	0.72	0.66	0.63
	PR4	3.83	0.84	0.85	0.57
	PR5	3.65	0.94	0.87	0.51

Perceived Value Cronbach's α value=0.903	FV1	3.84	0.84	0.85	0.73
	FV2	3.94	0.74	0.73	0.72
	FV3	3.87	0.83	0.82	0.77
	KF1	3.78	0.81	0.86	0.80
	KF2	3.72	0.83	0.88	0.77
Satisfaction Cronbach's α value=0.93	GA1	3.64	0.84	0.86	0.81
	GA2	3.64	0.88	0.83	0.82
	GA3	3.78	0.80	0.66	0.84
	GA4	3.64	0.84	0.85	0.81
	GA5	3.72	0.81	0.85	0.82
Ttust Cronbach's α value=0.89	PT1	3.94	0.75	0.93	0.68
	PT2	3.78	0.88	0.65	0.80
	PT3	3.72	0.90	0.91	0.76
	PT4	3.75	0.85	0.85	0.81
Purchase Intention Cronbach's α value=0.87	BI1	3.65	0.92	0.91	0.76
	BI2	3.78	0.84	0.81	0.80
	BI3	3.85	0.85	0.93	0.71

Table 2 –Overall results of formal questionnaire item analysis

Croncach's Alpha	Croncach's Alphavalue based on standardized items	Items
0.971	0.971	28

The overall Cronbach's α value for the entire scale is 0.971, approaching 1. A Cronbach's α value exceeding 0.9 indicates high reliability for the entire scale. When examining individual constructs, the reliability for the "Popularity" dimension is relatively lower, with a Cronbach's α value of 0.8. However, it meets the standard considered reliable by scholars ($0.8 < \alpha \leq 0.9$, indicating high consistency and reliability of the measuring tool).

4.2 Discriminant Validity Analysis and Hypothesis Testing

4.2.1 Discriminant Validity Analysis

Discriminant validity aims to examine whether there are differences between items related to different constructs. According to Hair et al. (2010), the square root of the Average Variance Extracted (AVE) for each construct should be greater than the correlation coefficients between constructs. From Table 2 it is evident that the square root of the average explained variance values for all constructs exceeds the correlation coefficients between the constructs. This observation aligns significantly with the recommendation of Hair et al. (2010). Following the Fornell-Larcker criterion, the correlation coefficients between different constructs should be smaller than the square root of the AVE for each construct. Therefore, this table demonstrates that the Cronbach's Alpha values for each construct are higher than the correlation coefficients between the constructs, indicating good discriminant validity.

Table 3 - Correlation coefficient matrix for each construct

Contracts	Interactivity	Consistency	Popularity	Perceived Value	Satisfaction	Trust	Purchase Intention
Interactivity	0.81						
Consistency	0.64	0.87					
Popularity	0.55	0.71	0.80				
Perceived Value	0.72	0.78	0.70	0.90			
Satisfaction	0.77	0.69	0.65	0.85	0.93		
Trust	0.69	0.80	0.71	0.83	0.77	0.89	
Purchase Intention	0.67	0.77	0.64	0.85	0.77	0.87	0.87

Footnotes: Dark diagonal portion values represent the average explained variance within each, Off-diagonal values outside the dart diagonal depict the correlation coefficients between different constructs.

4.2.2 Path Analysis of the Hypothesized Model

In this subsection, the path analysis of the hypothesized model is conducted using the Amos software (version 26.0), as illustrated in Figure 2. The diagram depicts a positive impact model of interactivity, consistency, popularity, perceived value, and satisfaction on trust and purchase intention. The structural equation model reveals the following path coefficients: interactivity to trust ($\beta=0.11$), consistency to trust ($\beta=0.44$), popularity to trust ($\beta=0.18$), perceived value to trust ($\beta=0.49$), satisfaction to trust ($\beta=0.19$), and trust to purchase intention ($\beta=0.77$).

Notably, the influences of "consistency" and "perceived value" on "trust" are particularly high, and the impact of "trust" on "purchase intention" is the highest (T-value: 31.503***), demonstrating statistical significance. Additionally, all conclusions from the hypothesis testing results in Table 4 indicate that the model fits well with the data. This suggests a good fit between the proposed model and the collected data.

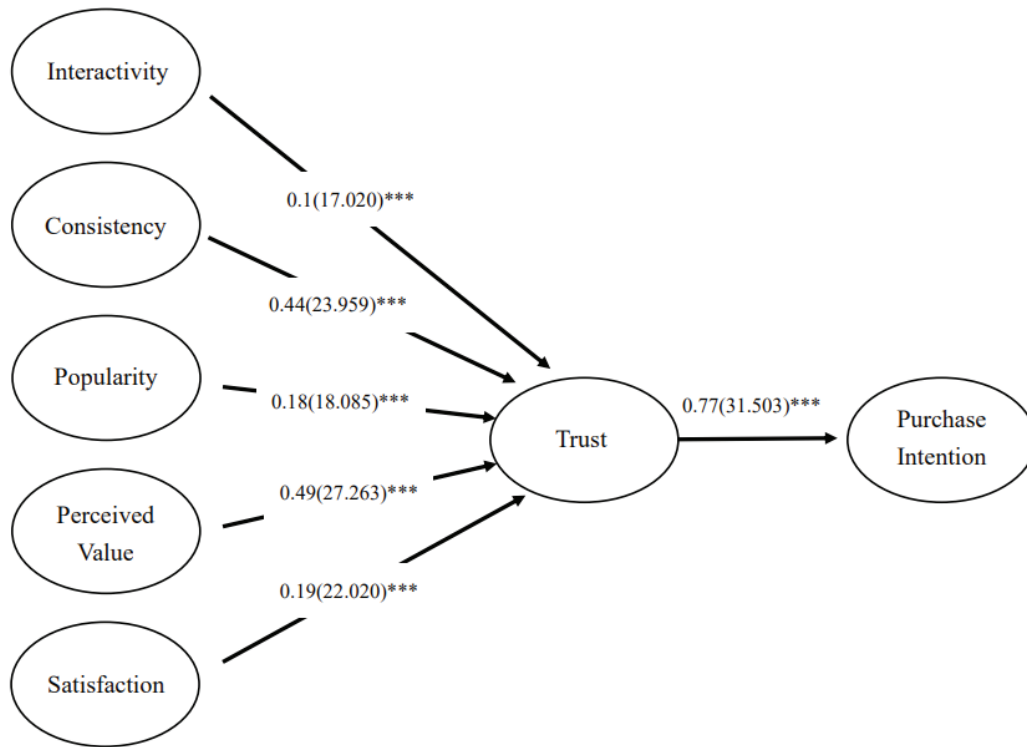


Figure 2 Results of path analysis for the hypothetical model

4.2.3 Validation of Research Hypotheses

Based on the earlier correlation coefficients and the path analysis results of the hypothesized model, it is evident that there are significant correlations among the variables studied in this research. To further explore the relationships between variables and verify the significance of the hypotheses, linear regression analysis is employed. The analysis and validation results are summarized in Table 4 for a comprehensive examination of the established hypotheses.

Table 4 – Result of Research Hypotheses

Research Hypotheses	Result
H1: There is a positive relationship between interactivity and trust.	Valid
H2: There is a positive relationship between consistency and trust.	Valid
H3: There is a positive relationship between popularity and trust.	Valid
H4: There is a positive relationship between perceived value and trust transfer.	Valid
H5: There is a positive relationship between satisfaction and trust.	Valid
H6: There is a positive relationship between trust and purchase intention.	Valid

V. Conclusions and limitation

Past studies have seldom delved into the application of trust transfer in influencer marketing, and there has been a lack of in-depth attention to how to translate this knowledge into practical value. Using YouTube KOLs as an example, this study analyzed the impact of interactivity, consistency, popularity, perceived value, and satisfaction on trust, as well as their further relationship with purchase intention. The findings demonstrate a positive impact of the trust relationship between social media users and influencer brands and the trust transfer between influencer brands and sales targets. Notably, consistency and perceived value exhibited relatively higher significance levels. This suggests that social media users generally believe that when the recommended products or services by KOLs align with their own image or attributes, or demonstrate sufficient expertise, users tend to develop higher trust. In other words, when users trust an influencer brand, they also trust the products or services recommended by the influencer, thereby increasing purchase intention. In summary, the results of this study validate a positive and significant relationship between trust transfer from KOLs and purchase intention among social media platform users. Users are likely to transfer trust to sales targets due to trust in influencer brands. Factors such as interactivity, consistency, popularity, perceived value, and satisfaction further deepen the association between KOL trust transfer and user purchase intention, providing empirical support.

This study utilized online surveys to gather sample data. However, the survey was limited to specific social media platforms such as Instagram, Facebook groups, Dcard, and Line communities. Given that KOLs are distributed widely across

platforms like Facebook, YouTube, TikTok, and blogs, presenting themselves in various forms, the study may not comprehensively capture all users. This selective bias might limit the generalizability of the research findings to the entire population of KOLs in Taiwan. Additionally, there may be regional biases leading to an ineffective reflection of opinions and perspectives across different regions and demographics. As the sample is drawn from specific regions or social media platforms, it might restrict diversity among participants in terms of race, gender, age, etc. This limitation could make it challenging for the study results to fully capture the diversity of the target audience. Future researchers should consider expanding the sample range to enhance the comprehensiveness of the data, ensuring the research findings are more representative and applicable. This step would increase the credibility and applicability of the research.

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Exploring the Impacts of Perceived Usability, Usefulness, and Security on Usage Intention for Online Recruiting Platforms

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Abstract

In a rapidly evolving digital era, online recruiting platforms have become indispensable tools for human resource management practitioners and job seekers. Although online recruiting platforms offer convenience and efficiency in connecting employers with potential candidates, concerns about usability, usefulness and security might hinder the intention to use for job applicants. To explore the impacts of factors associated with usage intention, 172 students enrolled in Extension Education of a Taiwan university were surveyed. The PLS-SEM statistical procedures were performed to test the hypotheses of the study. The results revealed that usage intention was directly influenced by perceived usefulness and security, whereas perceived usability did not exert any direct impact on usage intention. In addition, perceived usability had an indirect influence on usage intention for online recruiting platforms, with perceived usefulness acting as a partial mediator. However, the same mediation effect was not observed for perceived security. In other words, concerns about security had a significant challenge to the adoption of online recruiting platforms, surpassing worried about their utility.

Keywords

Perceived Usability, Perceived Usefulness, Perceived Security, Usage Intention, Online Recruiting Platform

Introduction

Online recruiting platforms provide a centralized hub for job seekers to exhibit their skills and experiences for employers, while offering employers efficient tools to search for resumes, assess qualifications, and conduct virtual interviews. In modern talent acquisition, online recruiting platforms play a crucial role to streamline the hiring process and to connect employers with a diverse pool of candidates beyond geographical boundaries. As a result, online recruitment platforms have become the primary method of recruitment for both employees and employers [1, 2].

Popular examples of online recruiting platforms include LinkedIn, Indeed, Glassdoor, Monster, and many others. In addition to portals and job banks, more and more businesses and organizations nowadays also actively utilize various social media to search for the required manpower [3, 4, 5, 6, 7]. In the United States, for example, 93% of recruitment managers browse applicants' online resumes and social media accounts to explore information

about job applicant [8]. The impact of modern technology on employee recruitment is indeed significant.

Although online recruiting platforms have already become the primary recruitment and selection methods for corporate organizations and job seekers, discussions and research are mainly conducted from the perspective of employers, exploring the advantages and disadvantages of different online recruitment channels. In contrast to the viewpoint of businesses, this study examined factors associated with usage intention of online recruiting platforms from the perspective of job applicants. Based on the framework of Technology Acceptance Model, this study aimed to explore the relationships between perceived usability, usefulness, and usage intention for online recruiting platforms, with consideration of perceived security. Seven research questions were answered in this study:

1. What was the impact of perceived usability on usage intention for online recruiting platforms?

2. What was the impact of perceived security on usage intention for online recruiting platforms?
3. What was the impact of perceived usefulness on usage intention for online recruiting platforms?
4. What was the impact of perceived usability on perceived usefulness for online recruiting platforms?
5. What was the impact of perceived security on perceived usefulness for online recruiting platforms?
6. What was the mediation effect of perceived usefulness on the relationship between perceived usability and usage intention for online recruiting platforms?
7. What was the mediation effect of perceived usefulness on the relationship between perceived security and usage intention for online recruiting platforms?

Literature Reviews

The design of this study was primarily derived from the “Technology Acceptance Model (TAM)” with the integration of security perception into the model. Therefore, this section briefly reviewed the literatures on the TAM and online recruitment to provide a comparative reference for subsequent analysis and recommendations.

Technology Acceptance Model

The TAM (See Figure 1), developed by Fred Davis and his colleagues in the late 1980s, is a widely used theoretical framework that explains and predicts an individual's attitude, behavioral intention and usage toward a specific technology[9]. In the model, Davis and his colleagues mainly argued that attitude of acceptance toward using a particular technology depends on two crucial factors: Perceived Usefulness and Perceived Ease of Use, in which Perceived Ease of Use also has a significant impact on Perceived Usefulness. In addition, behavioral intention toward using a particular technology, which was influenced directly by their attitudes of acceptance, has a significant and positive impact on actual usage of technology.

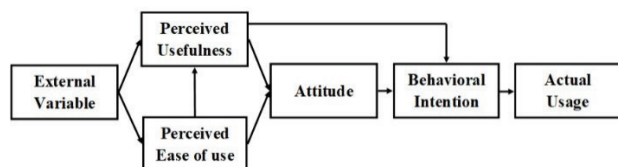


Figure 1 - Technology Acceptance Model

Although the Technology Acceptance Model has evolved over time, the theory continuously remains relevant and fresh in understanding user behavior towards newly invented technologies. Various studies in different fields had found that both Perceived Usefulness and Perceived Ease of Use have significant positive impacts on attitude toward usage, thereby influencing an individual's intention to use[10, 11, 12, 13].

Some studies supported that perceived usefulness had a significant and positive impact on behavioral intention to use. In other words, when perceived usefulness of technology increased, individuals were more willing to use it, even if they held neutral or negative attitudes toward the technology[14, 15]. Additionally, other research also validated that Perceived Usefulness was influenced by Perceived Ease of Use, which indicated that an individual's perception of ease or difficulty to use a technology also affected their perception of whether the technology was useful[16, 17, 18].

Although many empirical studies on the TAM have been conducted, and the explanatory power of the model has been widely recognized, users' concerns about security issues have not been taken into account when applying the model in the context of information technology. Because information security are crucial for searching jobs online, this study aimed to include individuals' perception on security to the TAM to explore the relationships among perceived usability, usefulness, and security on usage intention for online recruiting platforms.

Online Recruiting platforms

People seeking jobs online continued to increase in the past decades, making it the primary way to find employment. For job applicants, using online recruiting platforms to search for job opportunities and to submit resumes not only effectively reduces the cost of job hunting but also improves effectiveness of recruitment and selection. From the perspective of employers, online recruitment refers to the general practice of organizations or companies using the internet as a tool to search for and attract job applicants, which included the following methods (but are not limited to): (1) posting recruitment messages through job banks, (2) disclosing recruitment information on companies' websites, (3) placing recruitment advertisements on portal websites, (4) publishing job vacancy on professional websites, (5) broadcasting recruitment information in social media or online communities [19, 20]. The online recruiting platforms for job applicants discussed in this study mainly focused on the first method mentioned above.

Related studies regarding evaluation of internet technology commonly measured factors such as value,

convenience, and security, which was also applied to assess online recruiting platforms in this study. The evaluation of value (or usefulness) in previous research was measured based on an individual's perception of informativeness, interactivity, timeliness, spatiality, and entertainment value. Informativeness was the extent to which information provided was detailed, accurate, and relevant to the user's needs or interests. Interactivity was the degree to which a system, interface, or content allows users to engage, participate, or respond in a dynamic and responsive manner. Timeliness was the quality of being current or up-to-date, indicating how relevant information was at a given point in time. Spatiality referred to the representation or organization of information in space, especially in terms of physical or virtual locations. Entertainment value was the level of enjoyment, amusement, or pleasure that something provided to its audience, often associated with engaging and enjoyable experiences[21, 22].

Perception of job applicants on convenience (or ease of use) for online recruiting platforms mainly came from two aspects. Firstly, due to the characteristics of the internet to surpass geographical limitations, online recruiting platforms could overcome the constraints of space and time in the real world, thereby enhancing ease of use. Secondly, online recruiting platforms provided a two-way communication channel for real-time information exchange, effectively enhancing both immediacy and interactivity for usage of technology[23, 24, 25].

Issues related to information security for online recruiting platforms were measured in this study. In the context of information technology, security plays a crucial role in ensuring the privacy and anonymity of digital information. Privacy was the right of individuals to control and manage their personal information. It involved the protection of sensitive data from unauthorized access, use, or disclosure. Anonymity referred to the state of being anonymous or unidentified in online interactions. It involved concealing the identity of individuals or entities participating in digital activities[26, 27].

Methods

Research framework, hypotheses, measurements, sampling and data collection, and data analysis were addressed in this section to valid the research design and procedures.

Research Framework

Figure 2 delineated the research framework of this study, where Usage Intention (UI) served as the dependent variable and Perceived Usability (USA), Perceived Security (SEC) and Perceived Usefulness (USE) were all

positioned as the independent variables in relation to usage intention. In addition, USE was also assumed as a mediating variable for the other independent variables and the dependent variable.

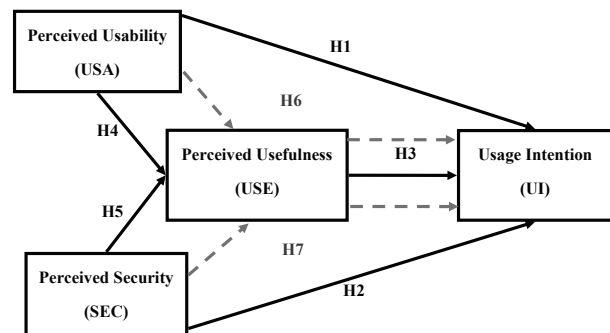


Figure 2 - Research Framework

Hypotheses

The hypotheses below delineated the relationships among variables depicted in Figure 2.

H1: Perceived usability had a significant and positive impact on usage intention for online recruiting platforms.

H2: Perceived security had a significant and positive impact on usage intention for online recruiting platforms.

H3: Perceived usefulness had a significant and positive impact on usage intention for online recruiting platforms.

H4: Perceived usability had a significant and positive impact on perceived usefulness for online recruiting platforms.

H5: Perceived security had a significant and positive impact on perceived usefulness for online recruiting platforms.

H6: Perceived usefulness had a significant and positive mediation effect on the relationship between perceived usability and usage intention for online recruiting platforms.

H7: Perceived usefulness had a significant and positive mediation effect on the relationship between perceived security and usage intention for online recruiting platforms.

Measurements

Survey approach was adapted for this study, in which the measurements of the study were primarily derived from the questionnaires designed by Davis, Bagozzi &

Warshaw[28], Igbaria & Tan[29], and Wu[30]. The questionnaire comprised three main sections: the first session was to assess participants' perception on usability, security, and usefulness for online recruiting platforms. The second session was to evaluate participants' intention to use online recruiting platforms. The third part collected relevant demographic information from the respondents. A five-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree) was applied to code the scales of USA, SEC, USE, and UI. After the initial draft of the questionnaire was designed, it was then reviewed by experts for its content validity and adjusted accordingly to finalize the measurements.

The indicators for perceived usability included respondent's perception on required time for learning to use, ease of operation, and user convenience. As for perceived usefulness, the measurement contained five constructs, which were informativeness, interactivity, timeliness, spatiality, and entertainment value. Each construct contained several indicators to measure. Regarding perceived security, the variable was measured for respondent's perception on information privacy and anonymity for online recruiting platforms. Finally, usage intention mainly measured indicators such as willingness to search for job using online recruiting platforms, willingness to register resume, and willingness to recommend others to use online recruiting platforms.

Sampling and Data Collection

The target population of this study were extension education students from a Taiwan university. Students enrolled in extension education program were mostly part-time, holding full-time jobs during the day. As a result, their utilization of online recruiting platforms was more likely to be guaranteed. Based on convenience sampling methods, a total of 172 valid questionnaires were collected for analysis (See Table 1).

Table 1 –Sample Demographic Data (n = 172)

Variable	Regular Frequency	Relative Frequency
Gender		
Male	26	84.9%
Female	146	15.1%
Age		
Below 25	105	61.0%
Above 25	67	39.0%
Currently employed		
Yes	138	80.2%
No	34	19.8%
Work Experiences		
Below 1 year	39	22.7%
1-3 Years	78	45.3%
Above 3 years	55	32.0%
Online recruiting platform experiences		
Yes	144	61.6%
No	28	38.4%

Data Analysis

A structural equation modeling with the partial least squares (PLS-SEM) was applied to examine the causal relationships among dependent, independent, and mediating variables. This statistical procedure was appropriate because this study incorporated multiple interconnected latent variables and the sample size prohibited the application of covariance-based structural equation modeling [31, 32, 33, 34].

Results

The following session summarized the results of analysis for the measurement model and structural model of the PLS-SEM statistical procedures. Based on the results of analyses, hypotheses testing was then performed.

Analysis of the Measurement Model

According to Henseler and Schubert [35], assessing outer loadings for all indicators to ensure reliability is necessary before constructing the initial model of PLS-SEM. Because the values of all factor loadings for indicators were no less than 0.5, no indicator from original constructs was removed from the initial model (see Figure 3).

Assessments of construct reliability, convergence validity, and discriminant validity were performed to evaluate the effectiveness of the measurement model. The results of these analyses were summarized in Table 2.

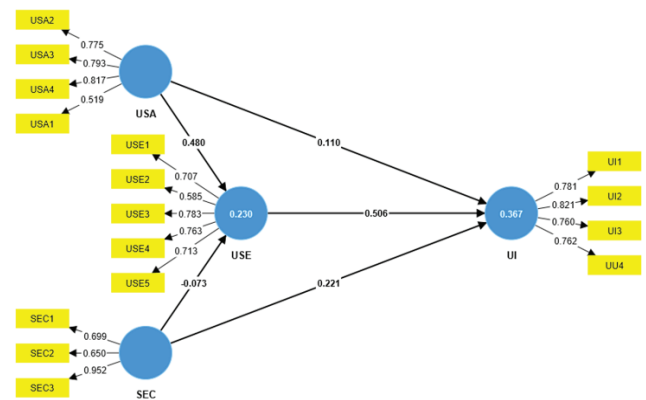


Figure 3 - PLS-SEM Initial Model

Table 2 – Results for reflective measurement models

Constructs	ID	OL	CA	CR	AVE
USA	USA1		0.711		
	USA2				
	USA3				
	USA4				
SEC	SEC1				
	SEC2				
	SEC3				

USE	USE1				
	USE2				
	USE3				
	USE4				
	USE5				
UI	UI1				0.611
	UI2				
	UI3				
	UI4				
	UI5				

Note. ID=Indicators, OL= OuterLoadings, CA=Cronbach's Alpha, CR=Composite Reliability, AVE=Average Variance Extracted, USA=Perceived Usability, SEC=Perceived Security, USE=Perceived Usefulness, UI=Usage Intention,

With the values of Cronbach's alpha and composite reliability ranging from 0.711 to 1.485, the findings indicated strong reliability for all constructs of the study. As for convergent validity, the average variance extracted (AVE) for all constructs were greater than 0.5, which confirmed that the internal consistency of the reflective scales were satisfied.

Fornell-Larcker criterion (see table 3) was applied to assess discriminant validity. According the Fornell and Larcker [36], it is necessary to compare the square root of the average variance extracted (AVE) with the correlations among constructs in the model. The results of analysis indicated that the Fornell-Larcker criterion was satisfied because the square root of the average for each construct exceeded the highest correlation observed between any two constructs.

Table 3 – Discriminant validity (Fornell–Larcker criterion)

VAR	USA	SEC	USE	UI
USA	0.736			
SEC	0.092	0.779		
USE	0.474	-0.029	0.714	
UI	0.370	0.217	0.551	0.782

Note. VAR=Variable, USA=Perceived Usability, SEC=Perceived Security, USE=Perceived Usefulness, UI=Usage Intention,

Discriminant validity of the measurements were also assessed through cross-loading analysis, as presented in Table 4. The findings also confirmed the discriminant validity because the factor loadings for each construct surpassed their corresponding cross-loadings.

Table 4 – Discriminant validity (cross-loading analysis)

VAR	USA	SEC	USE	UI
USA1	0.519	0.152	0.270	0.100
USA2	0.775	0.079	0.410	0.331
USA3	0.793	0.005	0.357	0.235
USA4	0.817	0.068	0.344	0.357
SEC1	0.074	0.699	-0.077	0.069
SEC2	0.072	0.650	-0.116	0.037
SEC3	0.082	0.952	0.011	0.254
USE1	0.342	-0.006	0.707	0.303
USE2	0.235	-0.174	0.585	0.212
USE3	0.414	0.045	0.783	0.505
USE4	0.299	-0.003	0.763	0.459
USE5	0.368	-0.035	0.713	0.407

UI1	0.301	0.168	0.426	0.781
UI2	0.296	0.086	0.543	0.821
UI3	0.240	0.315	0.301	0.760
UI4	0.314	0.140	0.424	0.762

Note. VAR=Variable, USA=Perceived Usability, SEC=Perceived Security, USE=Perceived Usefulness, UI=Usage Intention,

Analysis of the Structural Model

Once the reliability and validity of the measured constructs were confirmed, the next step was to assess the structural model [37]. Prior to perform the analysis of the structural model and to test the hypotheses of the study, multicollinearity diagnosis was conducted for latent variables (see Table 5). The examination indicated no significant collinearity issues between constructs because values of Variance Inflation Factor (VIF) were all smaller than 5.

The summary of the structural model analyses and hypothesis testing for variable interactions was presented in Table 6 and Table 7. The evaluation of the structural model involved consideration of various important criteria, such as path coefficients, coefficient of determination (R^2), effect size (f^2), and predictive relevance (q^2). In PLS-SEM, the examination of the magnitude and significance of path coefficients was employed to explore potential causal relationships among variables. The explanatory capacity of dependent variables was assessed through the coefficient of determination (R^2). Effect size (f^2) for standardized regression coefficients was computed to estimate the strength of the relationship between two variables. Finally, Q-square (q^2) was utilized to determine the predictive relevance of the model [38, 39].

Table 5 – Variance inflation factor of all constructs

Perceived Usability					
	USA1	USA2	USA3	USA4	
VIF	1.136	1.341	1.746	1.760	
Perceived Security					
	SEC1	SEC2	SEC3		
VIF	1.689	1.646	1.376		
Perceived Usefulness					
	USE1	USE2	USE3	USE4	USE5
VIF	1.426	1.261	1.527	1.551	1.326
Usage Intention					
	UI1	UI2	UI3	UI4	
VIF	1.576	1.667	1.574	1.518	

Note. USA=Perceived Usability, SEC=Perceived Security, USE=Perceived Usefulness, UI=Usage Intention,

According the assessments of these criteria of the structural model, Hypothesis 1 was rejected because the path coefficients between perceived usability and usage

intention was not significant ($t=1.529$, $p>0.05$). Both Hypothesis 2 and 3 were supported to confirm the causal relationship of perceived security ($t=2.109$, $p<0.01$) and usefulness ($t=6.452$, $p<0.001$) on usage intention for online recruiting platforms.

Hypothesis 4 was also accepted to validate the causal relationship of perceived usability on perceived usefulness ($t=8.813$, $p<0.001$). However, the path coefficient between perceived security and perceived usefulness were not statistically significant, resulting in the rejection of Hypothesis 5 ($t=0.581$, $p>0.05$).

According to coefficient of determination (R^2), 36.7% of the variance for usage intention was explained by perceived usability, security and usefulness. 23% of the variance for perceived usefulness was explained by perceived usability and security. Both values exceeded the 10% minimum threshold set by Falk and Miller [40].

Effect sizes of standardized regression coefficients (f^2) can be categorized into small effect size (0.02-0.15), medium effect size (0.15-0.35), and large effect size (above 0.35) [41]. Hypothesis 1 and Hypothesis 5 in this study did not achieve a minimum threshold of 0.02 effect size and Hypothesis 2, 3 and 4 were all classified as medium effects size.

Except for Hypothesis 5, Hypothesis 1, 2, 3 and 4 satisfied the assessment of Q-square (q^2) because the values were all greater than 0, which revealed that the predictive relevance of endogenous variables was good [42].

Table 6 – Structural model and hypotheses testing for Hypothesis 1, 2, and 3

Hypotheses	H1	H2	H3
Direct Effects	USA→UI	SEC→UI	USE→UI
Path Coefficients	$\beta=0.110$	$\beta=0.221$	$\beta=0.506$
t-Value	1.529	2.109**	6.452***
Supported	No	Yes	Yes
R^2	0.367		
f^2	0.015	0.076	0.311
q^2	0.003	0.032	0.136
95%CI (LL)	0.341	-0.096	0.341
95%CI (UL)	0.646	0.347	0.646

Note. USA=Perceived Usability, SEC=Perceived Security, USE=Perceived Usefulness, UI=Usage Intention
** $p<0.01$, *** $p<0.001$

Table 7 – Structural model and hypotheses testing for Hypothesis 4 and 5

Hypotheses	H4	H5
Direct Effects	USA→USE	SEC→USE
Path Coefficients	$\beta=0.480$	$\beta=-0.073$
t-Value	8.813***	0.581
Supported	Yes	No
R^2	0.230	
f^2	0.297	0.007
q^2	0.123	0.001
95%CI (LL)	0.380	-0.302
95%CI (UL)	0.595	0.183

Note. USA=Perceived Usability, SEC=Perceived Security, USE=Perceived Usefulness, UI=Usage Intention
*** $p<0.001$

According to the assessments of these criteria of the structural model, Hypothesis 1 was rejected because the path coefficients between perceived usability and usage intention was not significant ($t=1.529$, $p>0.05$). Both Hypothesis 2 and 3 were supported to confirm the causal relationship of perceived security ($t=2.109$, $p<0.01$) and usefulness ($t=6.452$, $p<0.001$) on usage intention for online recruiting platforms.

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Effect sizes of standardized regression coefficients (f^2) can be categorized into small effect size (0.02-0.15), medium effect size (0.15-0.35), and large effect size (above 0.35) [41]. Hypothesis 1 and Hypothesis 5 in this study did not achieve a minimum threshold of 0.02 effect size and Hypothesis 2, 3 and 4 were all classified as medium effects size.

Except of Hypothesis 5, Hypothesis 1, 2, 3 and 4 satisfied the assessment of Q-square (q^2) because the values were all greater than 0, which revealed that the predictive relevance of endogenous variables was good [42].

Assessment of the Mediating Effect

The analyses of mediating effects for perceived usefulness was presented in Table 8. Based on the analysis of direct and indirect effects, hypothesis 6 was accepted because the indirect effect of perceived usability on usage intention through perceived usefulness was positive and significant ($\beta=0.243$, $p<0.05$). In addition, the VAF revealed that the indirect impact constituted roughly 33.79% of the overall effect, indicating the existence of partial mediation.

Hypothesis 7, however, was rejected because the indirect effect of perceived usability on usage intention through perceived usefulness was not significant ($\beta=-0.037$, $p>0.05$). Meanwhile, the value of the VAF was only 16.2%, less than the minimum requirement (20%).

Table 8 – Hypothesis testing of mediating effects for Hypothesis 6 and 7

Hypothesis	H6	H7
Independent Variable	USA	SEC
Mediating Variable	USE	USE
Dependent Variable	UI	UI
Direct Effects(β)	$\beta=0.477^*$ ($t=9.091$)	$\beta=-0.191$ ($t=0.991$)
Indirect Effects(β)	$\beta=0.243^*$ ($t=5.148$)	$\beta=-0.037$ ($t=0.557$)
Total Effects(β)	$\beta=0.720$	$\beta=-0.228$
VAF	33.79%	16.2%
Supported	Yes	No

Note. VAF=Variance Accounted For

* $p<0.05$

Conclusion

To sum up the analysis of PLS-SEM, the fitting results of this study was displayed in Figure 4. In general, the analyses of structural model revealed that the relationships among perceived usefulness, perceived usability and usage intention conformed to the principles of the Technology Acceptance Model. In addition to perceived usefulness, perceived security also had a significant and positive impact on usage intention for online recruiting platforms.

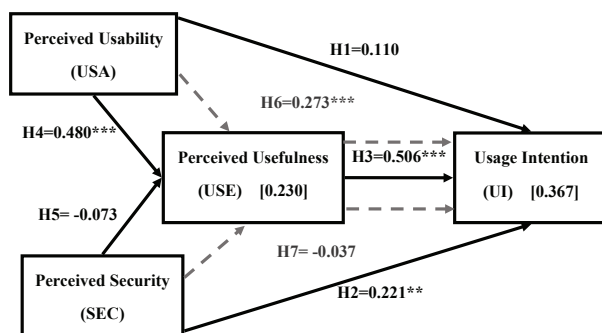


Figure 4 – The fitting result of PLS-SEM

This study also confirmed that that usage intention was indirectly influenced by perceived usability, mediated by perceived usefulness. The significant and positive direct effect of perceived usability on usage intention ($\beta=0.477$, $p<0.05$) disappeared after including perceived usefulness as a mediating variable in the model ($\beta=0.110$, $p>0.05$). In other words, the influence of perceived usability on usage intention was primary through perceived usefulness, which indicated that that the influence of perceived usability on usage intention was indirect. The finding of mediation effect for perceived usefulness aligned well with the Technology Acceptance Model even though attitudes toward online recruiting platforms was replaced by usage intention in this study.

As for the mediation effect of perceived usefulness on the relationship between perceived security and usage intention, both direct effect ($\beta=-0.191$, $p>0.05$) and indirect effects ($\beta=-0.037$, $p>0.05$) were not significant in the structural model. However, a significant and positive direct impact for perceived security on usage intention ($\beta=0.221$, $p<0.01$) was found in the study. This findings indicated that the impact of perceived security on usage intention was direct and could not be mediated by the perceived usefulness. Fortunately, the impact of perceived security on usage intention was roughly equivalent to a half value of perceived usability and usefulness.

Discussion

Derived from the findings of the study, the subsequent recommendations and implications were discussed. Firstly, this research revealed that individuals were more likely to express an intention to use online recruiting platforms when they perceived them as useful. As a result, the importance of adopting a value-centric approach in guiding the design, development and operation of online recruitment platforms should be emphasized. This strategy is geared towards delivering valuable information to job applicants, thereby enhancing the speed, engagement, and efficiency of the job search experience. Notably, the focus is on ensuring that these platforms not only provide relevant information but also play a significant role in assisting job seekers in quickly and effectively finding their desired employment opportunities.

Secondly, the study did not reveal a direct impact of perceived usability on intention to use, which was consistent with the Technology Acceptance Model. However, due to impact of the perceived usability on perceived usefulness for online recruitment platforms, this study also suggested that it is imperative to devote careful consideration to the user experience concerning job seekers, despite the fact that the perceived usability does not exert a direct impact on usage intention. It is

important to carefully develop online recruiting platforms to make them as easy to use as possible, ensuring that every aspect of the platforms is tailored to enhance the overall user experience for individuals seeking employment opportunities. By focusing on user-centric principles to continually refine the interface to meet the evolving needs of job seekers, organizations can create a more engaging and user-friendly online recruiting platforms, thereby fostering the increase of perceived usefulness and usage intention.

Thirdly, because job seekers' security perception affected their willingness to use it and could not be mediated by perceived usefulness, it becomes imperative for corporate organizations to proactively and comprehensively address information security concerns for applicants. It is extremely important for human resource practitioners to acknowledge that information security plays a pivotal role in influencing their willingness to utilize online recruiting platforms. Therefore, the prevention of deceptive and fraudulent activities should be a top priority in the realm of online recruitment. Implementing robust security measures not only safeguards the integrity of the recruitment process but also contributes significantly to enhancing job applicants' trust and confidence. By ensuring a secure environment, organizations pave the way for an improved perception of online recruiting platforms among potential candidates. As a result, awareness of the security protocols implemented can subsequently foster a positive attitude and willingness among job seekers to engage with online recruiting platforms.

Finally, in addition to reconfirming the validation of the Technology Acceptance Model, the results of this empirical study also suggested that it is necessary to incorporate the variable of security perception when applying the model to information technologies, recognizing the growing significance of data protection and privacy concerns in the digital landscape. As technology continues to advance, the inclusion of this critical dimension ensures a more robust and comprehensive understanding of individuals' attitudes and behaviors towards information-related technologies, thereby contributing to a more nuanced and insightful analysis.

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Exploring The Professional CareerLattice Model: A Paradigm Shift In Career Development

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Abstract

The conventional trajectory of career development, marked by a linear climb up the corporate ladder, has long been the predominant model shaping professional growth. However, in the face of an ever-evolving business landscape and the advent of technologies reshaping job structures, a paradigm shift is underway. This research focuses on the emerging concept of the career lattice model, which represents a departure from the traditional linear career path, introducing a more adaptable and dynamic framework for professional development. As organizational structures become more agile and the demand for a diverse skill set intensifies, the career lattice model gains prominence as an alternative approach. In this paradigm, individuals are encouraged to explore lateral moves, acquire a broad range of skills, and prioritize continuous learning over a rigid ascent through hierarchical levels. The motivation behind this research is to critically examine the theoretical underpinnings, practical applications, and potential implications of adopting the career lattice model in the realm of professional development.

Keywords

Career Lattice Model; Traditional Career Model; Career Development; Motivation

Introduction

The traditional career ladder model has become widely accepted as a standard framework for career advancement. However, in today's dynamic and rapidly evolving work environment, the need for a more flexible and adaptive approach to career development is becoming increasingly apparent. This study investigates the emerging concept of the career network model, which differs from the linear trajectory of the career ladder.

The career lattice model recognizes the diverse skills and interests that individuals bring to the workforce and acknowledges that career paths are only sometimes linear. This study explores the theoretical foundations, practical applications, and organizational implications of the professional lattice model. Through an extensive

literature review, case studies and interviews with experts across various industries, we aim to explore the advantages, challenges and potential outcomes associated with adopting this approach. Lattice-based approach to career development.

Key components of the career lattice model include skill development, horizontal mobility, continuous learning, and a focus on holistic career development. By providing a more flexible framework, the lattice model aims to empower individuals to explore diverse career opportunities within and beyond their current role, fostering a culture of enablement, adaptability and resilience to the evolving needs of the industry.

The author's findings contribute to the knowledge base on career development by providing

insights into the potential benefits of applying a career lattice model. Organizations can use these insights to re-evaluate and enhance their talent development strategies, creating an environment that supports employees in achieving personal and professional goals. The research ultimately seeks to inspire a paradigm shift in how individuals and organizations approach career development, promoting a more inclusive, dynamic and sustainable model for the future of work.

Methods

With the aim of gaining a clearer approach to the concept of digital transformation in human resource management and exploring new concept regarding professional lattice model, the author uses a qualitative method, synthesizing databases from international articles. The search process includes the following main steps:

- Database selection: Reputable academic databases, including PubMed, IEEE Xplore, Scopus, Google Scholar, and ProQuest, were selected to access a wide range of interdisciplinary literature .
- Search terms: A carefully constructed set of search terms and keywords were used, including "Career Lattice Model", "Traditional Career Model", "Career Development", "Algorithmic Trends", "Motivation" and "Strategic HR Management". Studies were included based on their relevance to the research objective, publication date (with a focus on the last decade), and compliance with ethical considerations related to Career Model in HR.

Literature Review:

The career lattice model is defined as a non-linear and flexible approach to career development, different from the traditional linear trajectory of the career ladder. It emphasizes horizontal mobility, continuous learning, and the acquisition of diverse skills as indispensable components of career advancement (DeFillippi & Arthur, 1996).The theoretical foundations highlight the need for a paradigm shift in approaches to professional development. The career lattice model, with its focus on lateral mobility, skills development and continuous learning, has emerged as a promising alternative to the traditional career ladder, better suited to meet these challenges and opportunities of the modern workplace.

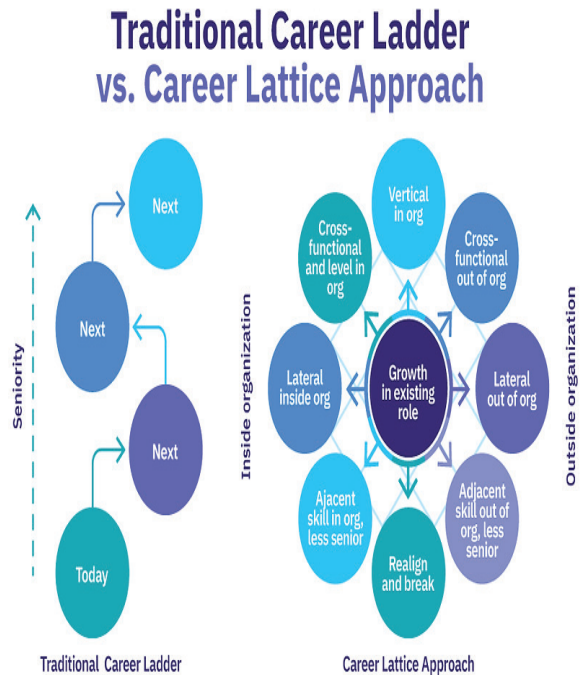


Figure 1: Compare the traditional career ladder model and the network career model

1. *The Traditional Career Ladder Model:* An individual's career trajectory is determined by sequential development, including advancement in positions, positions, higher responsibilities, and increased benefits over time (Hall, 1976).The traditional career ladder model has been the dominant force shaping career development for decades (Hall, 1976).This model implies a linear progression through the ranks within an organization, often characterized by a path of advancement and increasing responsibility (Katz & Kahn, 1978).While this model provides a structured approach to career advancement, critics say it may not adequately address the growing needs of modern professionals in a growing job marketdynamic (Arthur et al., 2005).

2. *The broadcast development of the career network concept:* The career lattice model represents a departure from the rigidity of the career ladder, offering a more flexible and adaptive structure for career development (DeFillippi & Arthur, 1996).Unlike ladders, networks recognize the value of lateral moves, skill diversification, and continuous learning as essential components of career development (Briscoe & Hall,

2006). This shift is driven by the realization that careers are no longer linear and that individuals often seek non-traditional paths to achieve both personal and professional satisfaction (Ibarra, 2004). This model brings significant benefits to organizations, including stimulating employees to acquire new skills, increasing work engagement and improving talent retention (DeFillippi & Arthur, 1996)

3. *Skill Development in Professional Networks* : A fundamental aspect of the career lattice model is its emphasis on skill development. Traditional career ladders may underestimate the importance of acquiring a broad skill set, focusing primarily on advancement within the organizational hierarchy (Sullivan, 1999). In turn, the lattice model encourages individuals to expand their skill base, allowing them to adapt to changing job requirements and make meaningful contributions in a variety of roles (DeRue & Wellman, 2009).

4. *Horizontal mobility and adaptability* : Horizontal mobility, a core principle of a career lattice, challenges the notion that upward mobility is the sole marker of career success (Arthur & Rousseau, 1996). Research shows that marginal experiences contribute significantly to an individual's adaptability and resilience in diverse professional environments (Ployhart & Moliterno, 2011). The ability to move laterally within an organization or between different industries promotes a comprehensive understanding of one's abilities and interests.

5. *Continuous learning as a foundation* : The professional career lattice model emphasizes continuous learning as a lifelong pursuit (Schein, 1978). In contrast to the ladder model, which may prioritize stability over adaptability, the lattice model encourages individuals to proactively seek new knowledge and skills throughout their careers (Tannenbaum & Yukl, 1992). This aligns with the needs of the modern workplace, where rapid technological advances require a commitment to continuous learning (Colvin, 2015).

How to apply the professional network model at business?

Organizations can take a professional career lattice approach by integrating several key strategies derived from academic research. We can mention some of the

following methods:



Figure 2: Several Key Strategies and skill requirements

1. It is necessary to widely disseminate the importance of the career lattice model to employees. When communicating the benefits of adopting a professional lattice approach to stakeholders, organizations can draw on academic research to highlight the significant benefits associated with this model. The career lattice approach, characterized by an emphasis on skills diversification, continuous learning and horizontal mobility, has been recognized as a strategic framework suitable for the growing needs of the modern workforce. First, organizations can highlight the positive impact of a professional lattice approach on employee motivation and engagement. Research shows that when employees are given opportunities to acquire new skills and explore diverse roles within the organization, their motivation and commitment increase significantly (Ployhart & Moliterno, 2011). This, in turn, enhances overall job satisfaction and contributes to a positive organizational culture. Furthermore, a professional lattice approach is associated

with improved talent retention. By offering dynamic and flexible career paths, organizations are better positioned to retain high-performing individuals who can seek external growth and development opportunities (Briscoe & Hall, 2006). Retaining top talent is critical to the success and continuity of an organization, and a professional lattice approach serves as a proactive strategy to address this imperative. Moreover, the alignment of personal aspirations with organizational goals is an essential aspect of the professional career lattice model. This approach allows employees to pursue individualized career paths while contributing meaningfully to organizational goals (Arthur & Rousseau, 1996). Academic research shows that such alignment increases employee job satisfaction and sense of purpose, fostering a more dedicated and productive workforce. Additionally, organizations can emphasize employee adaptability and resilience through a professional lattice approach. By encouraging horizontal mobility and diverse skill sets, individuals are better equipped to navigate the changing industry landscape and technological advances (DeRue & Wellman, 2009). This adaptability is essential in the face of rapid organizational and environmental changes, ensuring sustained performance and innovation.

2. Fostering a culture that values continuous learning and skill development is imperative (DeRue & Wellman, 2009). Encourage employees to participate in ongoing training programs and provide resources to acquire skills consistent with the fundamentals of the professional career lattice model.

3. Peer mobility within the organization is another important aspect. Organizations should provide opportunities for employees to explore diverse roles and functions, fostering a more dynamic and adaptable workforce (Briscoe & Hall, 2006). This may involve creating internal job rotation programs, cross-functional projects or mentoring initiatives to encourage peer mobility and broaden employee skill sets.

4. Furthermore, organizations can enhance their career lattice approach by implementing transparent and individualized career development plans (Arthur & Rousseau, 1996). This involves conducting regular career discussions between employees and managers, and identifying the individual's strengths, interests and areas of development. Such individualized planning is

consistent with the career lattice model's emphasis on individualized career paths.

Discussion:

Exploring the Career Lattice Model as a paradigm shift in career development emphasizes its importance as a transformative framework. This discussion delves into crucial aspects of this model, considering the theoretical underpinnings, practical implications, and broader organizational implications. The career lattice model challenges the traditional, linear trajectory of career development, offering a model that is deeply rooted in theoretical foundations. Drawing from the work of DeFillippi and Arthur (1996), this model is consistent with the competency-based view, which emphasizes the importance of acquiring a diverse skill set for career success. This theoretical foundation asserts that career advancement is not only associated with the ability to advance but also includes transitions and the continuous development of competencies.

Practical significance:

The practical significance of the career lattice model is underscored by its departure from conventional, rigid career trajectories. It advocates for individuals' active engagement in organizational movements, fostering adaptability and resilience (Briscoe & Hall, 2006). This practical importance is accentuated by the model's explicit emphasis on continuous learning, aligning with the dynamic nature characterizing the contemporary workplace (Colvin, 2015). The pragmatic utility of professional networking manifests in its capacity to afford employees a more pertinent and fulfilling career trajectory. This departure from traditional structures holds noteworthy implications for organizational dynamics, emphasizing the adaptive capacities of individuals and promoting ongoing skill development in tandem with the evolving demands of the professional landscape.

Organizational impact:

The organizational impact of applying the professional lattice model is multifaceted. Organizations will benefit from a talent development perspective by creating an environment conducive to skill diversification and continuous learning. This resonates with the findings

of Ployhart and Moliterno (2011) who argue that such strategies contribute to the creation of human capital that enhances organizational performance.

Furthermore, a professional lattice approach positively influences employee engagement and retention. Research by Sullivan (1999) shows that organizations that offer diverse career paths are more likely to retain top talent. By recognizing the value of different career trajectories, the lattice model reflects the modern workforce's desire for flexible and meaningful career experiences (Ibarra, 2004).

Challenges and future trends:

The prospective efficacy of the career lattice model is apparent; nevertheless, it is confronted by persisting challenges, notably resistance to organizational change and the imperative requirement for resilient infrastructural frameworks to facilitate seamless lateral movements. Mitigating these challenges is essential for the comprehensive realization of the benefits inherent in the career lattice model.

Looking towards the future, scholarly investigations should intensify their scrutiny of these challenges, delving into a more intricate analysis of the underlying factors contributing to resistance to change within organizational dynamics. Additionally, a nuanced examination of the intricate interplay of elements that necessitate robust systems for supporting lateral movements is imperative. Future research endeavors should address these identified challenges and explore innovative strategies geared towards the meticulous optimization of the implementation of the professional career lattice model.

The optimization of the professional career lattice model's deployment necessitates a multifaceted scholarly approach. This involves the development of strategies that not only navigate and mitigate the identified challenges but also leverage the intrinsic strengths of the career lattice framework. By adopting such a strategic and comprehensive approach, organizations can effectively harness the model's potential to instigate flexibility, foster skill development, and facilitate the progression of careers within the workforce. This scholarly investigation and strategic optimization are paramount for shaping the prospective trajectory of professional career lattices

within the dynamic milieu of contemporary workplaces.

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Burnout and Engagement in the Context of Job Demands-Resources Model: The Mediating and Moderating Role of Self-Efficacy

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Abstract

How to create high levels of employee engagement and how to avoid burnout in the workplace is main issue in human resource management. According to Job Demands-Resources (JD-R) model, this study aims to investigate when self-efficacy plays as a mitigator on the impact of job demand on burnout, and explains why job resources are translated into work engagement. A sample of 237 Mongolian employees is used to test hypotheses. Results show that self-efficacy does offset the relationship between job demands and burnout. Meanwhile, self-efficacy plays as a mediator on the impact of job resources on work engagement. The implications of these findings for the context of JD-R model are discussed.

Keywords

Job Demand, Job Resource, Self-efficacy, Employee Engagement, Burnout

1. Introduction

The Job Demands-Resources (JD-R) model [1][2] attributes the characteristics of work environments and employee well-being. Resulted from JD-R model, the attributions of working setting are separated into two categories: job demands and job resources. Job demands are referred as aspects of work standing in need of the sustained effort and as a result of being related to physical and psychological costs [3]. Job resources are referred as aspects of work (e.g., physical, social, or organizational) functional in realizing work-related goals, meeting different job demands at psychological costs, and motivating personal growth and development [4][5]. Job demands are the most important predictors of burnout [6], whereas job resources are the distinctive predictors of work engagement [7].

Two independent psychological processes which are health impairment and motivational process [8] are evoked by these two types of job demands and resources. On the basis of the health impairment process, high levels of job demand requiring sustained physical or mental effort may carry off employees' resources and bring about energy draining and psychological health symptoms such as burnout [9]. By contrast, on the basis of the motivational processes, the obtainability of job resources

results in work engagement (Schaufeli & Bakker, 2004). The motivational process is incurred by plentiful job resources and may lead to employee engagement.

According to Conservation of Resources (COR) theory [10], there are two main assumptions: (1) individuals invest resources to respond to threatening situations and keep negative outcomes from arising; (2) Individuals not only endeavor to conserve these resources but also store them up. Considering the above assumptions, self-efficacy as personal resource is recognized to the potential moderating role in the relationship between job demands (threats) and burnout (negative outcome). In addition, considering the motivational process of the JD-R model combined with the second assumption of COR theory, self-efficacy as personal resource is recognized to the mediating role to explain job resources enrich efficacy beliefs, which in turn increase employee engagement. This study suggests the combination of COR theory with the buffer hypothesis in the health impairment process of JD-R model and with fostering hypothesis in the motivational process of JD-R model.

Based on the above, this study attempts to take self-efficacy as the core concepts, burnout and engagement in the context of job demands-resources model as its

consequence variable. Based on job demands-resources model mainly and resource conservation theory, job demands may affect employee burnout and job resources may affect employee work engagement. Self-efficacy as personal resource plays not only as a mitigator on the impact of job demand on burnout, but also as a mediator on the impact of job resources on work engagement. Through the health impairment process, self-efficacy is expected to moderate the positive job demands—burnout relationship. on the other hand, through the motivational process, self-efficacy is also expected to mediate the positive influence of job resources on work engagement.

2. Literature review and hypothesis building

2.1 The moderating role of self-efficacy

Burnout informs employee about psychosocial risk and health problems in the workplace [11]. As [12] statement: “Energy, involvement, and efficacy—these are the direct opposites of the three dimensions of burnout.”, burnout is considered as an erosion whereby “Energy turns into exhaustion, involvement turns into cynicism, and efficacy turns into ineffectiveness”. Burnout is defined as a multidimensional construct that encompasses emotional exhaustion (i.e., feelings overly drained and depleted of emotional and physical resources), depersonalization (i.e., displaying negative, immoderately detached reactions to person being served or cared for.), and lack of personal accomplishment (i.e., feeling incompetent and lacking success at work) [13][14]. Past studies have examined the impact of job demands on the exhaustion component of burnout [2] [6][7] [15].

Rather than focal point of task-specific self-efficacy [16], this study investigates a general construct, namely, individuals' perceptions of their capability to master the necessary job skills with motivational and cognitive resources and to satisfy their needs in a broad context [17]. The accumulation of successes and persevering positive experiences can enhance general self-efficacy [17]. Employees with high level of general self-efficacy have better mastery that assists them to cope with demanding conditions more effectively, and in turn avoid them to experiencing negative outcomes [6]. Self-efficacious employees will focus on motivational and cognitive resources, formulate a comprehensive environment and how they response to it. As a result, they will experience lower levels of burnout. Self-efficacy buffers the relationship between job demands and burnout, that is to say, employees low in self-efficacy show that when job demand is high, their levels of burnout increase. Therefore, the following hypothesis is suggested:

Hypothesis 1: Self-efficacy moderates the relationship

between Job demands and burnout.

2.2 The mediating role of self-efficacy

Work engagement is characterized by vigor (i.e., energetic at work with strong mental resilience, willingness to work investment, and perseverance in the face of obstacles), dedication (i.e., work with enthusiasm and passion), and absorption (i.e., being happily immersed in work so as time flies and difficulty in detachment from work), which is a motivational and work-related state of fulfillment [18]. Work engagement is not a specific and temporary state, but a more general affective-cognitive state.

The attainability of job resources that help achieve work goals [19] drives the motivational process. Job resources act a motivator because they facilitate employee growth, learning, and development. Work engagement may be promoted by job resources through a motivational process which meet basic needs and which enhances the possibility of achieving work goals. Job resources may be identified as important predictors that highlight engagement on the likelihood of personal development through work. Personal resources are concerned as individuals' perceptions of their potential to successfully control and influence their environment [20]. Self-efficacy as personal resource is included as a principal extension of the JD-R model [21]. Self-efficacy promotes motivation with affecting the challenges individuals run after, the effort they invest, and the persistence with facing difficulties. Self-efficacy indeed acts as a self-motivating mechanism in the relationship between job resource and work engagement. Hence, the following hypothesis is suggested:

Hypothesis 2: Self-efficacy mediates the relationship between Job resources and work engagement.

Grounded on the aforementioned discussion, the research framework is organized as shown in Figure 1.

Figure 1 Hypothesized Model

3. Method

3.1 Samples

The data was collected through online questionnaire. Questionnaire with a clear research purpose introduction were send through the internet such as e-mail and social media. The research population in this study were the employees, who are currently working in Milk JSC established in 1958. This manufacture factory produces and trades 100% milk products.

Data was distributed through questionnaire survey online over 3 months period. A total of 380 survey questionnaires are mailed to Milk JSC's employee. A sample of 311 questionnaires was collected. Due to incompleteness feedback or loss of data, 74 of these samples were invalid which were removed from total response. As a result, the total 237 response can be used. The effective feedback rate was 76%. Among the employees, 56.5% were female. 33.8% of employees fall in 31-35 years old, 31.6% in 26-30 years old, and 40.5% in 2-5 years. 34.6% of employees' work experience in industry fall in 6-10 years in their current organization. 50.2% of the employees held a bachelor degree or above.

3.2 Measurement

The survey items used in this study were originally written in English. It is needed to follow back-translation procedure proposed by [22] to translate them into Mongolian for the accurate understanding. A 5-point Likert-type scale is adopted for all variables measurement with ranging from (1) "a little or no extend" to (5) "a great extension."

3.2.1 Job demands

The measurement of job demands was adopted from the 12-item scale developed by [3], is used in this questionnaire. Employees were asked to assess the use of three subdimensions: workload, change in task, and emotional load. Example items are "I have to work extra hard because I have to finish my order", "I have the proposed changes in my tasks are introduced well", and "I confronted with things that affect me personally in my work". Cronbach's alpha is .895.

3.2.2 Job resources

The measurement of Job resource was adopted from the 6-item scale developed by [3] including two dimensions: autonomy, coaching by supervisor and professional development. Employees were asked to assess the use of two subdimensions: autonomy, and coaching by supervisor and professional development. Example items are "On my job, I have freedom to decide how I do my work", "My supervisor uses his/her influence to help me solve my problems at work", and "I have sufficient possibilities to develop myself at work". Cronbach's alpha is .736.

3.2.3 Self-efficacy

The measurement of self-efficacy consists of 10 items, which were adopted from [23], is used in this questionnaire. Example items are "I can always manage

to solve difficult problems if I try hard enough", "I can remain calm when facing difficulties because I can rely on my coping abilities", and "When I am confronted with a problem, I can usually find several solutions". Cronbach's alpha is .770.

3.2.4 Work engagement

The measurement of work engagement 14-items scale adopted from [24] with three dimensions of engagement including vigor, dedication and absorption. Employees were asked to assess the use of three subdimensions: vigor, dedication, and absorption. Example items are "At my work I always persevere, even when things do not go well", "I find the work that I do full of meaning and purpose", and "When I am working, I forget everything else around me". Cronbach's alpha is .922.

3.2.5 Burnout

The measurement of burnout 15 items scale was adopted from [25]. Example items are "I am harder and less sympathetic with people than perhaps they deserve", "I feel that organizational politics or bureaucracy frustrate my ability to do a good job", and "I feel that I do not have time to do many of the things that are important to doing a good quality job". Cronbach's alpha is .894.

3.2.6 Control variables

The following variables are controlled for in the hypothesis testing: several demographic variables (i.e. gender, age, and education) and work-related (i.e. work experience in industry) background variables, because they have been found to be related to employee burnout and work engagement. Gender has been found to influence affective commitment [26], because of empathy rooted in women is higher than in men [27]. Age differences of employees are with different positions on themselves, others and work. Young and highly educated employees pay more attention to economic exchange and fair treatment [28]. Consequently, gender, age, education, and work experience in industry were chosen within the analyses.

4. Analysis

4.1 Correlation analysis

Descriptive statistics and correlational analysis of measured variables are reported in Table 1. Job demand is significantly and positively related to self-efficacy ($r=.168, p<0.01$), and burnout ($r=.701, p<0.01$). Job demand is non-significantly related to job resource ($r=.104, p=.109$) and work engagement ($r=.098, p=.133$), significantly related to self-efficacy ($r=.168, p<0.01$). Job resource is significantly and positively related to self-efficacy ($r=.520, p<0.01$), and work engagement ($r=.647,$

$p < 0.01$).

Job resource is non-significantly related to burnout

	Mean	SD	1	2	3	4	5	6	7	8	9
1. Gender	1.565	.496	1								
2. Age	3.569	1.196	.190**	1							
3. Education	4.265	.961	.190**	.310**	1						
4. WEind	2.455	1.191	.107	.762**	.312**	1					
5. JD	3.380	.466	.138*	.057	.219**	.012	(.895)				
6. JR	3.732	.453	.010	.083	.027	.111	.104	(.736)			
7. SE	3.523	.330	.059	.098	.195**	.157*	.168**	.520**	(.770)		
8. Burnout	3.150	.431	.134*	.033	.081	-.025	.701**	.069	.095	(.894)	

	Burnout			SE		WE	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Gender	.048	.048	.037	.029	.047	.027	.038
Age	.036	.035	.016	-.128	.002	.086	.039
Education	-.083	-.082	-.041	.168**	.013	-.081	-.035
WE	-.063	-.062	-.025	.042	.194*	.247*	.182
JD	.711***	.713***	-.902*		--	--	--
JR	--	--	--	.512***	.619***	--	.472***
JD*SE	--	--	2.086***	--	--	--	--
SE	--	-.010	-1.096***	--	--	.538***	.287***
F	32.852***	28.630	28.170***	14.919***	28.118***	18.445***	30.749***
R ²	.501	.501	.528	.313	.462	.361	.519

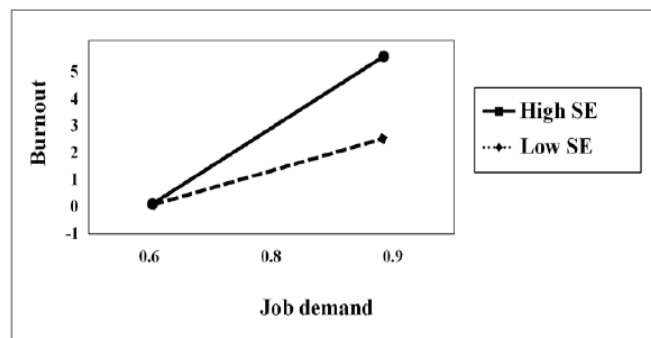


Figure 2 The interaction of job demand and self-efficacy on burnout

To test the effect of job resource on self-efficacy, self-efficacy was regressed on LMX with control variables of gender, age, education and work experience in industry shown as Table 2 (M4: $\beta = 0.512$, $p < .001$).

In accordance with [29], conditions are necessary to test H2. The analysis results show a significant mediation effect of self-efficacy. When self-efficacy was entered into the equation as shown in M7, job resource significantly predicted work engagement ($\beta = .472$, $p < .001$), whereas self-efficacy significantly predicted work engagement ($\beta = .287$, $p < .001$). The effect of job resource on work engagement did drop from .619 ($p < .001$) to .472 ($p < .001$). Therefore, H2 was supported.

5. Research discussion and suggestion

This study aims to test the moderating role of self-efficacy with regard to the JD-R model, and its impact on burnout (hypothesis 1). The other study objective is to test the mediating role of self-efficacy with regard to the JD-R model, and its effect on work engagement (hypothesis 2). Hypothesis 1 and 2, the so-called interaction hypothesis,

are confirmed.

5.1 Practical implication

The first relevant result is that high levels of self-efficacy buffered burnout when job demands are high, as was expected. The empirical evidence of the moderation of self-efficacy in the relationship between job demands and burnout contributes significantly in explaining the health impairment process of the JD-R model. This finding may highlight that this personal resource operates not only at affective-cognition but also at behavioral-practice. Self-efficacy as personal resource of a more practical nature such as an individual ability to allocate time or energy to invest in specific tasks. This attribution may also be vital for human resource manager aware of the specific job demands and burnout prevention.

The mediation of self-efficacy in the relationship between job resources and work engagement contributes significantly. The empirical evidence explains the utility mechanism of the motivational process of the JD-R model. This significant process from job resources to work engagement through self-efficacy mainly emphasizes a more active role in the model's motivational process. Since through the activation of employees' beliefs in more capable to perform their tasks the capacity in a resourceful environment, job resources can draw forth more positive appraisals of work engagement situations.

5.2 Limitation and future research

As far as the study's limitations, several limitations in this study are considered to be acknowledged as a starting point for future work. First, due to self-reported data used to identify all variables with the increase of the likelihood of common method, cross-sectional and longitudinal study design are suggested to validate our findings over time for further research. Second, using only a homogeneous sample of Mongolian employees in Milk JSC, it limits the generalizability of the results to the heterogeneity of other occupations. Therefore, it is important for future research to study other organizational contexts. Finally, future research can consider different kinds of job demands/resources, as well as personal resources for deepening the complexity of the study model.

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Learning from Supervisor and Communicative Career Competencies: A Moderation-Mediation Analysis

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Abstract

Purpose: The present research aims to explore the influence of learning from supervisor on communicative career competencies and the mediating effect of using resources. Furthermore, the moderating role of intentional behavior is also examined.

Design/Methodology/Approach: - The data from 316 employees working in India were collected. The authors employed Hayes PROCESS Macro (Model 4 and 7) and bootstrapping procedure to investigate the hypothesis.

Findings: Learning from supervisor was found to be positively associated with communicative career competencies through using resources. Furthermore, intentional behavior moderates the association between learning from supervisor and using resources, in way that association is stronger when intentional behavior is high. Also, intentional behavior moderates the indirect impact of learning from supervisor on communicative career competencies.

Practical Implications: - The present study emphasized supervisor to demonstrate more supportive behaviors such as thinking together to solve work-related problems, see employees' mistake as learning curve, help employees' succeed and furnish resources and opportunities, which in turn builds communicative career competencies of employees.

Originality/value: -The present research is the pioneer effort to investigate the relationship among learning from supervisor, intentional behavior, using resources and communicative career competencies.

Keywords

Learning from Supervisor; Communicative Career Competencies; Using Resources; Intentional Behavior; Moderated-mediation analysis

Paper type: Research Paper

Transformational Leadership and Employee Contextual Performance: Role of Self-determination and Competency.

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Abstract

In today's world of high competition, leadership plays a crucial role in ensuring the overall well-being and prosperity of organizations. Effective leaders are responsible for offering a clear sense of purpose, inspiration, and direction to their followers. Leadership plays a crucial role in ensuring the long-term sustainability and expansion of an organization by employing strategic planning, resource allocation, and effective stakeholder management. However, no study has explored the effect of specific aspects of leadership. Our study examined the impact of transformation leadership on contextual performance of employees. We also explored the mediating roles of individual attributes, like self-determination and moderating role of competency. Data was collected through questionnaire survey from 327 employees belonging to manufacturing and service sectors of Indian organizations. Results obtained through regression, path and effects analysis using the statistical tools of SPSS, PROCESS macro and AMOS, show that transformational leadership style of the leader has a direct and positive effect on contextual performance of employees. It also has an indirect effect on self-determination and competence. The findings contribute to the literature on leadership and employee attributes that promote employee contextual performance. Theoretical and practical implications, and future research directions are discussed.

Keywords

Transformational Leadership, contextual performance, self-determination, competency, leadership, employee performance, mediation, moderation.

Study on Military Veterans Returning to Their Garrison in Kinmen: Nostalgia Tourism and Well-being

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Abstract

The 2023 Kinmen Military Call-up Order"tourism promotion activity, hosted by the Kinmen County Government Tourism Bureau, attracted over 13,000 retired Military Veterans who once served in the Kinmen Garrison to revisit the island. This included some veterans over 90 years old, with thousands of family members accompanying them. Recalling the unique scenes of hundreds of thousands of soldiers in green uniforms shuttling through the streets during Kinmen's martial law period from 1956 to 1992, the Kinmen County Government appreciated the veterans' dedication to defending the homeland. In particular, the familiarity and deep affection veterans have for Kinmen motivated the county government to encourage and summon the veterans to return to Kinmen during the off-peak tourist season, boosting Nostalgia Tourism on the island. Every few years, veterans stationed along Kinmen's former frontline borders also arranged reunions at their old Kinmen Garrison posts. They often took the initiative to tidy up the environment, with pre-mission reminders, to ensure the tasks could be completed smoothly like during their service days.

This study aimed to explore the relationship between Nostalgia Tourism – veterans revisiting their old Kinmen Garrison posts – with Authentic Pride and Well-being, and to understand the psychological motivations behind veterans' Nostalgia Tourism. understand the psychological motivations behind veterans' Nostalgia Tourism. Through a questionnaire of 379 Military Veterans who returned to Kinmen, we found significant positive correlations between Nostalgia Tourism and Authentic Pride, Authentic Pride and Well-being, with Authentic Pride fully mediating to bring Well-being through Nostalgia Tourism.

This study provides insights into veterans' psychological needs and emotional states when revisiting old posts, with implications for management. It also provides an empirical basis for formulating post-retirement counseling and social support strategies.

Keywords

Military Veteran, Kinmen Garrison, Nostalgia Tourism, Authentic Pride, Well-being

Rendang: Agent of Indonesian Culture in the International World

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Abstract

Rendang is the most delicious local Indonesian food in the world and has a special place in the hearts of those who enjoy it. This article aims to examine what makes rendang chosen as the most delicious food in the world by CNN International in 2011 and 2018 based on the experiences of people who have eaten rendang abroad and written their reviews on TripAdvisor. Content analysis was carried out based on 339 comments about rendang on TripAdvisor in Asia, Australia, Middle East, Europe, United Kingdom, and North America and were classified into six themes, namely the taste of rendang, ambience of Indonesian restaurants, rendang's value for money, throwback memories with rendang, Indonesian restaurants abroad are like gems, and the differences between Indonesian and Malaysian rendang. These six themes reflect what you need to know about the history and origins of rendang. In the medium-term, rendang can be considered an agent of Indonesian culture that can introduce the richness of Indonesia's culinary to the international world.

Keywords

Local food, rendang, content analysis, agent of Indonesian culture

Introduction

Indonesia is famous for its diverse culinary delights that are rich in flavor with a blend of spices, textures and appetizing aromas [20]. This diversity is formed due to cultural assimilation that happened during the trade era hundreds of years ago which coincided with the entry of Hinduism, Buddhism, Christianity and Islam into local society, as well as colonialism which lasted 350 years. Consequently, there is a distinct influence in Indonesian culinary history in terms of how to prepare, cook, serve, and consume food. For example, in local Indonesian food we can see the influence of Indian (meat and vegetable curry), Arabic (satay), and Chinese (noodles) cultures which have been adapted to local tastes, customs and ingredients. Meanwhile, Spain and Portugal took part in bringing chilies from South America which became one of the characteristics of Indonesian food. Europeans also brought vegetables such as potatoes, tomatoes, pumpkin, cabbage, cauliflower and carrots [34].

Apart from that, geographically Indonesia is the largest archipelagic country in the world with a total of 17,508 islands whose tropical climate and high humidity support a rich and unique combination of various natural resources. Meanwhile, Indonesia has richness and cultural diversity with 1,331 ethnicities classified into 600 major ethnic groups [2]. Each of this ethnic group has its own local food as well as various characteristics and uniqueness, such as the ingredients used, the cooking and the type of eating utensils used, the presentation of food, and the

different ways of eating these foods [34].

These local foods can attract tourists searching for extraordinary experiences and also appeal to those who value authenticity and locality [37]. For many tourists, local food is a gateway to understanding a destination's intangible and cultural heritage [5] which can be represented by local food culture to give tourists an idea of the destination's typical lifestyle [6] and the specificity of a region [25]. Moreover, local food and dining experiences are an essential part of a tourists' holidays and are one of the motivating factors for visiting a destination [5].

As the main driver of tourists' memorable experiences, local food has been widely discussed in the hospitality and tourism literature [11] because it has a positive influence on memorable destination experiences [29] which can inspire their travel plans [8], influence destination choices [19; 25], and foster travel satisfaction [25]. As a consequence, many tourist destinations have tried to offer local foods to foreign tourists to improve the image of a destination.

Because previous studies reveal that local food can be used as a competitive criterion for tourist patronage behavior towards a destination [22], local food has now become a key element emphasized in destination marketing policies/strategies [30] and will continue to grow because every country has its national and regional iconic dishes [5].

Accordingly, tourism marketing must be able to design the right strategies to promote local food by understanding tourists' perception of a destination and predict their future behavior to increase the value of local food consumption [9]. Typically, local food is sought after by tourists because of its taste, presentation and uniqueness [1], destination image, service quality, cultural heritage and atmospheric environment [13;24; 33].

In Indonesia, there is countless local food because in 2023 Indonesia has 38 provinces consisting of 416 districts and 98 cities. Based on research conducted by senior culinary expert Murdijati Gardjito from 2014 to 2016 using IT-based mapping, there were 3,259 Indonesian foods recorded [17]. The list of foods can still grow because there are still many culinary delights whose names are not yet known.

Of the local Indonesian foods, rendang (slow-cooked spicy beef) was named one of the foods included in the Intangible Heritage category by the Indonesian Ministry of Education and Culture in 2013 [32]. Rendang was also chosen as a national dish, along with *soto* (traditional Indonesian soup), *nasi goreng* (fried rice), satay, and *gado-gado* (mixed vegetables) by Indonesia's Ministry of Tourism 2018 [35].

Rendang's popularity abroad began to increase in the 1980s when it was introduced to foreign tourists visiting Indonesia. However, rendang has become increasingly popular throughout the world after being ranked 1st in CNN International's "World's 50 Most Delicious Foods" in 2011. Several years later, CNN again crowned rendang as number 1 in the "World's 50 Best Foods" in 2018 [15] and ranked 11th in the same category in 2021.

To find out what makes rendang chosen as the most delicious food in the world, this article aims to examine it based on the experiences of people who have eaten rendang abroad who then wrote their reviews on TripAdvisor. Content analysis is used to analyze comments about rendang on TripAdvisor.

The writing structure in this article is the history and origin of rendang, the philosophical meaning of rendang, the history of rendang's popularity, and the power of social media as a basis for discussing the answers to the research question.

The History and Origin of Rendang

Rendang is a local food of the Minang people who live in Minangkabau, West Sumatra, Indonesia (Minangkabau: *minang*=win and *kabau*=buffalo). Rendang is made with

meat simmered in coconut milk and spices [21]. For the Minang people, rendang has been around for a long time and has become a traditional dish served at various traditional events and daily dishes [7].

Historically, the name rendang comes from the Minang language, namely *randang*. The word *randang* refers to a cooking technique called *marandang*, which means processing and stirring food for more than 7 hours so that the resulting dish becomes dry [7; 21]. The texture of meat becomes soft and aromatic with spices so that the meat is browned in color. The complex cooking process gives rendang a very unique and delicious taste.

The existence of rendang cannot be separated from cultural acculturation that entered Minang. One culinary dish that is similar to rendang is curry which originates from India. This happened when traders from Gujarat, India who brought spices started coming and living in the Minang area at the beginning of the 14th century to carry out trade contracts [4; 7]. These spices and herbs were then used and modified in the cuisine of the Minang people.

Therefore, it is believed that rendang has existed since the time of the Pagaruyung Kingdom, precisely during the time of King Adityawarman (1347-1375 AD) [38]. However, the meat used at that time came from buffalo because for the Minang people, buffalo were an important animal whose rank was considered much higher than other animals [10]

Furthermore, many opinions say that curry, a typical Indian food, is the origin of rendang. This is proven by the use of coconut milk or *karambia* in the Minang language as a thickener for rendang, just as India uses coconut milk as a thickener in making its curry dishes [4].

This is also confirmed by a statement from the heir of the Pagaruyung Kingdom who said that there was a possibility that rendang was a curry dish that was further processed by stirring it continuously so that it became drier and darker. As a result, rendang lasts longer than curry which still contains has a lot of sauce [4; 38].

The Philosophical Meaning of Rendang

For the Minang people, rendang is a food of pride and honor because it is usually served at sacred traditional events or special celebrations, such as grandparents' coronation ceremonies, weddings and other traditional events [4; 12]. At these events, rendang is the main dish because it is considered a sacred dish in traditional Minangkabau events [35].

The tradition of preserving meat has been carried out

by the Minangkabau people for a long time. They usually preserve meat in a conventional way, without using chemicals [36]. They believe that rendang is a manifestation of the philosophy of the Minangkabau people, namely: (1) patience to carry out a long cooking process of rendang (more than 7 hours), (2) persistence in stirring rendang until the coconut milk dries, and (3) wisdom in setting and controlling the fire during the cooking process [4; 21].

Apart from that, there is also a deeper philosophy for each ingredient used in making rendang. First, as the main ingredient, buffalo meat symbolizes tribal leaders (*niniak mamak*) and female leaders (*bundo kanduang*) who can provide good understanding and prosperity for future generations [4]. Second, coconut (*karambia*) which symbolizes the intellectuals (*cadiak pandai*) who will be a unifier between groups and individuals in social life in Minangkabau [4].

Third is chili (*lado*) which symbolizes religious scholars (*alim ulama*) who are sharp and firm in teaching religion (*syarak*) and provide good understanding to the community. Lastly, various types of spices symbolize the unity of every individual living in Minangkabau who has their own role to advance the social life of the community [4]. In other words, spices signify the entire Minangkabau community.

History of the Popularity of Rendang

Rendang is increasingly known and has spread far beyond its original region because of the Minangkabau migration (*merantau*) culture [7]. Since ancient times, many Minang people have left their hometown and migrated to other cities in Indonesia. At that time, the modes of transportation were not as good as today, so they brought rendang as provisions for long journeys [7]. Rendang can last up to one month.

At that time, Minang people liked to travel and sail to the Strait of Malacca and Singapore to trade in the early 16th century [4]. That is until now why rendang is widely known both in Sumatra and the Malay Peninsula [7].

Apart from working as employees or doing business, a number of Minang people have also become entrepreneurs by opening Minang Restaurants throughout Indonesia, even expanding to several other countries, such as Asia, Australia, Europe, and the United States [7]. This restaurant introduces rendang and other Minangkabau dishes widely.

Sharing Dining Experiences via Social Media

In an era where technology is increasingly developing, the Internet has a very significant influence on people's lives, thereby causing an evolution in customer consumption habits [18]. Customers can shop, communicate, obtain information and share thoughts without leaving the house, just by moving a finger [14; 16]. Information and experiences related to the products are spread among people who are socially and geographically dispersed.

Information provided on consumer opinion sites is more influential among consumers [14] because 93% of consumers say online reviews will affect shopping choices and purchasing decisions [31]. Moreover, previous study reveals that customers usually place great importance on atmosphere, service quality, food-beverage quality, and price [26]. These factors shape future consumption behavior and eating experience satisfaction.

Therefore, sharing reviews on social media, whether positive or negative, is very important for food beverage management. Overall performance should at least equal to or above expectation. If it is below expectations, it means there are many complaints cited by customers. This condition needs to be addressed immediately to avoid a bad image which could result in a decrease in the number of customers.

Research Method

Although there are many websites for travel advice and customer reviews, TripAdvisor is frequently used before planning a trip [27] because it is an established platform known internationally with a wide user base. This site is an application that can be used as a travel planning guide by utilizing the reviews of other tourists to make decisions. Consumers trust comments posted on TripAdvisor.

To answer this research question, content analysis was carried out on reviews and comments from customers who had eaten rendang at restaurants registered on TripAdvisor abroad, both positive and negative comments. The results of this analysis can be used as a guide for new customers who want to dine in at a restaurant or order via delivery service.

To get the right comments, the keywords typed on the TripAdvisor platform are "Indonesian Rendang." Additionally, to ensure no comments are missed, city or country keyword are also added, for example "Indonesian Rendang" AND "Middle East."

Comments collected from restaurants that sell rendang. Usually, they write the type of restaurant as Asian, Indonesian, Singaporean, Malaysian, Thai to attract consumers who like Southeast Asian food. But some owners also add "Halal" and/or "Vegetarian."

Comments are selected from customers who have eaten rendang in their food choices and written reviews on TripAdvisor. There are 339 comments from restaurants in 18 countries written between 2010 and 2023. The countries are grouped by region, namely Australia, Southeast Asia, East Asia, South Asia, Middle East, Europe, United Kingdom, and North America. The details can be seen in Table 1.

Table 1. Comments by Region and Countries

Region	Comments	Countries/Cities
Australia	33	Sydney (6), Darwin (12), Kalbarri (9), Perth (6)
Southeast Asia	83	Singapore (45), Malaysia (23), Thailand (5), Philippines (10)
East Asia	42	Taiwan (9), Hong Kong (17), China (10), Japan (6)
South Asia	15	India (11), Sri Lanka (4)
Middle East	16	United Arab Emirates (14), Turkey (2)
Europe	44	Netherlands (15), France (8), Portugal (2), Switzerland (19)
United Kingdom	65	London (54), Oxfordshire (11)
North America	41	Oklahoma (5), Oregon (6), Virginia (30)
Total	339	

Findings

The results of content analysis based on comments about rendang on TripAdvisor were classified into six themes, namely the taste of rendang, ambiance of Indonesian restaurants, rendang's value for money, throwback memories with rendang, Indonesian restaurants abroad are like gems, and the differences between Indonesian and Malaysian rendang.

The Taste of Rendang

The deliciousness of rendang is expressed in a various words chosen by customers, such as so tender with a lovely flavor, tasty and chewy, spicy, yummy, super delicious, amazing, fresh, aromatic, brimming with flavor, wonderful flavor, rich and flavorful. because the gravy worked together beautifully. These various expressions occur because rendang sauce blends beautifully into the beef.

That is why they said rendang is a must try food, great food, best dish, absolutely nothing disappointed, perfect, absolutely best, superb, outstanding, excellent, absolutely fantastic, extraordinary, super nice, terrific, cooked to perfection, and a food to die for.

Rendang has a spicy taste because the majority of Indonesian people like spicy food which comes from the spices and chilies used to season rendang. However, many Indonesian restaurants abroad have adjusted their spiciness levels because they are worried that many foreigners will not be able to stand it. Therefore, comments written by several customers who have lived in Indonesia or have tasted rendang when visiting Indonesia are "it doesn't taste as spicy as the authentic rendang" or "the level of spiciness has been localized" when eating it in Indonesian restaurants abroad.

However, a customer in Zurich, Switzerland wrote a comment that was quoted on behalf of other customers:

"I ordered rendang which was slow cooked food heaven. It had been prepared properly and the beef was so tender that it could be cut with a spoon. The flavors were so delicious and you knew this was a dish that had been prepared with love."

In summary, rendang is considered the best local Indonesian food because it is an authentic beef that is tender and spicy with amazing aroma of spices and yummy taste. It tastes as good as the ones in Indonesia.

Ambiance of Indonesian Restaurants

The ambiance inside the Indonesian restaurant was described by several customers in various countries. For example, a cozy restaurant with beautiful views from where we sat, attention to detail and taste, and all the staff were very positive and helpful to give prompt service. It is really like the luxurious restaurants here and back home. They even provide a place to pray.

How did the customers find out the location of Indonesian restaurants that were often rarely visited by tourists? For those who were craving Indonesian cuisine or wanted food that is different from usual, they would search restaurants that have positive reviews on TripAdvisor. Sometimes they got recommendations from the staff where they stay.

On average, customers were satisfied because they had delicious food, received excellent service from attentive staff and friendly owner. This experience made customers feel like truly valued customers in a lovely surrounding. "Every aspect of our dining experience was superb, from the décor, service, food, and attention.

Rendang's Value for Money

Many customers claim that with large portions, the overall price of rendang is cheap or even super cheap, very reasonable, good value, brilliant value, or absolutely worth the money.

A positive review was given by a customer: "Portions were generous, ensuring we left more than satisfied." Another customer also added,

"At a time when everything was so expensive in Singapore, rendang was not only one of the most delicious foods but also one of the most inexpensive."

Indeed, there was a customer who ate rendang at a Michelin-starred restaurant in Taipei and commented on the price, but at the same time gave a positive recommendation.

"Great taste but overpriced. Would recommend for muslim who is searching for halal food and of course people who are curious about the taste of beef rendang."

Throwback Memories with Rendang

Many customers specifically wanted to eat at Indonesian restaurants that served rendang to commemorate their past experiences when working as expatriates, vacationing in Indonesia, or other memories. For example, an Englishman dining in France felt like a throwback to Java or Bali Resto when entering the restaurant. They feel like they were at home, especially for his Indonesian wife.

A customer from Switzerland who has a Southeast Asian wife and visited an Indonesian restaurant in Lisbon, Portugal was so happy because his wife felt like she was back home! Additionally, he wrote,

"The beef rendang was nicely prepared (certainly not crispy!!) and tasty. The staff were very attentive and quite efficient. Don't miss your chance and taste indonesia during your Paris trip."

An Australian expatriate who has worked in Indonesia for 8 years was interested in trying authentic Indonesian food in Dubai. Overall, they were satisfied with the quality of the food and the authenticity of the taste, except that it seemed a tad bland, not quite spicy enough.

While a Filipino wrote, "Rendang spiced nicely reminds me of my Indonesian roommates cooking in college."

For Indonesian citizens, they usually wrote, "The taste of rendang was truly Indonesian and it made us feel at home." Feeling like home is one of the reasons customers keep coming back.

Another Indonesian customer also felt so happy after eating in a restaurant in Arnhem, the Netherlands:

"We can't believe how much this place feels like home; the decor gives off a very traditional Javanese vibe. We ordered the beef rendang. Truly a home far away from home."

Meanwhile, another Indonesian who was initially very skeptical was very happy because the food at the Indonesian restaurant he visited in Zurich, Switzerland, tasted very similar to the authentic Indonesian food, especially the rendang.

Indonesian Restaurants Abroad are Like Gems

A very happy feeling was expressed by a number of customers who found an Indonesian restaurant that served delicious and authentic food. This feeling was written clearly by a customer in Roppongi, Japan:

"I was very surprised when I discovered the authentic taste of Indonesian food. I didn't expect much before eating because I thought it might taste more like Japanese food than authentic Indonesian food. I loved discovering this hidden gem in Tokyo."

Meanwhile customers in Dubai, England and America felt the same joy and stated, "I am very happy to have found a real hidden gem." An Australian put it specifically on rendang in a slightly different way, "This little unpretentious gem is my all-time favourite for irresistible beef rendang."

Differences between Indonesian and Malaysian Rendang

Until now, rendang can be found in many other countries, including Malaysia. Indeed, Malaysia once claimed rendang as a traditional Malaysian dish. However, in 2013 UNESCO recognized rendang as a traditional Indonesian food [23]. Apart from that, existing historical records show that the origin of rendang comes from Indonesia [38].

The ingredients for rendang dishes in Indonesia and Malaysia are actually not much different, namely chili, ginger, galangal, shallots, lime leaves, turmeric and coconut [23]. Nevertheless, the original Minangkabau rendang and the one found in Malaysia have differences.

From the comments written on TripAdvisor, there were a number of customers who knew the difference between Indonesian and Malaysian or Singaporean rendang. They said Indonesian beef rendang is not sweet, drier, and

darker in color. Meanwhile, Malaysian or Singaporean rendang is sweeter, soupy, and a red-colored gravy.

The difference lies in the cooking method. During the cooking process, Indonesian rendang is always stirred continuously until it is dry and darker color [23]. The texture of Indonesian rendang is drier because it is cooked for a minimum of 7 hours, while Malaysian rendang is wetter because it is only cooked for 4 hours [38].

Meanwhile, Malaysian rendang does not use coconut milk but milk. Then in the third part of the cooking process, roasted grated coconut is added. That is why Malaysian rendang is reddish yellow in color with a little sauce [23].

An Indian who ate in Indonesian restaurant and understood how to prepare rendang wrote,

“Rendang is a tender braised beef stewed in traditional spice blend and coconut milk. Sauce is absorbed by the meat which makes it a thickish gravy.”

It's not surprising that the taste and texture of Indonesian and Malaysian rendang are different.

Additionally, while dining in Bengaluru, India, someone wrote:

“The cuisine is quite close to Indian cuisines, especially those of the South Indian States so no doubt quite popular in Bengaluru. Must try rendang.”

However, there was also a customer in Bengaluru who didn't know that rendang is cooked longer than Indian curry. “The flavor and taste of beef rendang were good but found it to be a bit on the dry side. I always thought it came in curry form!

Therefore, when ordering rendang, customers should specifically state whether they want dry or soupy rendang, spicy or not spicy so as not to be disappointed.

“The beefrendang I have had before always comes with lots of luscious gravy. I didn't realise there are two types and the restaurant serves the dry one with no gravy. It was a tasty dish but very dry.”

Discussion

The objective of this article is to examine what makes rendang as Indonesian local food chosen as the most delicious food in the world by CNN International in 2011 and 2018 based on the experiences of people who have eaten rendang abroad and written their reviews on TripAdvisor.

The results of the content analysis revealed 6 themes, namely, the taste of rendang, ambiance of Indonesian restaurants, rendang's value for money, throwback memories with rendang, Indonesian restaurants abroad are like gems, and the differences between Indonesian and Malaysian rendang.

This is in line with the previous studies which claim that local food and dining experiences are sought after by customers because of its taste, presentation and uniqueness [1], price [26], food-beverage quality, service quality, atmospheric environment [13; 24; 26; 33]. These factors shape future consumption behavior and eating experience satisfaction.

These six themes can be summarized as follows. First, the taste of rendang: rendang is considered as the best Indonesian food because it is an authentic spicy beef which is tender, has great seasoning, amazing smell and yummy taste. Second, ambiance of Indonesian restaurants: customers were satisfied because every aspect of the dining experience was superb, from the décor, service, food, and staff attention.

Third, rendang's value for money: with large portions, the overall price of rendang is absolutely worth the money. Fourth, throwback memories with rendang: for Indonesians rendang is a nostalgic moment when celebrating Eid al-Fitr with extended family in their hometown, while for foreigners rendang is a memory of their time in Indonesia.

Fifth, Indonesian restaurants abroad are like gems: the joy of being able to eat authentic Indonesian food, especially beef rendang, after all these years. Sixth, the differences between Indonesian and Malaysian rendang: The texture of Indonesian rendang is drier because it is cooked for a minimum of 8 hours, while Malaysian rendang is wetter because it is only cooked for 4 hours.

From the findings of this study, it is revealed that rendang is a local Indonesian food that is famous throughout the world. The popularity of rendang internationally is not only because of its delicious taste, but also because of its hundreds of years of history and the culture associated with this food [15].

These six themes reflect what you need to know about the history and origins of rendang.

Conclusion

Rendang has been named the most delicious local food in the world because hundreds of years of history and the culture associated with this food are the secrets behind the deliciousness of rendang.

In the medium-term, rendang can be considered an agent

of Indonesian culture that can introduce the richness of Indonesia's culinary to the international world because in any Indonesian restaurant abroad, rendang is almost guaranteed to be one of the mainstay menus. The popularity of rendang can also expand the reach of the Indonesian culinary business internationally, increasing income and employment opportunities for Indonesian people living abroad.

This research has a limitation of only collecting comments from TripAdvisor. If expanded to use Google My Business, Yelp, or Zomato, the themes explored could be richer.

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Tourism Management and Customers' Satisfaction: A Natural Language Processing and Machine Learning Framework

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Abstract

The emphasis on enhancing the competitiveness of tourism facilities has elevated the necessity for methodologies that can quantify tourist satisfaction to the forefront of academic discourse. Undoubtedly, positive visitor satisfaction results significantly influence the development of a region and the financial sustainability of private businesses, through the promotion of tourist expenditures, repeat visits, positive recommendations, and the enhancement of a destination's reputation.

To achieve a comprehensive understanding of the factors that influence tourist satisfaction, it is necessary to undertake an in-depth examination of the cognitive processes that underlie their satisfaction or dissatisfaction with a vacation or the entire tourist experience. This research applies the Topic-Modeling Based Index Assessment (TOBIAS) in conjunction with Sentiment Analysis to analyze the substance of textual and score-based online customer reviews on Booking.com and TripAdvisor. The objective is to identify the determinants that contribute to the discrepancy in tourism satisfaction levels between inland and coastal areas. The implications for academia and management are then discussed.

Keywords

Tourism satisfaction; Online Review, electronic-word-of-mouth (e-WOM); natural language processing; TOBIAS Model

Introduction

Since the late 1970s a substantial corpus of scholarly work in the field of tourism has been devoted to understanding consumer happiness, approaching it from various angles and with diverse objectives (Disegna and Oñti, 2016). Most satisfaction studies are based on expectation and perception models, cognitive evaluation, congruity and equity models, and perceived overall performance (Neal and Gursoy, 2008). The expectation and perception models proposed by Oliver (1980), which expresses consumer satisfaction as a function of expectation and expectancy disconfirmation, is one of the most used in the definition of tourism satisfaction (TS). Following this model, Truong and Foster (2006) have defined the TS as the difference between expectations and perceived performance, and the “fit” between tourist expectations and host destination attributes (Truong and Foster, 2006, p. 843). Similar definitions are proposed by other researchers (see for instance, Tribe and Snaith (1998); Chen et al (2011)).

Moreover, some researchers have underlined the necessity to investigate the TS considering different aspects, such as Yuksel and Yuksel (2008) that stated the TS can be evaluated taking into account three different levels: the Product-service level satisfaction, which refers to individual product service experiences delivered by a single organization in the production chain; the Dimensional level satisfaction, which is obtained summing the satisfactions derived from individual products and services within the given component of tourism; finally the Total satisfaction, which is obtained summing together the individual products-service level satisfactions and dimensional level satisfactions.

The scholar's interest in understanding TS, consequently, is related to the influence of tourist happiness on the development of a destination and the profitability for private businesses because a positive level of customers' satisfaction

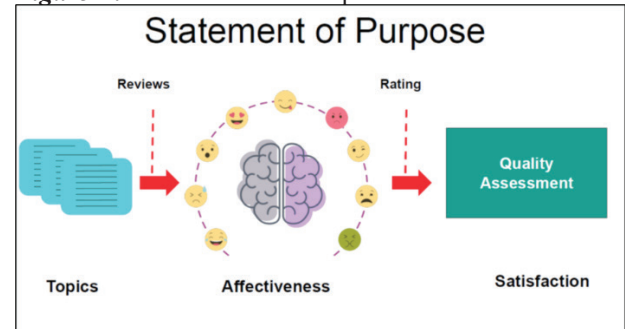
will further stimulates tourist expenditure, repeat visits, positive recommendations, and reputation enhancement. Therefore, measuring tourism satisfaction and its determinants becomes crucial for policymakers and managers (Sukiman et al, 2013) interested in improving the tourism supply of their destination. Several empirical studies focus on these issues following both qualitative and quantitative approaches. Among these, increasing interest has recently emerged in measuring customer satisfaction directly or indirectly from online reviews with various scopes and methods (Zhou and Yao, 2023).

This study aims to contribute to this recent line of study by investigating information contained in online customer reviews through electronic word-of-mouth (from now on e-WOM) in the form of text and scores. The main goal is to understand TS through online review analysis, using natural language processing the within-regional variation (inland and coastal tourism) in Sardinia, an Italian region. More specifically, the purpose is to understand if there are differences in topics used by customer reviewers in their online reviews and how these differences and topics impact customer satisfaction between coastal and inland geographical areas. At this scope, after investigating each topic's impact on the Sardinian region's customer satisfaction level, we split the dataset into two sub-samples: one related to the destination located in the inland area (meant as the central area of Sardinia), the other one in the coastal. Online customer reviews are retrieved from TripAdvisor and Booking.com platforms and related to activities, attractions, and services. To retrieve and process data from the web, we apply a new method recently proposed by Ortu et al (2022). This method, called TOPicmodeling Based Index Assessment through Sentiment (from now on TOBIAS), allows modelling the effects of the topics, moods, and sentiments of the customers' comments describing a phenomenon, such as the perception of the quality of service, over the level of satisfaction expressed by customers. This method's novelty relies on combining natural language processing and causal inference to explain customers' assessment of a phenomenon. TOBIAS Model is built by combining different techniques and methodologies. In other words, firstly, we used Sentiment Analysis that identifies sentiments, emotions, and moods; secondly, through the Topic Modeling we find the main relevant topics inside customer online review comments. Then, by Partial Least Square Path Modeling we estimate how topics affect an overall rating that summarizes the performance of the analyzed phenomenon. Finally, through TOBIAS Model we estimate how topics affect customer satisfaction.

In order to provide a concise and simplified overview of the logic framework employed, we have included the statement of purpose of our research in Figure A. When customers assess the quality of their experience, they are influenced by their emotional state (which we call Affectiveness), which in turn is influenced by specific topics

(such as breakfast, room, wi-fi and so on). Through the TOBIAS Model, we will show how the topics used by customers impact their satisfaction of the lived experience.

Figure A: Statement of the Purpose of the research



Since inland and coastal tourism present specific characteristics, we expect to identify differences in topics and impact on satisfaction levels among these two geographical areas by customers. Results are then interpreted.

Our contribution is threefold: first, we contribute to tourism literature on customer satisfaction; second, we contribute at the statistical level proposing a new model for analyzing consumer satisfaction; finally, we contribute at the level of managers and policymakers through the interpretation of results by offering strategies to be adopted for the tourism destination.

Tourism development industry and the value of electronic reviews

The tourism industry is one of the most important sources of the global economy and is rapidly growing and according to the World Travel & Tourism Council¹ in 2022, the Travel & Tourism sector contributed 7.6 percent to global GDP; an increase of 22 percent from 2021 and only 23 percent below 2019 levels. It creates, in 2022, 22 million new jobs, representing a 7.9 percent increase on 2021, and only 11.4 percent below 2019. Domestic visitor spending increased by 20.4 percent in 2022, only 14.1 percent below 2019. International visitor spending rose by 81.9 percent in 2022, but still 40.4 percent behind 2019 numbers

1 The World Travel & Tourism Council (WTTC) generates studies detailing the economic and employment ramifications of travel and tourism for 185 countries/economies and 26 geographic or economic areas worldwide. These reports, which we produce in collaboration with Oxford Economics, are crucial in supplying tangible evidence to public and private sector entities regarding the enormous economic value that travel, and tourism contributes. This enables them to formulate investment and policy decisions that are in line with the interests and requirements of tourism industry. <https://wttc.org/research/economic-impact> retrieved the 07th of December 2023

(WTTC, 2022).

The advent of the digital age and the proliferation of online platforms have a profound impact on the tourism sector and its target audiences (Buhalis, 2003; Chen et al., 2015; Tham et al., 2013). Emerging tools and communication technologies, like mobiles, social networks, and others, have altered the method in which customers make purchase decisions (Klaus, 2013; Leung et al., 2013). Through e-WOM, consumers may share their experiences directly with others (Akehurst, 2009). In order to inform their entire strategy, the tourism sector must assess the impact that online communication channels, including blogs, forums, and rating websites, have on the behaviour of its clients (Murphy et al., 2007; Murphy et al., 2000). In this scenario, an increasing number of people are expressing their experiences online as electronic reviews (e-Reviews) gain traction (Hills & Cairncross, 2011; Litvin et al., 2008). E-Reviews are crucial to the tourism business, according to research due to their substantial beneficial impact on sales (Chaffey et al., 2009; Goldsmith & Horowitz, 2006), and represent the most important source of e-WOM in the tourism industry (Gretzel & Yoo, 2008; Ip et al., 2012; Parra-López et al., 2011).

The enhanced transparency of these platforms has facilitated peer engagement and pricing and promotion comparisons (Klaus, 2013). Presently, customers exploit the chance presented by online e-WOM to distribute their sentiments and viewpoints to a broad audience of prospective consumers. Consumer opinions are expressed in several formats, including peer rankings and reviews, which may be favourable or negative in nature (Browning et al., 2013). According to Cheung et al. (2008), customers are more inclined to consider unfavourable forum posts made by other consumers rather than favourable ones and are significantly swayed by the views of others when purchasing holiday products due to the substantial financial and emotional investment involved (Swarbrooke and Horner, 2007) customers. This demonstrates how internet sources have surpassed personal recommendations and familial connections as the key resource customers use during the decision-making process (Papathanassis & Knolle, 2011).

Empirical studies measuring tourism satisfaction with destinations have proliferated in quantity during the last decades (Bramwell, 1998; Chon & Olsen, 1991; Danaher & Arweiler, 1996; Kozak, 2001; Kozak & Rimmington, 2000). An approach commonly employed to investigate tourism satisfaction, as before mentioned, is the examination of e-WOM, which has gained significant traction in academic circles as a result of the proliferation of online communication platforms used for both transportation and recreational purposes. As a result, the technological advancements in the tourism industry have, from one hand, impacted tourist behaviour and, on the other hand, by creating an intriguing capability to gather and disseminate vital information regarding a specific tourism supply.

Academics place much emphasis on the critical role that e-WOM plays in shaping consumer decision-making (Bieger & Laesser, 2004; Cheung et al., 2008; Wen, 2009). As Swarbrooke and Horner (2007, p. 416) define it, word-of-mouth (from now on WOM) can be defined as the following: "the phenomenon whereby individuals who have used a product or service positively or negatively communicate their opinions on the product or service to others. WOM is perceived as significantly more reliable and trusted compared to other forms of regulated marketing communication, such as advertising and promotion (Breazeale, 2009; Dye, 2000). This credibility became critical with the transition from WOM to e-WOM (Pan et al., 2007), which is particularly pertinent to the tourist industry.

In fact, e-WOM is distinguished from conventional WOM by its capacity to reach a vast audience via the Internet (Black & Kelley, 2009). Another distinction is that the information-seeking customer generally does not have a personal acquaintance with the source of the statement (Black & Kelley, 2009; Bronner & De Hoog, 2010; Pan et al., 2007). E-WOM, contrary to WOM, is seen as an information that does not "vanish as soon as it is uttered" (Stern, 1994, p. 7). Conversely, online material is not only accessible on a global scale but is also retained indefinitely (Cheung et al., 2008) so that at any moment, consumers may view this information repeatedly at their convenience (Xie et al., 2011).

In relation to the primary concept of e-WOM, both the perception of usefulness and the attitude toward the utilization of a social network as an effective communication channel for the selection of tourism destinations are examined. This line of investigation focuses specifically on the element of enjoyment, underscoring the importance of the entertainment provided by the social network. It functions as a more resilient predictor of consumer sentiment and inclination to participate in tourism-related endeavours (Di Pietro et al., 2012; Phelan et al., 2013). We utilize the definition of e-WOM provided by Litvin et al. (2008, p. 461) for this study. According to this definition, e-WOM encompasses "all informal communications that are directed at consumers via Internet-based technology and pertain to the usage or attributes of specific goods, services, or their vendors."

Tourists who are satisfied with their destination are more likely to express positive feedback on different internet platforms. It is especially beneficial for tourist destinations when businesses and providers of tourism services incorporate these advertisements (Cuomo et al., 2021; Descarten, 2023). Moreover, e-WOM has also been recognized as a commercially viable approach to establishing connections with visitors and tourists. For these reasons, we concentrate our study on the function of e-WOM in the tourist industry in order to provide a significant contribution to both the academic community and policymakers. Therefore, our aim is to provide an answer to the follow-

ing research questions:

RQ1: *There are differences among topics expressed in online reviews by customers between inland and coastal location?*

And

RQ2: *What topics, more than others, in online customers reviews impact positively and negatively the tourism satisfaction?*

In order to address these inquiries, this study use a combination between Sentiment Analysis and TOBIAS model to examine the online reviews of two prominent platforms, Booking.com and TripAdvisor. The sample is restricted to the Italian region of Sardinia.

Methods

Sentiment Analysis

The process of obtaining and analysing textual material to identify attitudes and views expressed within is referred to as sentiment analysis (from now on SA) (Rahmadan et al., 2020). The principal objective of this endeavour is to examine, analyse, and extract subjective sentiments and ideas articulated by persons in written format, to quantify the emotional states communicated.

SA attempts to differentiate between subjective and objective material by initially identifying subjectivity and objectivity in texts. Furthermore, it evaluates the polarity by allocating emotion ratings to text, which may be quantitative (limited to a particular range) or qualitative (positive/negative). Moreover, SA investigates discrete emotions, which allows a more intricate examination by extracting emotions represented in human language, such as *love* and *joy*.

There are several text levels - document, phrase, and aspect - at which SA may be implemented, along with various analytical methodologies (Kaur et al., 2017; Liu, 2012). One approach is lexicon-based, which consists of corpus-based methods that analyse co-occurrence statistics or syntactic patterns within text corpora using predefined positive and negative seed words, and dictionary-based methods that rely on sentiment scores assigned to individual terms by linguistic experts (Darwich et al., 2019). Another approach involves machine learning, which is categorized into three main types (Madhoushi et al., 2015): supervised, unsupervised, and semi-supervised. The first one, supervised learning, is known for its robustness, is commonly used in SA, especially in document classification, delivering satisfactory results (Sodanil, 2016). On the other hand, unsupervised methods do not rely on prior information for sentiment detection; examples include rule-based classifiers (Vashishtha and Susan, 2019; Hu et al., 2013). In sum, semi-supervised learning incorporates both annotated and unannotated data, wherein the latter is utilized to understand the overall distribution among categorization features, a foundational concept that serves as the basis for semi-supervised learning (Liu, 2012).

Until now, SA has become indispensable for deriving critical information, supporting decision-making, generating forecasts, analysing trends, and enabling commercial applications in several sectors.

Topic Modeling

In our research we use a Topic Modeling that is an unsupervised learning method that recognizes underlying patterns and themes in a set of documents and facilitates their representation according to the frequency of the words that constitute them. Among the most conventional techniques for topic modeling, we can find the Latent Dirichlet Allocation (LDA) (Blei et al, 2003), which is a hierarchical Bayesian model, and Non-Negative Matrix Factorization (NMF) (Févotte and Idier, 2011), which use linear algebra for topic extraction. Both techniques describe a document as a bag-of-words and model every document as a collection of latent topics. Yet since these bag-of-word representations do not take into account the context of words in a sentence, bag-of-words input may not accurately represent documents. Different scholars heavily criticized its effectiveness in analysing social media data (Egger and Yu, 2021; Sánchez-Franco and Rey-Moreno, 2022). To overcome these issues, recently, new techniques such as Top2Vec (Angelov, 2020) and BERTopic (Grootendorst, 2022) have been introduced. Top2Vec is an algorithm that uses word embedding, which means that by vectorizing the text data, it is possible to locate semantically similar words (Egger and Yu, 2022). On the other hand, BERTopic is a topic model that generates coherent topic representations in a three-step algorithm. It starts by creating document embedding with a pre-trained language model. Moreover, it lowers the dimensionality of the document embedding and generates semantically close clusters that represent each one a single topic, and finally, it extracts the topic representation through a class-based variation of Term Frequency-Inverse Document Frequency (TF-IDF). In summary, Topic Modeling is a valuable technique in Natural Language Processing (from now on NLP) and text analysis, and its role is expected to grow significantly as the volume of digital data produced each day increases. This technique has been applied to various real-world problems, for instance, Ortu et al (2022) has applied a topic modeling technique to infer university student satisfaction using their issues reports. Moreover, Moreno et al (2023), applied a BERTopic algorithm to Airbnb customer reviews to identify service characteristics relevant to guest satisfaction.

Partial Least Square - Path Model

Partial Least Squares (from now on PLS), first proposed by Wold (1966, 1995), relates the information observed in two sets of tables of observations of the same phenomenon. They are used specifically for: i) *Correlation*, ii) *Regression* and iii) *Path Modeling* (Abdi and Williams, 2013). The main tool of PLS is the Single Value Decomposition (from now on SVD), given a $J \times K$ matrix $\mathbf{Z}$ (Henseler et al, 2009) (see formula 1):

$$\mathbf{Z} = \mathbf{U}\mathbf{\Lambda}\mathbf{V}^T = \sum_l^L \delta_l \mathbf{u}_l \mathbf{v}_l^T \quad (1)$$

where $\mathbf{U}$ is a singular left $J \times L$ matrix, $\mathbf{V}$ is a $K \times L$ is the singular right matrix and, $\mathbf{\Lambda}$ is a $L \times L$ diagonal matrix of the L singular values. The key concept here is that the SVD provides the best reconstitution (in the least squares sense) of the original matrix by a matrix with a lower rank (Takane, 2003).

PLS Correlation (from now on PLSC) generalizes this idea to two tables. Given two variables X and Y the correlation matrix $\mathbf{R}$ is given by (see formula 2):

$$\mathbf{R} = \mathbf{Z}_X^T \mathbf{Z}_Y = \mathbf{U}\mathbf{\Lambda}\mathbf{V}^T = \sum_l^L \delta_l \mathbf{u}_l \mathbf{v}_l^T \quad (2)$$

where $\mathbf{Z}_X$ and $\mathbf{Z}_Y$ are the standardized matrices of observations, and the Latent Variables are denoted as the projection of the original matrices to the relative singular matrices (see 3):

$$\mathbf{L}_X = \mathbf{Z}_X \mathbf{V} \quad \mathbf{L}_Y = \mathbf{Z}_Y \mathbf{U} \quad (3)$$

The goal of PLSC is to find the latent vectors with maximal variance (see 4):

$$\mathbf{l}_{X,l} = \mathbf{Z}_X \mathbf{v}_l \quad \text{and} \quad \mathbf{l}_{Y,l} = \mathbf{Z}_Y \mathbf{u}_l : \quad \text{cov}(\mathbf{l}_{Y,l}, \mathbf{l}_{X,l}) \propto \mathbf{l}_{Y,l}^T \mathbf{l}_{X,l} = \max \quad (4)$$

whilst the goal of **PLS Regression** (from now on PLSR) is to predict a table of variables using the information in another table of variables. PLSR aims to find a latent variable matrix L that *simultaneously* models $\mathbf{X}$ and predicts $\mathbf{Y}$ (see equations 5 and 6)

$$\mathbf{X} = \mathbf{T}\mathbf{P}^T \quad \text{and} \quad \hat{\mathbf{Y}} = \mathbf{T}\mathbf{B}\mathbf{C}^T \quad (5)$$

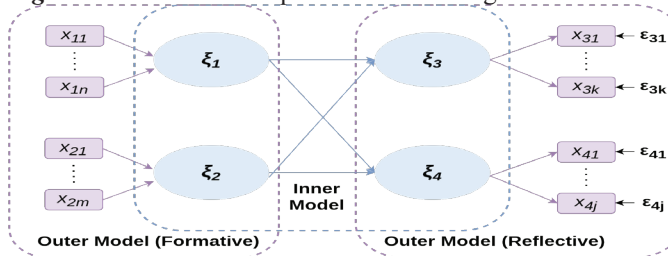
$$\hat{\mathbf{Y}} = \mathbf{X}\mathbf{B}_{\text{PLS}} \\ \mathbf{B}_{\text{PLS}} = \mathbf{P}^T + \mathbf{B}\mathbf{C}^T \quad (6)$$

where $\mathbf{P}$ and $\mathbf{C}$ are the *loadings* of $\mathbf{X}$ and $\mathbf{Y}$ respectively, and $\mathbf{B}$ is a diagonal matrix.

Latent variables are ordered according to the variance of $\mathbf{Y}$ that they explain. Equation 6 shows the regression form of previous equation, $\mathbf{B}_{\text{PLS}}$ is the multiple regression weights (loadings) with J rows and K columns.

PLS Path Modelling (from now on PLS-PM) can be considered as the least square alternative to Structural Equation Modelling, which is based on maximum likelihood. Formally, a PLS-PM is defined as two sets of linear equations, the *inner* and *outer model*.

Figure 1: Partial Least Square Path Modeling PLS-PM



In Figure 1, the *inner model* describes the relationships among the latent variables. The inner model is a causal chain system (i.e. with uncorrelated residuals and without correlations between the residual terms of a certain endogenous latent variable and its explanatory latent variables). Latent variables are the model measurements that are not directly observed, while manifest variables are measurements of the model directly observable. These relationships are represented in the following equation 7:

$$\xi = \mathbf{B}\xi + \epsilon \quad (7)$$

where ξ is a vector of latent variables, $\mathbf{B}$ denotes the coefficient matrix of their relationships, and ϵ represents the inner model residuals. The assumption is that the inner model constitutes a causal chain system, the specification of predictors reduces the equation 7 to equation 8.

$$(\xi | \xi) = \mathbf{B}\xi \quad (8)$$

The *outer model* describes the relationships between latent and manifest variables. Manifest variables are represented in two modes: i) Reflective (Mode A) and ii) Informative (Mode B). The reflective model has causal relationships from the latent variable to the manifest variables in its block. Thus, each manifest variable is assumed to be generated as a linear function of its latent variables and the residuals.

The formative mode of a measurement model has causal relationships from the manifest variables to the latent variable.

$$\mathbf{X}_x = \mathbf{\Lambda}_x \xi + \epsilon_x \quad (9)$$

$$\xi = \Pi_x \mathbf{X}_x + \epsilon_x$$

Manifest variables are subject to predictors specification, which reduces equation 9 to equation 10.

$$(\mathbf{X}_x | \xi) = \mathbf{\Lambda}_x \xi \quad (10)$$

$$(\xi | \mathbf{X}_x) = \Pi_x \xi$$

The PLS algorithm is essentially a sequence of regressions in terms of weight vectors. The weight vectors obtained at convergence satisfy fixed point Equations (Dijkstra, 2010).

Therefore, the basic PLS algorithm includes the following three stages (Lohmöller, 1989):

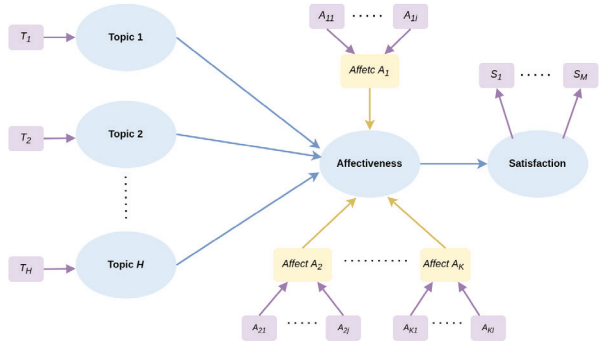
1. Iterative estimation of latent variable scores
 - (a) Outer approximation of the latent variable scores (Tenenhaus et al, 2005)
 - (b) Estimation of the inner weights
 - (c) Inner approximation of the latent variable scores
 - (d) Estimation of the outer weights
2. Estimation of outer weights/loading and path coefficients.
3. Estimation of location parameters.

These three steps are repeated until the difference in outer weights between two iterations is less than a predetermined threshold. After step one, the algorithm returns latent variable scores for all latent variables.

TOBIAS Modeling

TOBIAS Model is built by combining different techniques and methodologies. In this study we hypothesize that the satisfaction expressed by customers is influenced by their emotional state, and the emotional state is triggered by specific topics. We modelled these complex relationships using our framework TOBIAS, where the formal model is illustrated in Figure 2.

Figure 2: TOBIAS Model applied to our study



The inner model depicts the relation of Satisfaction depending on the Affectiveness, whilst the latent variables related to Topics are modelled as the main drivers that trigger the Affectiveness.

Regarding the outer model, the manifest variables of Satisfaction block are reflective and express the overall quality of the services as perceived by final users. The Topic blocks are formative. Hence, Affectiveness is a formative block referring to all measures of the emotional state that can be measured from text, such as sentiment, emotion, etc. Its manifest variables can be grouped into K homogeneous subblocks according to the emotional state they describe.

Data source

We carried out the analysis considering the online reviews published on *TripAdvisor.com* and *Booking.com*. *TripAdvisor* is a travel guidance platform in 43 markets and 22 languages that supports travellers in planning a trip. It is possible to find information about where to stay, what to do, and where to eat (<https://tripadvisor.mediaroom.com/us-about-us>).

Booking.com has been founded in 1996 in Amsterdam. It is the largest travel marketplace that supports tourists and entrepreneurs. It is available in 43 languages and offers more than 28 million total reported accommodation listings, Booking.com aims to make it easier for everyone to experience the world (<https://www.booking.com>).

Context of the analysis

We focus on the reviews of the Hotel located in Sardinia, an Italian region located in the centre of the Mediterranean Sea, distinguishing between the hotel located in the centre of the region Sardinia (labelled *inland*) and

those hotels located in the coastal (labelled *coastal*). The Italian region of Sardinia is an ideal context to test, on the one hand, the use of the TOBIAS model for TS, and on the other hand, to draw interesting results. In fact, Sardinia is a region well known and appreciated for its coastal tourism, while it is less known for inland tourism. Official regional data shown that through June 30, 2023 Sardinia had 2,568,741 tourist arrivals² with an increase of 12.46 percent over the previous year. The island has been on an upward trend since 2019, a year that as we will recall suffered a dramatic inflection related to the effects of the COVID-19 pandemic. The use of the TOBIAS model can be extended to any geographic space in the future, whether it is a region or a nation state, or even an entire continent.

Data retrieval

We gathered more than 99 thousand of reviews of 614 Sardinian hotels, that 396 were coastal Hotels, while 218 were inland hotels, as shown in Table 1.

Table 1: Data retrieval

Dataset Statistics	
Inland reviews	23,375
Coastal reviews	76,130
Total Reviews	99,505
Inland Hotels	218
Coastal Hotels	396
Total Hotels	614

Although the number of hotels located in coastal areas is higher than those located in the inland, the number of reviews for the inland is highest. Indeed, of 99,505 reviews, 76,130 were from coastal hotels, while 23,375 were from inland hotels.

The TOBIAS Model applied to our analysis.

The exploitation of TOBIAS Model for our analysis is described as following:

The TOBIAS model consists of three parts:

- (1) **Topics** (recurring topics in customer online reviews).

2 RAS Regione Autonoma della Sardegna, official government site, <https://www.regione.sardegna.it/notizie/turismo-assessore-chessa-i-dati-ci-danno-ragione-nel-2023-incremento-di-arrivi-rispetto-ai-primi-sei-mesi-del-2019> retrieved the 2nd of January, 2024.

- (2) **Affectiveness** (it is defined by sentiment and emotions of the customers and it is influenced by all Topics, Emotions and Sentiment. Emotions are: *Sadness, fear, Anger, Joy and Love*; while the label Sentiment expresses a value between -1 and +1 and means the tourist's perception negative or positive towards the experience they had).
- (3) **Satisfaction** (it is our response variable – see Table 2).

More in details, in TOBIAS Model used for this study, the covariates are two. The first one is the *Affectiveness* because it represents a measure of the emotional state generated by the sentiments and the emotions. The second one is the latent variable *Topic*, which is generated by different topics expressed by reviewers. As previously stated, we have identified distinct topics in the published evaluations of inland and coastal hotels, which highlight the variations in how the hotels are perceived by customers in relation to their location.

Table 2: PLS-PM variables latent and manifest

Latent	Manifest	Description
Satisfaction	<i>Rating</i>	Average hotel's score
	<i>Sentiment</i>	-1 negative, +1 positive
Affectiveness	<i>Joy</i>	Joy probability
	<i>Love</i>	Love probability
	<i>Anger</i>	Anger probability
	<i>Fear</i>	Fear probability
	<i>Sadness</i>	Sadness probability
Topic expressed by customers	<i>Breakfast</i>	Probability of review concerning the quality of the breakfast
	<i>Staff</i>	Probability of review concerning the quality of staff
	<i>Experience</i>	Probability of review concerning the quality of experience
	<i>Wi-Fi</i>	Probability of review concerning the quality of Wifi and TV
	<i>Quietness</i>	Probability of review concerning the quality of sleeping
	<i>Insects</i>	Probability of review concerning the presents of bugs
	<i>Shower</i>	Probability of review concerning the quality of shower
	<i>Room</i>	Probability of review concerning the quality of room
	<i>Booking and Payments</i>	Probability of review concerning the booking and payment systems
	<i>Parking</i>	Probability of review concerning the quality of parking

Results and discussion

Given the distinct attributes of coastal and inland tourism, it is anticipated that variations in subject matter and the resulting effects on consumer satisfaction levels will be discernible across these two geographic regions.

Results obtained allow us to answer our first research question: RQ1 *Are there differences among topics expressed in online reviews by customers between inland and coastal location?* Yes, topics that emerged from online reviews by consumers are different depending on whether they are inland or coastal destination. As stated in the evaluations, several items are disregarded by tourists. Relevant inland-based topics are displayed in Figure 3 as follows: *Breakfast, Room, Experience, Wi-Fi, Quietness, Towels, Insects, and Shower*. Coastal-related topics are illustrated in Figure 4 as follows: *Breakfast, Staff, Parking, Wi-Fi, Booking & Payments, Quietness, Animation, and Hairdryer*.

Moreover, our second research question RQ2 *What topics, more than others, in online customers reviews impact positively and negatively the tourism satisfaction?* was answered through the TOBIAS Model that showed that: for the hotels located in the inland there is a positive impact of the topics on the Affectiveness but a negative impact of the Affectiveness toward the Satisfaction, as shown in Figure 3. This means means that the multiplier effect of the model ultimately highlights how the topics used in reviews exert a negative effect on customer's satisfaction.

On the contrary, the signs in the model defined for the hotels located on the coastal are characterized by a constant and negative sign, as shown in Figure 4. In other words, the variable Topics impacts negatively on Affectiveness that impact negatively on Satisfaction, always due by the multiplier effect (see Figure 4).

Thus, differences exist between hotels situated on inland and those situated in coastal regions regarding the subject matter and the influence of the independent factors on the response variable, as demonstrated by the study findings.

Hence, the results of TOBIAS Model confirm the existence of differences related to the location of the hotels. This finding is consistent with previous research in the literature, which has shown that various factors, including location, culture, and traveller demographics, have an impact on how destinations and hotels are perceived (see, for example, Zhang et al. (2015); Wang et al. (2020); Soler et al. (2019); Assaf et al. (2017); Ding et al. (2022)).

Secondly, by analysing the results, it is also possible to identify similarities among the topics. For instance, some topics such as *Breakfast*, *Staff*, and *Wi-Fi* have been identified in the reviews independently of the location of the hotel. On the contrary, some topics characterized specific areas. For instance, the topics *Parking*, *Animation*, and *Booking & Payments* are identified only in the reviews written for the hotel located on the coast. In the same way, the topics *Insect* and *Experience* have been identified only in the reviews related to the hotel located in the center of Sardinia.

Additionally, differences have been recorded in terms of coefficients and signs among the topics. For instance, the topic *Breakfast* presents an elevated and negative coefficient (-0.54) for the hotel located in the inland. Our results are in line with the literature since the relevance of the topic *Breakfast* has been previously underlined by different researchers. For instance, Smirnova (2022) has stated that the word breakfast is one of the most mentioned in the reviews and it is usually related to positive feedback. Similarly, Kim and Kim (2022) have stated that this topic presents a high frequency, and it can be considered as a central word inside the reviews.

Particularly interesting is the evaluation of some specific topics. For instance, it is recorded a positive impact for the topic *Animation* toward the Satisfaction of the hotel located on the coast. The relevance of this aspect has been previously underlined by other researchers. As an example, Sotiriadis (2014) has stated that “In sea-and-sun destinations animation services became a constituent part in hotels” (Sotiriadis, 2014, p. 692). An alternative viewpoint, as presented by Keča and Ivančić (2022) posits that animation has the potential to influence visitor loyalty and pleasure (p. 88).

Additionally, an elevated and final negative effect has been recorded for the topic *Room* in the inland (0,8345) as shown in Figure 3. In literature, other researchers have highlighted the relevance of this topic (Smirnova, 2022; Albayrak and Caber, 2015), and the negative impact on satisfaction (Liu et al, 2023). As a conclusion, the findings indicate that perceptions of services, amenities, and facilities vary across hotels situated in various locations such as inland or coastal.

Comparing hotels situated on inland and along the coast in terms of sentiment and emotions reveals that there are notable parallels, as seen in figures 3 and 4. The coefficients present similar values and signs. The negative emotions as *fear*, *anger*, and *sadness* have a negative impact on satisfaction. On the contrary, emotion as *joy* and *love* have a positive impact on satisfaction. This finding is consistent with the research conducted by Ali and Amin (2014), which found that “customer emotions also significantly influenced customer satisfaction” (Ali and Amin, 2014, p. 260). Our results confirm this statement and demonstrate how emotion can impact on tourism satisfaction.

Figure 3: TOBIAS Model for inland

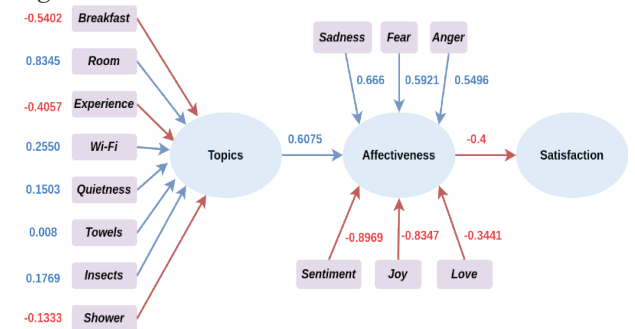
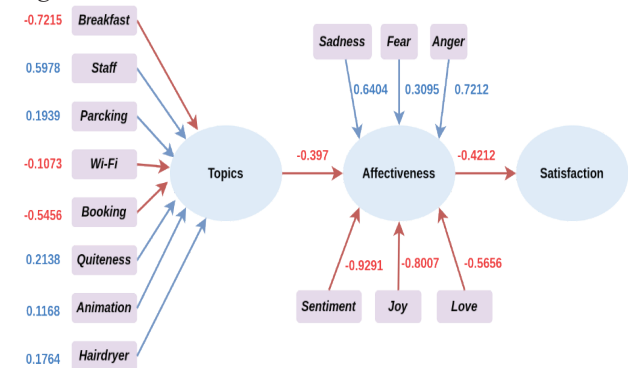


Figure 4: TOBIAS Model for Coastal



Conclusions

The study findings indicate that there are distinctions between hotels located on inland and those positioned in coastal regions with respect to the topic matter and the impact of the independent factors on the response variable. The degree of tourism satisfaction is impacted by the affectiveness value which is contingent upon the sentiment and emotions evoked by the tourism experience. These factors are linked to the topics that significantly contributed to the determination of whether the experience was positive or negative. While these results are consistent with previous research, they do provide a more comprehensive explanation for the sources of the positive or negative sign of the customer's experience and, by extension, of the sign of tourist satisfaction.

By identifying the specific subjects that impact tourist satisfaction, for instance, it becomes possible to provide recommendations to both managers and policy makers.

Indeed, managerial implications arise when the manager is required to recognize that the significance of the hotel's internal components in relation to guest pleasure varies depending on its geographical location—that is, whether the hotel is situated on inland or coastal. Thus, managers may allocate resources towards those internal components (topics) that are geographically relevant to the hotel. Additionally, policymakers must exercise caution when formulating regulations for the development of some features (such as *parking* lots) for which hotels are obligated to receive government help in the provision of services. As well, pest management policies for *insects*.

The primary limitations are confined to the sample area and the electronic platforms employed; nevertheless, this may potentially provide as an opportunity. Indeed, this research endeavor and the implementation of the TOBI-AS model are replicable in additional areas of Italy and beyond, across entire nation-states and continents, as well as on other web platforms such as AirB&B and those associated with other sectors. The results may be unexpected and demonstrate how significant information may be gleaned from the study of subjective data stated on internet platforms (which are consequently readily available) for governmental authorities and tourist operators, as in this instance.

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Applying Deep Learning and Data Augmentation Techniques to Cardiac Arrhythmia Detection

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Abstract

Heart disease has emerged as a primary cause of global mortality in recent years, and the detection of cardiac arrhythmias stands as a crucial and precise early medical intervention for preventing heart diseases. In this paper, we propose a deep-learning modeling scheme evaluating the Long Short-Term Neural Network (LSTM) and Bidirectional Long Short-Term Neural Network (BiLSTM) algorithms to predicting cardiac arrhythmias. As a result, the optimized model incorporating data augmentation with the BiLSTM algorithm yields the best performance which achieving an accuracy rate of 96.1% for the MIT-BIH dataset.

Keywords

Long Short-Term Memory, Bidirectional Long Short-Term Memory, Data Augmentation Techniques, Arrhythmia

Introduction

According to the latest announcement from the World Health Organization in the "2023 Global Health Estimates Report," it is indicated that from the year 2000 to 2019, heart diseases have consistently been a leading cause of global mortality. Taking 2019 as an example, approximately 9 million lives were claimed by heart diseases, accounting for 16% of the total global deaths. Heart diseases often coexist with arrhythmias, making the detection of arrhythmias a primary step in diagnosing heart conditions. Common causes of arrhythmias include hypertension, ischemic heart disease, alcohol consumption, smoking, and the stressful modern lifestyle. Electrocardiography (ECG) is the most effective clinical diagnostic tool for detecting arrhythmias due to its simplicity, cost-effectiveness, and non-invasiveness.

ECG works by measuring the weak electrical currents conducted to the body surface during heart contractions. This results in electrical potential changes in various parts of the body, aiding in the diagnosis of heart diseases or conditions affecting myocardial function. These conditions may include arrhythmias, myocardial infarction, coronary artery disease, and certain medical complications like diabetes and hypertension. However, ECG signals exhibit high noise and complexity, requiring doctors to sequentially examine ECG waveforms for

diagnosis. The process is intricate and time-consuming, and even experts may encounter subjective interpretation errors. Therefore, automatic detection of arrhythmias has become a crucial and challenging task.

Under normal circumstances, the heart beats rhythmically at a rate of sixty to one hundred beats per minute. As each heartbeat originates from the depolarization of the sinoatrial node, a normal cardiac cycle is referred to as Sinus Rhythm, as illustrated in Figure 1. A cardiac cycle consists of three waves, two intervals, and two segments. In an ECG, there are identifiable P-waves (atrial depolarization), QRS complexes (ventricular depolarization), and T-waves (repolarization). If any of these waveform components are missing or abnormal, it is considered an Arrhythmia.

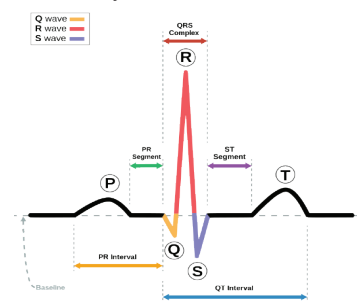


Figure 1 - Sinus Rhythm ECG

The morphology of ECG varies among individuals and is influenced by factors such as age, gender, and health conditions, which also impact the classification outcomes. Early arrhythmia classification methods involve steps like data preprocessing, heartbeat segmentation, feature extraction, and classification [1].

ECG machines, serving as tools for real-time arrhythmia detection, often rely on direct visual inspection of ECG waveforms as a common diagnostic approach. Therefore, identifying abnormal waveforms has become a significant research area. Since 1985, there has been research on detecting the position of QRS waves in ECGs. The Pan-Tompkins algorithm[2], based on QRS complex slope analysis, has been widely applied for heartbeat segmentation due to its simplicity and effectiveness. Li et al.[3] utilized wavelet transformation to decompose the signal into four frequency bands for identifying characteristic waveforms in ECG. Minami et al. [4] detected R waves using local maxima and applied fast Fourier transform to convert the signal into frequencies. They achieved a recognition rate of 98% by feeding five spectra into a neural network for classifying three types of conditions. Osowski et al. [5] employed feature extraction methods like Hermit sequences and higher-order statistics, followed by support vector machine classification. Escalona-Morán et al. [6] proposed a logistic regression-based ECG classification method.

Artificial intelligence is dedicated to developing algorithms that match or surpass human capabilities. Currently, it has achieved significant accomplishments in fields such as speech and image recognition. In the medical field, the integration of artificial intelligence has led to the emergence of smart healthcare. A McKinsey report suggests that smart healthcare will impact six major areas, including chronic disease management, self-management and disease prevention, disease diagnosis, diagnostic triage, clinical decision support, and care services. Smart healthcare is expected to become a solution to alleviate the shortage of healthcare manpower [7].

The interpretation of electrocardiograms (ECGs), particularly demanding on doctors' cognitive resources, has prompted the development of various applications of artificial intelligence. Chang et al. [8] utilized Long Short-Term Memory (LSTM) networks on a dataset from China Medical University Hospital to classify 12 types of arrhythmias, achieving an accuracy of up to 98.2%. Singh et al. [9] constructed three algorithmic models—Recurrent Neural Network (RNN), LSTM, and Gated Recurrent Unit (GRU)—to identify normal or abnormal heart rhythms, with classification accuracy exceeding 82.5%. However, the imbalance in abnormal scenarios of arrhythmia data, with significantly fewer cases compared to normal heart rhythms, poses a challenge in predictive classification performance. Many researchers have attempted to address this issue.

Zhou et al. [10] proposed using the ACE-GAN algorithm

to handle data imbalance, while Pandey & Janghel [11] applied the Synthetic Minority Over-sampling Technique (SMOTE) technique in conjunction with CNN to address data imbalance. While these arrhythmia classification studies have achieved significant performance in international standard databases, they have not yet applied the models to actual clinical data and compared predictive outcomes in clinical settings.

The onset of heart disease is characterized by its rapid progression, short window for emergency intervention, and challenging prevention. However, if early diagnosis, prompt treatment, and preventive measures are implemented, it can be a crucial lifesaving opportunity. ECG data acquisition devices are primarily categorized into intracorporeal, surface, and extracorporeal types[12]. Intracorporeal devices involve surgical implantation, with external recording of ECG. Surface devices, such as ECG machines commonly found in hospitals, use adhesive patches on the body to detect ECG signals. Extracorporeal devices, typically wearable, utilize chest or wrist bands in a non-contact manner to detect heart rhythms. This overcomes the invasiveness of intracorporeal devices and the limitations of surface devices, which are confined to hospital settings and face challenges in long-term recording. By combining models capable of timely and effective prediction of arrhythmias, it is possible to prevent the occurrence of heart diseases.

Considering the significant potential in the application of smart healthcare and the severe impact of heart diseases on global public health, timely and accurate prediction of cardiac arrhythmias can help mitigate the rapid onset of heart diseases. In this study, the MIT-BIH Arrhythmia Database and data collected from a Taiwanese hospital's arrhythmia database using wearable devices provided by Singular Wings datasets were utilized.

Due to the lower occurrence rate of arrhythmias compared to normal cardiac rhythms, the dataset formed an imbalanced distribution. In model classification, imbalanced datasets often succeed in identifying the majority of normal samples but may overlook the prediction accuracy for minority abnormal samples.

Therefore, this research employed the technique of random oversampling by categorizing heart rhythms into normal and abnormal. Two algorithms, LSTM and BiLSTM, were implemented for predictive analysis. Model building, analysis, and evaluation were conducted to achieve real-time prediction of cardiac arrhythmias. The results of the models were compared and discussed to seek optimal outcomes.

Method

This study aims to construct an arrhythmia prediction model using the publicly available MIT-BIH arrhythmia database provided by PhysioNet. LSTM and BiLSTM algorithms will be employed. The model will be trained and tested with the application of Dropout to determine

the optimal number of neurons and hidden layers. Various optimizers will be tested to construct and optimize the model. Furthermore, the performance of this model will be compared with common algorithms using different validation datasets to assess its superiority. The objective is to ensure that the classification effectiveness of the model can provide health management information effectively and in real-time. The research framework is illustrated in Figure 2.

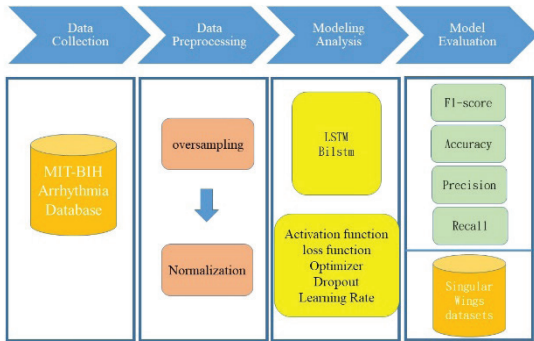


Figure 2 - research framework

This study was conducted on a Windows 10, 64-bit operating system, with an Intel (R) Core (TM) i5-6300HQ CPU @ 2.3GHz 3.2GHz processor, 16.00 GB RAM, and NVIDIA(R) GeForce GTX 950M graphics card. The programming language used was Python (version 3.5), and the data preprocessing was performed using the Keras framework within TensorFlow.

Dataset

This study utilizes ECG signals obtained from two sources: the publicly available MIT-BIH arrhythmia database provided by PhysioNet and arrhythmia data collected by a Taiwanese company, Singular Wings, from a certain hospital in Taiwan. The MIT-BIH arrhythmia database was collected by Boston's Beth Israel Hospital using an ECG machine from 1975 to 1979. It consists of dual-channel dynamic ECG recordings from 47 patients, comprising 48 records, each lasting for 30 minutes. The signal has a sampling rate of 360Hz. Each dataset includes a header file recording information such as data name, data length, and sampling frequency, along with an annotation file and a data file. The annotation file provides comments on ECG attributes and diagnoses, with diagnoses confirmed by two or more cardiac experts after verification [13].Singular Wings datasets utilized wearable sensors developed by Singular Wings Medical. These sensors were worn as chest straps beneath the chest and were employed to collect ECG data from patients in a Taiwanese hospital between the years 2019 and 2021, using the Singular Wings dataset. The dataset comprises 265 recorded sets of data with a sampling rate of 250 Hz, and the data includes annotations.

Data Augmentation

Due to the substantial imbalance in the original datasets and the notable dissimilarity in the distribution of normal and abnormal data between the MIT-BIH and Singular Wings datasets, a considerable disparity exists. Specifically, the MIT-BIH dataset exhibits a significantly larger quantity of normal data compared to abnormal data, whereas the Singular Wings dataset displays a prevalence of abnormal data over normal data.

To mitigate the issue of class imbalance, the Random Oversampling (Resample) function was employed. This technique involves randomly selecting samples with replacement to address the skewed distribution of data. In the MIT-BIH dataset, where the number of normal samples far exceeds the number of abnormal samples, a random oversampling of 20,000 samples was performed on the pool of 72,741 normal samples. Simultaneously, the abnormal samples were oversampled from 8,652 to 20,000 using the same technique.

In the Singular Wings Company dataset, both the 22 normal samples and the 189 abnormal samples in the training set underwent oversampling, resulting in a total of 20,000 samples for each class. Following the oversampling process, the Min-Max normalization method was applied to scale the data proportionally, ranging from 0 to 1. This normalization step was implemented after achieving a balanced 1:1 ratio between the two classes through random oversampling. This approach offers notable advantages, including a significant improvement in model computational speed and the prevention of original excessively large data values from dominating the overall model.

Algorithm 1:Long Short-Term Memory

LSTM (Long Short-Term Memory) is a type of recurrent neural network (RNN) known for its proficiency in handling long-term sequential data and addressing issues like gradient vanishing and exploding commonly associated with traditional RNNs. It has been successfully applied in various fields. LSTM is characterized by various gates, namely the forget gate, input gate, and output gate, as illustrated in Figure 3.

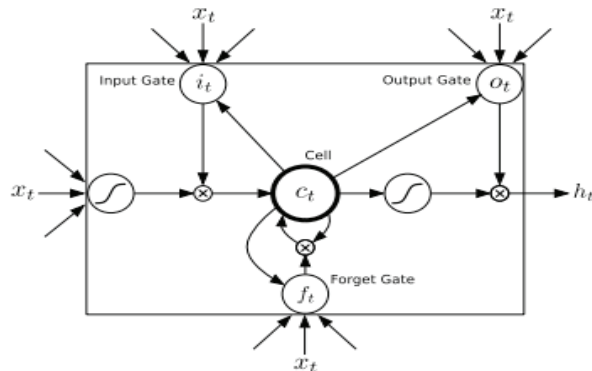


Figure 3 - LSTM Structure Diagram

The computations are performed using the following equations as shown in equation (1-5):

$$f_t = \sigma(W_{fx}X_t + W_{fh}h_{t-1} + W_{fc}c_{t-1} + b_f) \quad (1)$$

$$i_t = \sigma(w_{ix}X_t + W_{ih}h_{t-1} + W_{ic}c_{t-1} + b_i) \quad (2)$$

$$c_t = f_t \odot c_{t-1} + i_t \odot \tanh(W_{cx}X_t + W_{ch}h_{t-1} + b_c) \quad (3)$$

$$o_t = \sigma(W_{ox}X_t + W_{oh}h_{t-1} + W_{oc}c_{t-1} + b_o) \quad (4)$$

$$h_t = o_t i_t \odot \tanh(C_t) \quad (5)$$

In the above equations:

X_t : One-dimensional electrocardiogram signal.

h_t : Output.

$L \square W \square b$: Are the weight matrix and bias for the respective gate.

f_t : Forget gate, controls the extent to which the previous storage unit is forgotten.

i_t : Input gate, determines the amount each unit is updated (output generated by the storage unit).

o_t : Output gate, displays the internal storage state.

σ : Logistic sigmoid function.

$\square$: Represents vector multiplication.

$\odot$: Memory cell.

Algorithm 2: Bidirectional Long Short-Term Memory Training (BiLSTM)

BiLSTM, short for Bidirectional Long Short-Term Memory network, encodes the input sequence both from the beginning to the end and from the end to the beginning. Due to its powerful ability to handle sequential data, BiLSTM has been successfully applied in natural language processing and image processing. By utilizing BiLSTM, information from both directions of the sequence can be considered [14].

In a conventional LSTM, the analysis of information in a time window is conducted to obtain predictions for the next moment. Consequently, the output values of the time series information are only related to the preceding time step. After processing historical information, we obtain complete time series data. The structure of BiLSTM consists of two unidirectional LSTMs stacked on top of each other. Thus, the input to BiLSTM includes the time series before and after the predicted time. At each point, the input is fed into both LSTMs in opposite directions, and the output is determined by both LSTMs. Each unidirectional propagation is similar to the forward LSTM propagation algorithm introduced in the previous section. The structure of BiLSTM is illustrated in Figure 4.

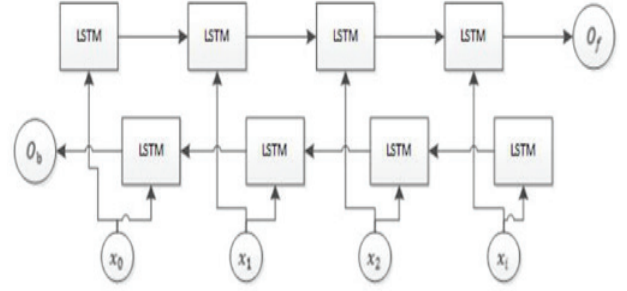


Figure 4 - BiLSTM Structure Diagram

Model Evaluation Metric

This study quantitatively assesses the model's performance using common metrics for binary classification models. The evaluation methods primarily include the following indicators: confusion matrix, accuracy, precision, recall, and F1 score [15]. In this context, considering the binary classification with positive samples representing normal heart rhythm (0) and negative samples representing abnormal heart rhythm (1), the predicted results can fall into four categories, as shown in Table 1. True Positive (TP) occurs when the actual heart rhythm is normal, and the model predicts normal. False Negative (FN) occurs when the actual heart rhythm is normal, but the model predicts abnormal. False Positive (FP) occurs when the actual heart rhythm is abnormal, but the model predicts normal. True Negative (TN) occurs when the actual heart rhythm is abnormal, and the model predicts abnormal. The confusion matrix leads to several derived indicators reflecting the model's performance. Accuracy is the ratio of all correctly predicted results to the actual results. Precision is the ratio of the model predicting normal heart rhythm to the actual normal heart rhythm. Recall is the ratio of actual normal heart rhythm and predicted normal heart rhythm. F1 score is the harmonic mean of precision and recall, providing a comprehensive measure of the model's performance. The calculation methods are summarized as follows (6-9):

$$\text{Accuracy: } (TP + TN) / (TP + FN + FP + FN) \quad (6)$$

$$\text{Precision: } TP / (TP + FP) \quad (7)$$

$$\text{Recall: } TP / (TP + FN) \quad (8)$$

$$\text{F1 score: } 2 * (\text{Recall} * \text{Precision}) / (\text{Recall} + \text{Precision}) \quad (9)$$

A higher F1 score indicates better model recognition performance.

Table 1 - confusion matrix

Indicator		Prediction	
		Normal Rhythm (0)	Abnormal Rhythm (1)
Actual	Normal Rhythm (0)	True Positive(TP)	False Negative(FN)
	Abnormal Rhythm (1)	False Positive(FP)	True Negative(TN)

Results

Model Construction

This study aims to establish a predictive model using deep learning. The data collected for analysis and modeling is from the MIT-BIH Arrhythmia Database. The dataset exhibits a significant imbalance in the distribution of normal and abnormal rhythms, making it an imbalanced dataset. Therefore, in the process of constructing the model, data augmentation is employed. The algorithms used include LSTM and BiLSTM, with the construction parameters detailed in Tables 2 and 3. Through experimentation with different models and different parameter settings, the goal is to create the optimal prediction model for arrhythmias.

Table2 - LSTM Parameter Initial Configuration

Layer (type)	Output Shape	Param
BiLSTM_1 (BiLSTM)	(None, 187, 64)	8704
dropout_1 (Dropout)	(None, 187, 64)	0
lstm_2 (LSTM)	(None, 32)	10368
dropout_2 (Dropout)	(None, 32)	0
dense_1 (Dense)	(None, 50)	1650
dense_2 (Dense)	(None, 2)	102

Table3 - BiLSTM Parameter Initial Configuration

Layer (type)	Output Shape	Param
BiLSTM_1 (BiLSTM)	(None, 187, 64)	8704
dropout_1 (Dropout)	(None, 187, 64)	0
lstm_2 (LSTM)	(None, 32)	10368
dropout_2 (Dropout)	(None, 32)	0
dense_1 (Dense)	(None, 50)	1650
dense_2 (Dense)	(None, 2)	102

Model Optimization

This study will conduct model fine-tuning optimization based on hyperparameters, including activation functions, loss functions, optimizers, dropout rates, and learning rates, with a particular focus on the significant impact of learning rates on model performance. Initially, parameters will be set within 18 intervals ranging from 0.0002 to 0.01, each paired with three commonly used optimizers (Adagrad, RMSprop, Adam). Training epochs are uniformly set to 40 to establish the optimal model. The evaluation method for model performance will utilize the F1 score. In cases where F1 scores are identical, accuracy will be used as a secondary criterion. The LSTM algorithm will be tested with different optimizers.

For the LSTM algorithm paired with various optimizers, the Adagrad optimizer achieves the best result when the learning rate is set to 0.004, with an F1 score of 0.738. The Adam optimizer reaches optimal results when the learning rate is 0.003, achieving an F1 score of 0.953, with all metrics reaching their best values. However, an overfitting issue arises at a learning rate of 0.01. The RMSprop optimizer performs better with an F1 score of 0.948 when the learning rate is set to 0.004.

Combining the results of the LSTM algorithm with different optimizers and learning rates, as shown in Figure 5, it is evident that the optimal LSTM model is achieved with the Adam optimizer at a learning rate of 0.003, yielding the highest F1 score of 0.953. Additionally, within the LSTM algorithm, the performance of optimizers varies significantly across different learning rates. The impact of learning rates on model performance is substantial, and the Adagrad optimizer exhibits the overall poorest performance, with a maximum F1 score of only 0.738. This is notably lower compared to the other two optimizers, both of which achieve scores above 0.9. This difference may be related to the characteristics of the Adagrad optimizer, as its adaptive adjustment of learning rates can lead to excessive tuning, resulting in poor model convergence.

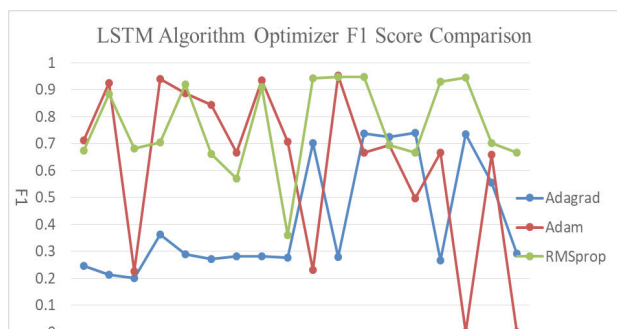


Figure 5 - LSTM Algorithm Optimizer F1 Score Comparison

Testing the BiLSTM model with different types of optimizers, the first optimizer, Adagrad, achieves optimal performance with an F1 score of 0.898 when the learning rate is set to 0.008. However, beyond a learning rate of 0.003, as the model's learning rate decreases, the performance of relevant evaluation metrics also decreases. The second optimizer, Adam, yields the best performance with an F1 score of 0.962 when the learning rate is set to 0.006. The third optimizer, RMSprop, produces the best model result with an F1 score of 0.963 when the learning rate is set to 0.006.

Combining the results of the BiLSTM algorithm with different optimizers and learning rates, as depicted in Figure 6, it is evident that the optimal BiLSTM model is achieved with the RMSprop optimizer at a learning rate of 0.006, yielding the highest F1 score of 0.963. In the BiLSTM algorithm, the Adagrad optimizer exhibits the overall poorest performance, with a maximum F1 score of only 0.898. This shows a certain gap in performance compared to the other two optimizers, which may be attributed to the Adagrad optimizer causing poor model convergence. In contrast, the RMSprop and Adam optimizers demonstrate stable performance trends across different learning rates, without significant fluctuations. This stability may be due to the improvements made by these two optimizers to address the tendency of Adagrad to overly adapt to various learning rates, allowing them to maintain steady performance across different learning rates.

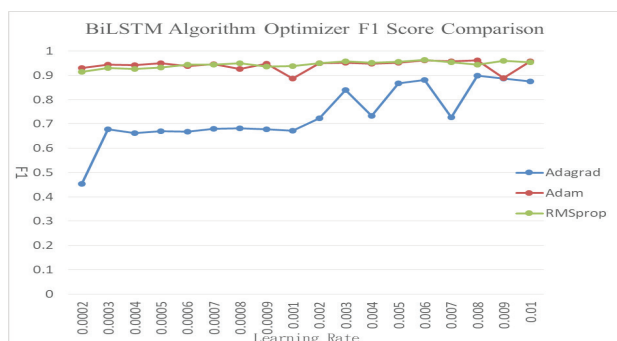


Figure 6 - BiLSTM Algorithm Optimizer F1 Score Comparison

After hyperparameter optimization for each algorithm, it was found that the optimal optimizer for LSTM is Adam, while for BiLSTM, RMSprop is the optimal choice. When evaluating the best algorithm based on various metrics, as shown in Figure 7, it is observed that BiLSTM is the best-performing algorithm, followed by LSTM. Additionally, it was noted that the Adagrad optimizer tends to exhibit over-adaptation issues at various learning rates, leading to poor convergence and resulting in lower model performance.

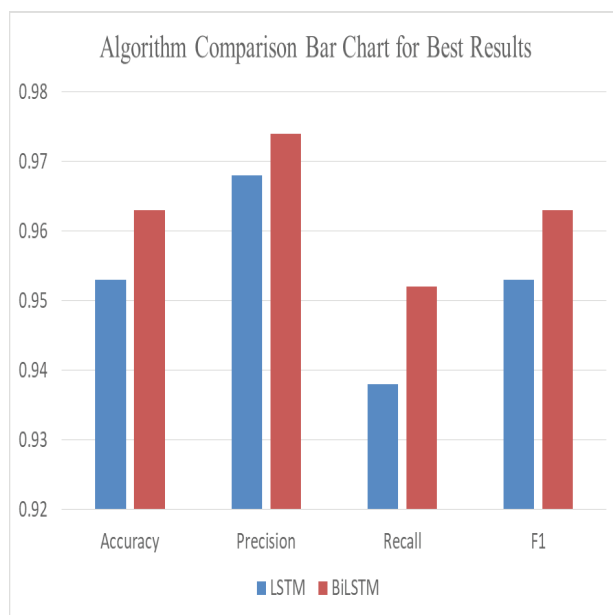


Figure 7 - Algorithm Comparison Bar Chart for Best Results

Performance Enhancement through Data Augmentation

In this study, the arrhythmia dataset MIT-BIH is extremely imbalanced. The evaluation and comparison between the augmented and non-augmented datasets for the best model based on F1 score after hyperparameter optimization are presented in Table 4. The F1 scores for the non-augmented dataset are consistently lower than those for the augmented dataset (see Figure 8). Specifically, for LSTM on the non-augmented dataset, the recall rate is 0.025 (see Figure 9). Upon analysis, it is determined that the significant imbalance between normal and abnormal data in the non-augmented dataset leads to suboptimal model classification. This underscores the importance of augmentation techniques in dealing with imbalanced datasets.

Table4 - Model evaluation with and without data augmentation.

Algo-rithm	Eval-uation Metrics	Augmentation	With-outAug-mentation
LSTM	Accuracy	0.953	0.893
	Precision	0.968	0.785
	F1	0.953	0.049
	Recall	0.938	0.025
BiLSTM	Accuracy	0.963	0.931
	Precision	0.974	0.912
	F1	0.963	0.550
	Recall	0.952	0.393

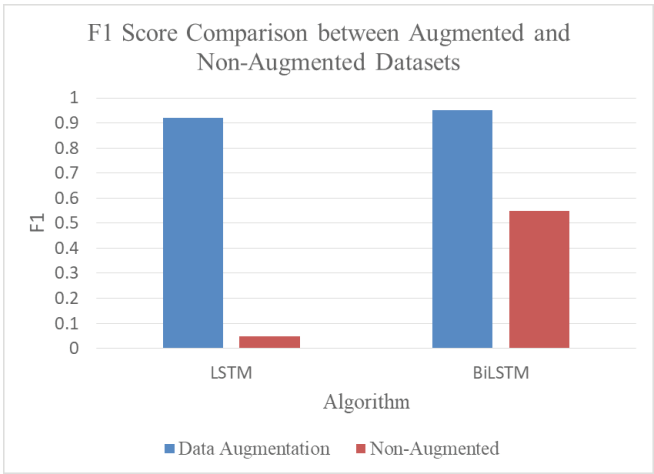


Figure 8 - F1 Score Comparison between Augmented and Non-Augmented Datasets

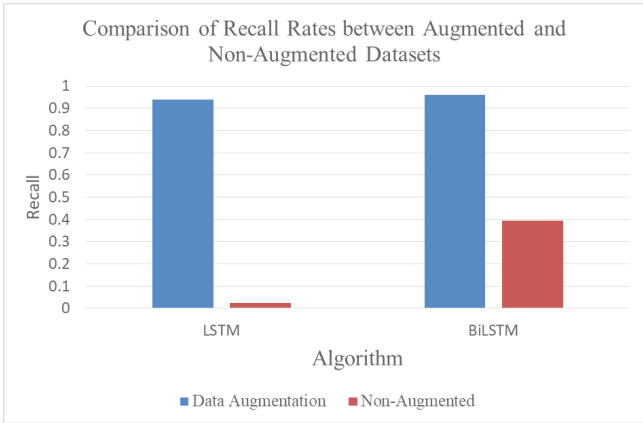


Figure 9 - Comparison of Recall Rates between

Augmented and Non-Augmented Datasets

Performance Comparison of Models on Datasets

After establishing models with the MIT-BIH dataset and applying oversampling techniques, the optimal models obtained through hyperparameter optimization were validated and compared using the augmented Singular Wings dataset. It was observed that the classification results for the Singular Wings dataset were suboptimal across all algorithms, as shown in Table5.

Despite the prior adjustment of oversampling techniques during the training process with the Singular Wings dataset, the limited original data still led to overfitting issues, impacting the classification results. Moreover, the model was initially built using the MIT-BIH dataset, and the data distribution between the two datasets in terms of normal and abnormal categories is significantly different. The MIT-BIH dataset has more instances of normal cases and fewer instances of abnormal cases, while the Singular Wings dataset has a higher proportion of abnormal cases than normal cases. This disparity in data distribution could also contribute to the suboptimal performance of the model on the Singular Wings dataset.

Table 5 - Comparison of Model Evaluation Metrics Across Datasets

Algo-rithm	Evaluation Met-rics	MIT-BIH	Singular Wings
LSTM	Accuracy	0.953	0.334
	Precision	0.968	0.371
	F1	0.953	0.418
	Recall	0.938	0.478
BiLSTM	Accuracy	0.963	0.447
	Precision	0.977	0.403
	F1	0.962	0.286
	Recall	0.947	0.222

Conclusion

This study focuses on exploring deep learning models applied to the prediction of electrocardiogram signals, including LSTM and BiLSTM. We use four evaluation metrics, namely Accuracy, Precision, F1, and Recall, to assess the performance of these models. Based on the numerical results, BiLSTM has emerged as the most suitable model. This may be attributed to the fact that electrocardiogram signals are temporal data, and BiLSTM is capable of capturing the long-term dependencies inherent in such time-series data. In comparison to other algorithms, BiLSTM exhibits advantages in learning temporal features. In the future, BiLSTM can be considered an ideal model for predicting cardiac

arrhythmias and could be employed in wearable devices for timely and accurate prediction of cardiac anomalies, enabling early warning and treatment of heart diseases. This research, through adjustments in optimizers and learning rates in deep learning algorithms, identifies that data augmentation has the most significant impact on model performance. The tuning of optimizers and learning rates also notably influences the model, particularly with the Adagrad optimizer performing less impressively than the other two. In future similar studies, considering Adam and RMSprop as primary optimizers may be a worthwhile direction. The optimal parameter combination obtained after optimization in this study serves as a predictive model for cardiac anomalies.

Applying deep learning models to cardiac arrhythmia prediction, this study successfully demonstrates accurate predictions on the MIT-BIH dataset. However, in the Singular Wings dataset, with fewer data and a class distribution opposite to that of the MIT-BIH dataset, challenges such as overfitting emerge, impacting prediction results.

In future research recommendations, given the challenges associated with limited data and divergent data distribution in a dataset from a hospital in Taiwan, it is advisable to explore various deep learning algorithms. This may include investigating the effectiveness of Convolutional Neural Networks (CNN) in conjunction with Bidirectional Long Short-Term Memory Networks (BiLSTM). Additionally, incorporating practices such as increased feature selection, adjusted loss function weights, and data preprocessing could enhance model performance.

Furthermore, integrating wearable devices is proposed as a potential avenue to attain more accurate prediction results, aligning with the overarching objective of advancing smart healthcare. This approach holds promise in addressing data limitations and improving the robustness of predictive models for healthcare applications.

Acknowledgement

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Impact of Value and Feedback of Facility AI Platform Service on Organization Performance based on SERVQUAL Model

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Abstract

Now that innovative technological advances and the 4th industrial revolution have begun, most manufacturing companies are facing new competitive environments and opportunities. They are trying to enhance existing labor productivity and accelerating efforts for the digital transformation of organizations through smart factory and AI platform service. Based on SERVQUAL model, this study analyzed the relationship between service quality and organization performance through user perception of value and feedback mechanism. This study employed SERVQUAL model into facility AI platform service for predictive maintenance beyond something like smart factory project. We empirically test that firms can improve their organization performance through value and feedback mechanism to adopt facility AI platform service. This study collects 98 data from Korean manufacturing companies which implemented their smart factory projects. After analyzing the data, we conclude that digital transformation through facility AI platform service has become one of their core capabilities to build competitive advantage.

Keywords

SERVQUAL Model, Service Quality, Value Perception, Facility AI Platform Service, Organization Performance

1. Introduction

Recently, information and communication technology has developed rapidly and is affecting society as a whole. In particular, technological advances such as the Internet of Things (IoT), artificial intelligence (AI), cloud, big data analytics, and mobile are enabling new types of services different from before (Lee, 2023). Without exception to the manufacturing industry, a new type of facility AI platform service is being proposed as artificial intelligence and platform technology are applied to equipment management work based on the Internet of Things. Digital transformation has become an indispensable foundation and way for companies to face the direction of networking and intelligence, improve quality and efficiency, and reshape the firm's core competitiveness (Lu et al., 2019). The rapidly changing business environment is making efforts to secure a new competitive advantage by redesigning existing business processes and promoting automation by allowing companies to develop and implement strategies of AI platform service for digital transformation. However, it is not easy to answer the question "How to measure the service quality of AI

platform service?" Researchers attempting to measure the effects of user perception on the subsequent success of facility AI platform service may use usefulness and user satisfaction as the primary measure (PZB, 1985, 1989). So it is important to study the impact of service quality of facility AI platform service on organization performance through user perception like perceived value and feedback mechanism of customers.

The questions with this study are: 1) what is the service quality of facility AI platform service 2) How to measure the service quality of AI platform service 3) Does it have a positive impact on organization performance through value and feedback? To solve these questions, this study suggests a research model based on MIS literatures and SERVQUAL model. Thus, this study proposes a research model to analyze the relationship between service quality and organization performance through user's value perception and feedback mechanism. This study focuses on facility AI platform service for smart factory of integrated enterprise systems, which understand both expressed and latent information needs or delivers superior value to the organization.

2. Literature Review

2.1 Digital Transformation of SMEs

Now that innovative technological advances and the 4th industrial revolution have begun, manufacturing companies are facing new competitive environments and opportunities. Manufacturing companies switch to production methods using digital technology and artificial intelligence along with existing production methods, and companies see service and quality improvement as an important value through feedback in the operation process, and decide whether to reuse the platform in the future. Digital transformation is an important phenomenon in the research of MIS, including the significant changes in society and industry through the use of digital technology. In a transitional economy, SMEs (small and medium enterprises) are small in scale and flexible in their business operations, and are most likely to organize production facility and equipment according to economic comparative advantages. With the increasing employment pressure in society, the advantages of SMEs in solving employment have also received more and more attention to digital transformation strategy like smart factory. Smart factory projects for digital transformation are particularly important for traditional manufacturing companies. With the deep integration of digital technologies in the manufacturing industry, there has been a digital transformation that has changed the traditional production and operations management methods and offers the potential for the improvement of product development, production efficiency and customer service (Wei et al, 2017). The digital technology trends and design principles used by SMEs in digital transformation include: computer-aided design (CAD) and manufacturing (CAM), 3D printing, artificial intelligence (AI), big data analytics, cloud computing, industrial Internet of Things (IoT), mixed reality (virtual and augmented reality), simulation of connected machines (Paschou et al., 2020). Digital transformation goes beyond the traditional IT role in supporting existing business processes, as it can redefine value proposition.

2.2 Facility AI platform service

The South Korean government announced an industrial policy to promote smart factory advancement as one of core manufacturing technology, build 1,500 leading models by supporting 30,000 smart factory demand companies by 2025, and cultivate 40,000 professionals by supporting advancement at the basic level. POSCO developed PosFrame, the world's first smart factory platform that reflects the characteristics of steel continuous processes, in 2018, and is the world's first steelmaker to introduce artificial intelligence into an intelligent steel mill (POSCO, 2018). Through this, a barrier-free operation system is realized, quality defects are identified in advance to minimize defects, and risk factors in the

workplace are identified in real time to realize a safe production environment. Various data collected in a smart factory can predict temperature changes through deep learning algorithms, which can be controlled in advance by developing into. As a result of the application of this case, it was selected as a "lighthouse factory in the world" to lead the future of global manufacturing at the 2019 Davos Forum in Dalian, China (Seo et al, 2022).

In the era of digital transformation, changes and innovations in facility management work are needed in the root industry. Accordingly, it is necessary to actively promote digital transformation in overall facility management, such as establishing a facility management system using digital technology, performing predictive maintenance through data analysis, and establishing response strategies for efficient repair and preservation.

2.3 SERVQUAL model

The SERVQUAL model was suggested by Parasuraman, Zeithaml, and Berry (PZB, 1989). service quality is an abstract and elusive construct because of three features unique to services: intangibility, heterogeneity, and inseparability of production and consumption (Parasuraman, Zeithaml, and Berry 1985). They proposed the model to apply many and retail businesses to seek profitable ways to differentiate themselves (PZB, 1989). SMEs that adopt digital transformation with information technology must be aware of both their product design and manufacturing environment. By constantly monitoring changes in the dynamic environments, SMEs can gain awareness of opportunities for greater access to new markets as well as advancements in technological initiatives.

Facility AI platform service in this study refers to the action of transforming existing employ handling operation into smart factory operation with robot and vision technology. For example, robot and vision technology with software applications could be utilized for job shop operations during production process. Generally, digitization mainly refers to digital operation processes, but have an influence on the value creation of business activities. Companies enhance the user experience and create additional customer value by allowing more efficient configuration between business processes (Pagani et al., 2017).

3. Research Model and Hypotheses

3.1 Research Model

Based on IS success theory (McLean and Delone, 1992; 2003; Petter et al, 2013)., most companies have conducted smart factory strategy implementation to improve competitive advantage. This study proposes new approach of value perception and explores the impact of usefulness and value perception on organizational performance based on IS success model. This study developed a research model (Fig. 1), which explain facility AI platform service

for obtaining the sustainable competitiveness.

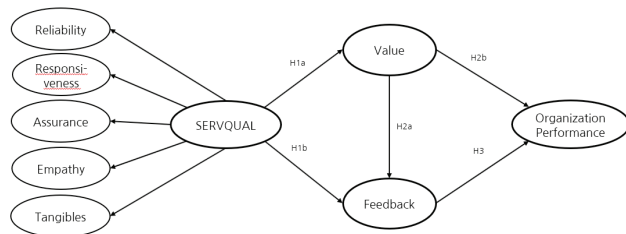


Fig. 1 Research Model

3.2 Research Hypothesis

Since this study has a research direction to explain the need for smart factory strategy by usefulness and value perception, the sustainable competitiveness of the firm can be obtained by the adoption of AI platform service for digital transformation.

H1: Service quality of facility AI platform service has a positive influence on (a) perceived value and (b) feedback of customers.

H2: Perceived value of facility AI platform service has a positive influence on (a) feedback of customers and (b) organization performance.

H3: Customers' feedback of facility AI platform service has a positive influence on organization performance

4. Research Method

4.1 Operational Definition

The purpose of this study is to conduct an empirical study on the relationship between 5 factors of SERVQUAL (reliability, responsiveness, assurance, empathy, tangibles) and organizational performance through value perception and feedback mechanism of the firm. Preexisting construct measures have been used in this study. According to previous studies of resource-based theory and dynamic capability theory, this study developed the operational definition and measurement items of independent variables 5 factors of SERVQUAL, perceived value, feedback, and organization performance. Some of questionnaire items were measured using a 5-Point Likert Scale ranging from 1 (very disagree) to 5 (very agree). Data was analyzed in three steps. First, we tested for outliers, normality, and missing values. Then, we evaluated the internal and external validity of the measurement scales, and finally, examined the reliability, validity, correlations, model fit and mediation effects.

4.2 Sample Statistics

This study collected the data for analyzing the level of smart factory readiness from 98 manufacturing firms. Survey respondents were comprised of decision makers (entrepreneurs) of 98 Korean SMEs, which were implemented smart factory project with robot and vision

technology. The survey was conducted from March 2023 to May 2023. A total of 98 firm data was collected, and valid responses were analyzed using SPSS 27 and PLS 4.0.

Table 1 - Sample Statistics

Item	Type	Freq	Ratio(%)
Industry	Automobile	51	52.0
	Mechanic	20	20.4
	Electronic	27	27.6
Facility Team Members	Under 5	65	66.3
	6~10	28	28.6
	11~20	2	2.0
	21-30	2	2.0
	Over 30	1	1.0
Smart Factory Project Period (Month)	Under 6	10	10.2
	7~9	60	61.2
	10-12	20	20.4
	13~18	7	7.1
	Over 18	1	1.0
4th ICT Technology Use (multiple choice)	AI	24	24.5
	IOT	86	87.8
	Big Data	32	32.7
	Cloud	4	4.1
	Mobile	3	3.1
	Robot	83	84.7
	Vision	27	27.6

4.3 Validity and Reliability

The respondent of the firm was interviewed by field experts. Based on some of visits and interviews, the data were collected through self-diagnosis of level measurement and field survey by external smart factory experts of the promotion team. <Table 2> shows the sample statistics on 98 firms in this study. Field survey has some advantage of exact diagnosis by external experts. Based on the level measurement, some questionnaires were organized into research variables in the research model. To establish convergent validity as recommended by Hair et al.(2014), factor loading and average variance extracted (AVE) were used.

Table 2 – Convergent Validity

Var	Items	Cross-Loading	AVE	Composite Reliability	Cronbach-a
SQ1	3_1_1	0.898	0.759	0.941	0.939
	3_1_2	0.895			
	3_1_4	0.837			
	3_1_5	0.853			
SQ2	3_2_1	0.785	0.642	0.896	0.894
	3_2_2	0.832			
	3_2_3	0.756			
	3_2_4	0.829			
SQ3	3_3_1	0.893	0.658	0.813	0.813
	3_3_2	0.852			
	3_3_3	0.714			
	3_3_4	0.773			
SQ4	3_4_1	0.841	0.662	0.831	0.823
	3_4_2	0.722			
	3_4_3	0.898			
	3_4_4	0.782			
SQ5	3_5_1	0.793	0.638	0.850	0.829
	3_5_2	0.834			
	3_5_3	0.808			
	3_5_4	0.759			
xVR	4_1_1	0.841	0.712	0.903	0.898
	4_1_2	0.873			
	4_1_3	0.902			
	4_1_4	0.785			
	4_1_5	0.814			
xFB	4_2_1	0.707	0.710	0.936	0.931
	4_2_2	0.900			
	4_2_3	0.894			
	4_2_4	0.921			
	4_2_5	0.786			
	4_2_6	0.824			
xPP	5_1_1	0.855	0.721	0.910	0.903
	5_1_2	0.784			
	5_1_3	0.896			
	5_1_4	0.874			
	5_1_5	0.833			

All the loadings for the final model were above 0.707. Furthermore, all the construct measures met the criteria of AVE > 0.5 ranging from 0.638 to 0.759. To establish internal consistency, All the Cronbach-a values are above the threshold 0.7 value which ranged from 0.813 to 0.939.

Table 3 – Discriminant Validity

	SERVQUAL	SQ1	SQ2	SQ3	SQ4	SQ5	xVR	xFB	xPP
SERVQUAL	0.762								
SQ1	0.931	0.871							
SQ2	0.941	0.853	0.801						
SQ3	0.916	0.760	0.794	0.811					
SQ4	0.714	0.559	0.608	0.709	0.813				
SQ5	0.556	0.550	0.445	0.533	0.528	0.799			
xVR	0.655	0.609	0.601	0.611	0.463	0.633	0.844		
xFB	0.719	0.665	0.653	0.673	0.582	0.654	0.839	0.843	
xPP	0.643	0.563	0.593	0.623	0.560	0.689	0.802	0.785	0.849

4.4 Hypothesis Testing

The results of hypothesis testing in this study are summarized as follows. For H1a and H1b, the result shows that SERVQUAL influences positively on perceived value and feedback of customers. For H2a and H2b, the result shows that perceived value influences positively on feedback of customers and organization performance. For H3, the result shows that feedback of customers

influences positively on organization performance. This result means that the usage of facility AI platform service enables the organization to achieve direct effects on improving organizational competitiveness.

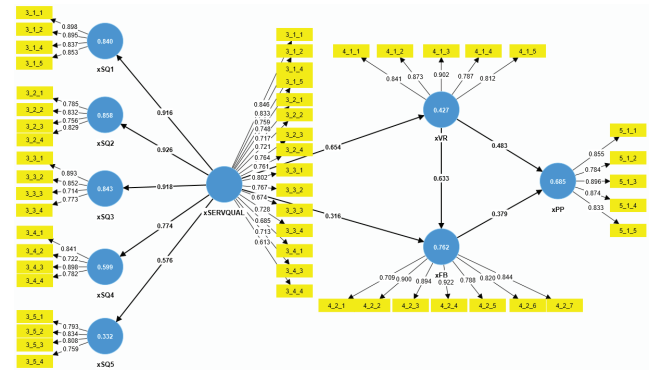


Fig. 2 The Result of Path Analysis

5. Discussion and Conclusion

The results from this study contribute to provide some theoretical basement for the development of corporate smart factory strategy. This study has suggested a new digital transformation strategy through facility AI platform usage. It emphasizes the importance of the relationship between service quality and organization performance through value perception and feedback mechanism of digital transformation. This study has some limitations. It is difficult to generalize the results because of small data sample size and limited research variables. In the future research, we will study value perception and feedback mechanism through smart factory strategy. Also, future research needs to enlarge the sample size. Future research needs to empirically study different countries and industries to implement smart factory project.

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Decentralized Identifiers Threshold-Aware Authentication with Zero-Knowledge Proof

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Abstract

Recently, a social consensus has been on protecting personal data privacy and security. In the Web 2.0 age, data was primarily in the hands of centralized institutions, whereas Web 3.0 uses blockchain features to ensure data security and privacy. This study introduces a Decentralized Identity (DID)-based identity verification system that preserves privacy and accurately identifies users. The study considers various conditional threshold variables and proposes a system to certify privacy-sensitive records for tracking contacts of confirmed cases during an epidemic. Within this system, users provide marked records linked to IoT-generated keys and hash records. The system employs intelligent contracts and zero-knowledge proofs to verify if identity recognition thresholds have been met.

Keywords

Decentralized Identifiers, Privacy, Zero-knowledge Proof, Consensus, Contact System

INTRODUCTION

Research Background

As Web 3.0 develops, physical environments are being virtualized under a blend of reality and virtuality, integrating digital systems into real-world settings through the Internet of Things (IoT) [1]. Conversely, the Metaverse's evolution offers realistic virtual environments, allowing access to necessary information at any time, place, or device [2]. Relying on centralized Web 2.0 entities could lead to data manipulation and privacy issues [4], which this study seeks to mitigate in Web 3.0's decentralized environment.

With the extensive use of information technology, issues like centralization, privacy, and online activity surveillance on Web 2.0 platforms are increasingly concerning [5]. Emerging technologies such as blockchain, cryptocurrencies, and zero-knowledge proofs are continuously evolving to form the core of Web 3.0. These technologies aim to create a decentralized, transparent Internet environment, enhancing user trust and privacy protection while developing Web 3.0 applications [6]. In the decentralized environment of Web

3.0, data is distributed across multiple nodes, particularly in blockchain applications, thus avoiding centralized storage. Blockchain employs hashing technology to link data into blocks, addressing the vulnerabilities of traditional centralized systems, such as susceptibility to tampering and information bottlenecks. However, challenges in user identity recognition still exist.

Developing decentralized identifiers for authentication is an essential and crucial issue in the decentralized Internet environment. This study proposes a method where data is stored on a selection of randomly chosen miners, allowing any host within the system to perform anonymized queries to verify record authenticity. In a Web 3.0 environment, all user activities recorded on the blockchain could compromise privacy. Several methods on the blockchain protect user data privacy, including Zero-Knowledge Proof (ZKP) [8], Homomorphic Encryption [9], Differential Privacy [10], and Multi-Party Computation (MPC) [11], each serving different purposes. ZKP, for example, can verify certain truths without revealing specific details. The study designs a mechanism using ZKP to demonstrate a user's ability to meet set thresholds.

Decentralized IDentity (DID) in Web 3.0 is a crucial technology being explored [13]. DID is a threshold-guided, privacy-centric identification technology where users can store personal and private information and credentials in DID operating on the blockchain. Its decentralized consensus mechanism enhances the credibility of identity proofs [14]. Storing data in blockchain and other decentralized systems, DID reduces the risk of hacking, data leaks, and manipulation. This research explores protecting data privacy under threshold-guided decentralized identity recognition.

Research Motivation

Traditional identity verification involves users authenticating their identity with centralized institutions. For example, verifying age for purchasing alcohol requires showing an ID to a store clerk, a process vulnerable to forgery or using an adult's ID. Centralized electronic identity verification also has the potential for fraud. In contrast, DID technology aims to move away from dependence on centralized institutions using a distributed consensus mechanism for identity verification.

DID stores user information on the blockchain to reduce problems associated with centralized control. Blockchain's consensus mechanism ensures the immutability of user information, thus preventing forgery. In the Web 3.0 framework, users maintain control over their DID data, addressing the risk of unauthorized use. However, DID still requires users to provide identity information and factual evidence for verification. This study explores how to collect de-identified user data, where identifying details are removed or concealed, preventing complete user information inference even if data is inadvertently leaked.

Integrating decentralized identification mechanisms, one of the features of zero-knowledge proofs (ZKP) is safeguarding user privacy. For instance, in ZKP, a prover can demonstrate a capability, like solving an addition problem, to a verifier without revealing the calculation process. The process can be repeated if the verifier remains skeptical until the prover's ability is confirmed. Accordingly, this research proposes improvements to the existing ZKP mechanism for verifying required identification data under privacy protection. Through collecting de-identified data and applying ZKP, a comprehensive mechanism to protect user data is achieved.

After data collection, it is essential to confirm if it belongs to the user. This study explores how to map collected data to the user in a decentralized environment. However, authenticating identity relies on more than a single record or variable. It is crucial to consider what data records are necessary to verify whether a user meets the identity threshold, maintain privacy, and obtain certification in a decentralized setting.

Protecting user privacy during identity verification and preventing data tracking by attackers during transmission are vital concerns. Data passes through numerous routers and miner nodes, and traditional shortest-path routing methods make it easier for attackers to track user data. Therefore, this research suggests using random routing or miner nodes for hop-by-hop data transmission, making it difficult for attackers to track personal data and ensure privacy during identity verification.

Users face several challenges during identity verification, especially in interactive verifications requiring real-time user interaction for data accuracy. For instance, in financial transactions, users must confirm their identity for account operations. Immediate provision of identity proof is vital. Additionally, data accuracy is crucial for successful identity verification, like verifying legal age. Combining these scenarios, the study concludes that real-time interactive identity verification should consider system timeliness, and data accuracy is essential when it affects verification outcomes.

Research Objectives

This study uses activities and records stored in the blockchain Web 3.0 for identity recognition. The objectives of the current study are as follows:

- **Identifying Types of Decentralized Data:** In the Web 3.0 Metaverse, activities and records can be stored in decentralized systems. For instance, digital assets in ETFs are stored on the blockchain. The proposed approach collects objective data generated through interactions and processed with identifiers and hashing techniques. By using consensus mechanisms, data integrity is ensured, and analysis of various issues is conducted while preserving privacy through zero-knowledge proofs.
- **Zero-Knowledge Proof Mechanism for Recognition Thresholds:** Blockchain's transparency allows all participants to view transaction records. To protect user identity and sensitive data from being traced, this research explores how zero-knowledge proof mechanisms can maintain privacy without revealing identities on the blockchain. Different data sizes and types, such as time, location, or environmental data, will be considered to understand their impact on zero-knowledge proofs.
- **Improving Contact Systems to Prove Data Ownership:** Confirming data ownership after verifying data sources and maintaining user privacy through zero-knowledge proofs is crucial. This study explores how to map collected data to users in various scenarios, ensuring that the data belongs to the correct user.
- **Multi-Dimensional Consensus Threshold Control Variables:** Data correlation to the user is not just based on a single record. Multiple records, dimensions, and nodes are required for proof. The

study will explore what constitutes sufficient proof to convince verifiers of a user's identity, considering various aspects like time, space, and activities.

- **Verification Timeliness:** In financial transactions, immediacy is critical to prevent unauthorized activities and provide users instant feedback. The study aims for real-time data verification in financial interactions to protect user rights, considering the acceptable response time and timeliness for such transactions.
- **Verification Accuracy:** Data accuracy is more important in scenarios like academic qualifications verification, where the response time can be longer due to less urgency. The study will consider the correctness of data in these contexts to ensure accurate identity verification.

LITERATURE

Decentralized Identification

Identity verification and management are primarily based on centralized and concentrated institutions. Therefore, a decentralized identity authentication method is needed to replace centralized entities' management of personal data [17]. The World Wide Web Consortium (W3C) proposed a decentralized identification method involving Verifiable Credentials (VCs) to authenticate users [14]. For instance, a school can issue a VC as a graduation certificate to graduates, who can then present this VC to potential employers for verification. However, a concern with this method is that the issuing institutions are centralized, which may lead to unfair situations. Thus, Kurbatov et al. [18] suggested that all participants should be able to issue VCs and include a rating mechanism to enhance the reliability of VCs and prevent forgery. However, this approach still relies on institutions or participants to issue proof, and the application scenarios of VCs might be limited. VCs may display sensitive information about the holder, such as personal identity and information. Therefore, this study explores recognizing users without relying on centralized institutions or subjective judgment while maintaining privacy.

- (1) This research proposes an approach that uses records from interactions with IoT devices for authentication to replace VCs. The proposed approach can address the subjectivity and reliance on centralized institutions inherent in VCs.
- (2) The records from Internet-connected devices will not contain sensitive personal information of users, only objective information like time and location, to prevent tracking and identification of the individual.

Zero-Knowledge Proof

As dependency on the Internet increases, users are required to store vast amounts of personal data online in exchange for services. Consequently, this leads to widespread data

dissemination on the Internet. Zero-knowledge proof allows users to maintain autonomy over their data [19] while achieving identity verification [20]. This study aims to use zero-knowledge proof to confirm whether users meet the thresholds for identity verification by collecting de-identified user data in a decentralized environment using a consensus mechanism concept to obtain proofs from multiple sources. This approach ensures trust in the data source without compromising user privacy during collection.

Personal Data and Blockchain

Literature proposed a hybrid blockchain-based identity verification scheme, using mobile devices to collect user data and address identity verification challenges [21]. This scheme leverages the blockchain's decentralized, immutable, secure, and transparent properties to support identity verification and user data privacy protection. Combining blockchain with traditional centralized databases enhances the system's scalability and efficiency. It integrates on-chain and off-chain data through zero-knowledge proofs to reduce blockchain workload. In traditional blockchains, transaction verification is done through computation and validation. However, with zero-knowledge proofs, part of the computation is moved to the cloud or local computers, and the results are transmitted to the blockchain for verification, thus saving on blockchain workload and increasing transaction speed.

The study uses blockchain to enhance the security of centralized databases by connecting individual de-identified data with the blockchain and the user through interactions with IoT (Internet of Things) devices. Using the DID format proposed by the W3C [22], users can authorize the system to control and manage data records. With DID, user records are not directly stored in the DID but linked through the blockchain for comparison, ensuring that de-identified data does not leak personal information, as shown in Figure 1.

De-identified data not only prevents the leakage of personal user data but also necessitates protection against tracking during data transmission. Traditional shortest-path routing methods [15] can easily trace data origins based on the start and end points. Random routing methods [23] can circumvent this issue by transmitting data through randomly selected nodes or 'hops,' thus reducing the risk of user data being easily traceable. However, while achieving un-tractability, not following the shortest path could lead to increased transmission time. Due to the need for random node selection, this study must evaluate whether to limit the minimum number of hops required to reach the destination to mitigate the issue of prolonged transmission times.

Contact History Mechanism and Decentralized Identification

Decentralized identification can be used to develop

mechanisms to record people's contact history and keep data private [24]. During the COVID-19 pandemic in Taiwan, the government and the public sought to understand potential contacts with confirmed cases, leading to the development of the Taiwan Social Distance app [25]. This app uses Bluetooth and location tracking to monitor contacts, with individuals uploading their infection records to a central server [26]. The server then notifies users of potential risks from these contacts.

Similarly, Apple and Google launched a contact tracing system, which differs from Taiwan's app by storing data on user devices, leaving the decision to upload to a central server to the user. Both contact tracing systems use a critical exchange method, generating daily keys on each device, which hashed to create rolling proximity identifiers for exchange. To verify contact risk, these identifiers are compared with the daily keys.

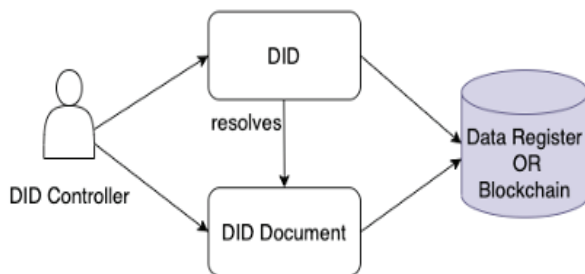


Figure 1 - DID architecture (Source: this study).

If data on the central server is tampered with, it could lead to inaccuracies in contact records. Ferretti et al. [27] proposed a COVID-19 contact tracing system combining the advantages of centralized and decentralized systems for improved performance and privacy protection. When an infection is detected, notifications are sent to a website, relayed to the central server, and then forwarded to users in the area. Users log these notifications on their local devices. If diagnosed with COVID-19, they can upload their list of contact events to the central server, which matches these with others' lists. Matched users are then notified of potential exposure.

The system allows participants to control their data on their devices and choose to share it with others or the central server. It also introduces a consensus-based data verification mechanism, using consensus algorithms for blockchain participants (nodes) to prevent data tampering. Public and private keys are used for identity verification, ensuring data integrity while maintaining participant anonymity.

Improvements to the framework proposed in Ferretti et al.'s research include:

- (1) Replacing the central server with blockchain and user devices for storing contact records. Blockchain's tamper-proof nature and consensus mechanisms ensure record integrity, allowing users to authorize their contact records for the system.
- (2) To generate records on the IoT, the system uses

communication between IoT devices and user DID, executing through smart contracts. This reduces the steps of uploading infection notifications to a central server and relaying them to other users.

Ring Signatures

The primary concept of ring signatures is to provide anonymity for the signer within a group [28]. When a message is encrypted with a ring signature, anyone can verify that it comes from a group member, but it is impossible to determine which member signed it. This method allows the signer to prove their membership in the group without revealing their specific identity. The critical concepts of ring signatures are:

- Anonymity: Allows for anonymous signing within a group.
- Unforgeability: Since ring signatures are executed through a blockchain consensus mechanism, attackers cannot forge the signature once signed.
- Untraceability: Observers in the network environment cannot determine which user generated the signature.

The operation of ring signatures involves the following steps:

- Creating the Ring: Initially, assume there are 'n' public keys: $P_1, P_2, \dots, P_n$. The signer selects some public keys, including their own, to form a ring.
- Generating the Signature: If the user wants to sign a message 'm' and their private key is x_i corresponding to their public key P_i , the user generates a random number for each public key in the ring, except for their own. The user generates the signature using these random numbers and their private key x_i . This signature appears to be generated by all public keys in the ring, not just by the private key x_i .
- Verifying the Signature: When the recipient receives the signature, they can use the entire ring of public keys to verify its validity. If the signature is valid, the recipient can confirm that a ring member signed the message but cannot determine which member it was.
- This study aims to utilize ring signatures to help users prove their identity rights while maintaining anonymity. For example, in voting, ring signatures can be used to prove a user's right to vote without revealing their identity.

RESEARCH QUESTIONS

This study explores how to collect user information in a decentralized environment while achieving privacy goals, thereby realizing decentralized identification. Centralized devices for data storage may not assure users of their data security. Hence, this research proposes using blockchain hash (Hash) technology to prevent data tampering and improve contact systems for verifying data ownership. It also plans to generate matrices using different types of data, followed by zero-knowledge proof, to determine if users meet the threshold criteria.

In network environments, network topology diagrams show how nodes are connected, aiding routers in data packet transmission and displaying resource distribution for more effective management. However, this research selects random hops for data transmission instead of traditional shortest-path routing. The network topology is divided into two layers: the physical network layer (as shown in Figure 2) and the logical network layer (overlay) (as shown in Figure 3). The topology consists of five roles: (1) Routers, forwarding user data and selecting routes; (2) Servers, for data storage and management; (3) Users, for identity verification or requesting verification; (4) Miners, for data storage verification and maintaining blockchain security and consistency; (5) Proxies, receiving user requests and forwarding them into the network. This study defines users as those requesting identity verification and storing data, distinct from Miners.

The connection rules for these nodes are as follows: 1) Routers can connect with all nodes; 2) Servers do not connect with other servers; 3) Users do not connect with other Users and Miners; 4) Miners only connect with Routers and Servers; 5) Proxies do not connect with other Proxies and Miners. These rules simulate real-world network transmission, ensuring each node follows set rules and checks for connections to prevent isolation.

The study aims to explore the privacy and efficiency of decentralized identity verification. Therefore, in routing, at least ten miners are randomly chosen as hops to reach the destination in the logical network layer, making it difficult for attackers to trace user data. However, too few miners make tracking easy, while too many can prolong transmission time. After selecting miners in the logical layer, data is still transmitted via the shortest path in the physical network layer, ensuring data privacy and efficiency.

In real-world networks, identity verification data transmission can be static or dynamic. Static networks involve setting roles in the network environment with defined functions like bandwidth and capacity, forming a static network with generated traffic. Dynamic networks begin as data is transmitted through routers, changing with different miner selections. Each miner's delay in handling data and capacity is assessed, forming a simulation of actual data transmission in a dynamic network.

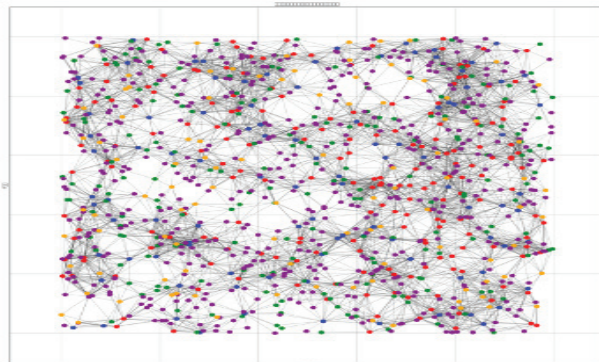


Figure 2 - Network Topology Diagram - Physical Network Layer. Note that the routers, servers, users, miners, and proxies are marked in blue, red, green, purple, and orange (Source: this study).

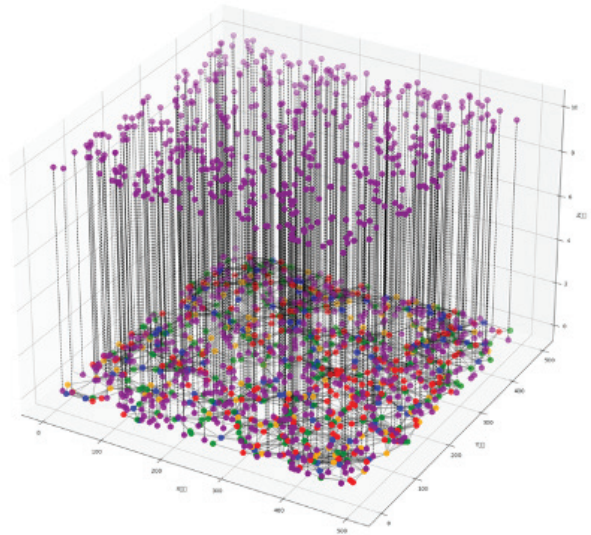


Figure 3 - Network Topology Diagram - Logical Network Layer (Source: this study).

PROPOSED DID OPERATIONAL MECHANISM

Data Source

In the Web 2.0 environment, data sources are typically provided through centralized institutions or facilities, which can lead to trust issues regarding data authenticity, even with blockchain recording. This study proposes a mechanism that collects data in a digital environment without reliance on centralized institutions, thus enhancing source accuracy and reliability, as shown in Figure 4.

The study utilizes real-world sensors or cameras to trigger contact systems. These devices record time and location data, which are hashed and stored on the blockchain. Through DID formats, users can match these blockchain records to ensure they can only access their data, preventing unauthorized access.

Contact History System

The proposed contact system uses sensors and other devices. Daily keys generated by these devices, once hashed, produce rolling contact indicators, updated every 15 minutes, thus preventing user tracking. Users compare their device's record with the verifier to confirm its accuracy to authenticate.

- (1) A 128-byte key, the rolling proximity identifier key, is generated.
- (2) This key and other information (like current time and date) are used to generate RPIs. RPIs consist of 256 bytes, including a 16-byte Proximity Identifier.
- (3) The contact identifier (16 bytes) is extracted from the RPI and broadcast to user devices for contact tracing.
- (4) RPIs are matched with the key to verify records.

Multidimensional Matrix

Various dimensions (space, time, etc.) are considered in collecting de-identified user data, as shown in Figure 5. The study proposes two-dimensional and three-dimensional variable structures for verifiers to conduct identity checks based on required dimensions. In the multi-dimensional matrix, different variable models are defined for each dimension, as shown in Figure 6. Verifiers do not authenticate all variables but determine how many are needed. For instance, in verifying age, users submit 'n' pieces of data corresponding to matrix dimensions, and verifiers match these against the contact device or system for hash verification.

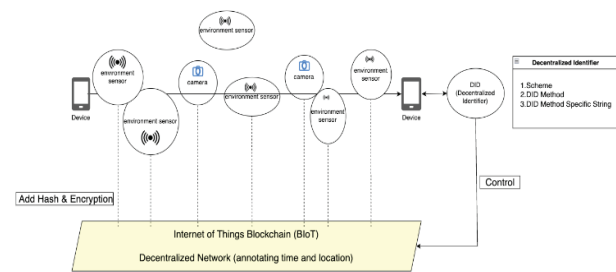


Figure 4 - Decentralized environmental data source (Source: this study).

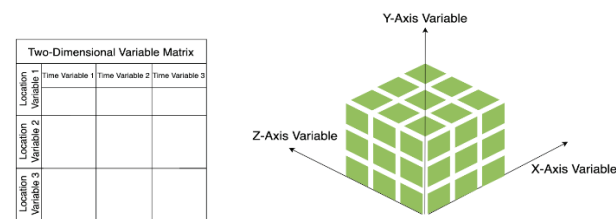


Figure 5- Multi-dimensional Matrix Diagram (Source: this study).

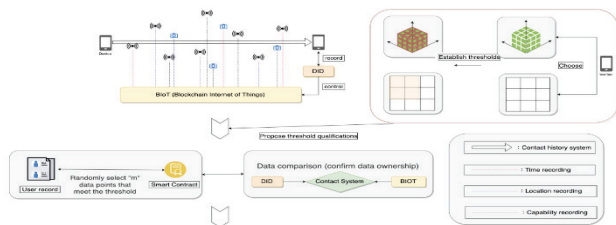


Figure 6 - Multi-dimensional Proof Threshold Diagram (Source: this study).

Zero-Knowledge Proof Threshold Mechanism

This study combines the decentralized identification mechanism with zero-knowledge proof to address trust and security issues in centralized data provision.

It proposes a zero-knowledge proof mechanism for different data types, aiming for privacy without revealing personal information. Unlike traditional zero-knowledge proof that requires user comparison, the verifier sets this study's threshold mechanism to determine if users meet the threshold.

Verification Time: The user's time records triggered by IoT devices are stored in corresponding year boxes to prove a user is over 18. The verifier checks the box against the claimed year via a smart contract to verify the user's age without revealing the exact age.

Verification Quantity: The visit times are recorded in the visit times box. If a user visits a place x times, the first x boxes are recorded as true. The verifier sets a threshold of visit times, and the smart contract automatically checks the box for the user's contact record. This method verifies the threshold without revealing the exact number of visits. Each box is marked based on the comparison of the contact history system and user device record. The box indicates possession of the record but does not detail the nature of the data. For example, in verifying time, the system confirms the user has time records at a specific library during their study period, convincing the verifier of the record's validity without disclosing the exact timing.

Verification Process

After analyzing the abovementioned issues, this study proposes a flowchart, as shown in Figure 7, for a decentralized identity recognition process guided by zero-knowledge proof thresholds. The system comprises two main actors: the Prover (User) and the Verifier. Users in a decentralized environment naturally interact with IoT devices, leaving records on both IoT device ends and user ends through the contact history system. Users authorize the system to control their records.

On the verifier's end, the verifier selects variable dimensions and thresholds (m variables) from the matrix structure proposed in this study, considering the number of records (n) owned by the user. Smart contracts access user records through user authorization. The system randomly extracts m data points from the user's n records, verified for integrity and ownership through the contact history system's public and private keys or hashing.

After confirming the data quantity and verifying that the data belongs to the user, the study's zero-knowledge proof mechanism is employed for verification. If the m data points pass verification, it proves that the user meets the threshold set by the verifier.

During the system's operation, various issues may arise, necessitating the exploration of the following problems:

- (1) System: If there is a delay in the system's response during the comparison or random selection process, which could impact user verification, the system should have a mechanism to handle this. Since users

study proposes a multi-dimensional matrix framework. It verifies user identity based on whether the verifier sets specific data or the user provides information that meets the threshold. Finally, these data are verified through zero-knowledge proofs to achieve privacy and confirm whether users indeed meet the specified criteria.

This study aims to achieve the expected benefits through the proposed mechanisms, and the anticipated outcomes are as follows:

Decentralized Identification Threshold Mechanism:

This mechanism aims to collect de-identified data and, in combination with a multi-dimensional threshold, thoroughly verify user identity. This way identifies whether users meet the threshold without revealing sensitive information.

Achievement of Zero-Knowledge Proofs: Improving the existing zero-knowledge proof mechanism is used to compare quantitative methods and show how better the proposed methods. This study expects to expand zero-knowledge proofs to create a mechanism for identifying whether users meet time, quantity, and other degrees of the thresholds.

Contact System Application: The existing contact history system's main purpose is to compare whether users have contact and the duration of that contact. This study anticipates improving the contact history system to record interactions of users with IoT devices in a decentralized environment. This allows users control over their records and authorize the system for identity verification.

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Subliminal Perception Mechanism of Speech Emotion and Intelligent Computation

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Abstract

Human speeches contain rich emotions, which are widely reflected in communication and publicity, campaign speech and court defense, etc. Existing researches on speech emotions are mainly based on its acoustic features and semantic expressions. Recent studies have found that the influence of speeches on emotions is closely related to the subconscious perception of the human brain. Therefore, this paper intends to make a new exploration based on the combination of acoustic feature models with EEG signal analysis. Firstly, the emotion models and neural mechanisms in speech emotions, including the interaction of emotion, brain and language, are analyzed. After that, a basic model based on acoustic features is built and applied to the practical analysis of the court defense in a legal film. Finally, this paper proposes an experiment based on EEG signals to find out how speakers affect the audiences and test audiences' EEG reactions.

Keywords

Speech Emotion, Intelligent Computation, Subliminal Perception, EEG Signal

Introduction

At present, a relatively complete system has been proposed for researches on speech emotion recognition. The extraction of emotional features in speech mainly focuses on acoustic and semantic aspects. From the acoustic aspect, the acoustic features can be divided into prosody features, spectrum features and sound quality features. The main parameters of prosody features include the average fundamental frequency of sound, fundamental range, speech speed, pauses and so on; for spectral feature analysis, MFCC, amplitude, etc., are often used; the parameters of sound quality features include formant frequency, definition, etc. Semantic features include features from both languages and contexts. Researchers perform fixed-length segmentation on the language to obtain feature vectors related to language features; The contextual features mainly cover the gender and cultural background differences of the speakers.

The emotion recognition models can be divided into discrete emotion models and continuous ones. The emotion classification algorithm is used on the discrete emotion model, while the emotion regression algorithm is used on the continuous emotion model. Researchers extract high-level emotion features from low-level emotion features. Standard methods include CNN, LSTM, etc. The accuracy of emotion recognition has reached

more than 80% at present.

Regarding auditory neural mechanism, the existing research methods include Oddball, Go-Nogo, Stroop and N-back. The Oddball experiment randomly presents two stimuli of the same sensory channel, with different presentation probabilities. The one with a higher probability is the standard stimulus and the other is the deviant stimulus. The experiment requires participants to indicate the occurrence of deviant stimuli. In recent years, there have also been variants of the Oddball experimental paradigm that include stimulus omissions and new stimuli in the experiment. The Go-Nogo paradigm cancels the probability difference between standard and deviant stimuli. It requires the candidate's response to the Go stimulus while withholding response to the Nogo stimulus. This paradigm saves experimental time but does not produce ERP components. Initially referring to the interference effect of word meaning on font color, the Stroop paradigm has been extended to auditory stimuli with two dimensions of incongruent attributes to investigate the influence of emotional information on non-emotional information. The N-back method requires participants to compare the current stimulus with the past N stimuli and is generally used in continuous processing tasks, thus it is currently the most commonly used method. Besides, though the neural mechanisms of emotion and

cognition have different effects, they interact with and influence each other in the brain. This has been confirmed by both static brain structure and dynamic brain function. However, this interaction between emotion and rationality can make subjective judgement of emotions notoriously difficult. Therefore, research methods for objective judgement of emotions are worth exploring. EEG is a measure of the electrical activity generated by groups of neurons in the cerebral cortex during brain activity. EEG signals originate from the central nervous system, which is highly associated with emotions, and has a high temporal resolution. EEG signals are typically described in terms of rhythmic activity and can be classified into five commonly used brain waveforms based on their frequency: delta, theta, alpha, beta, and gamma waves. Brain oscillations have three main functions: (1) coding specific information, (2) setting and modulating brain attentional states, and (3) assuring the communication among neuronal ensembles. Alpha oscillations function as the inhibition of task-irrelevant brain regions, while gamma oscillations function as neuron selection, activation and synchronization. Currently, most emotion-related calculations are based on the emotional features obtained from the speech itself, and there is less consideration for EEG signals to obtain emotion-related parameters, resulting in a large amount of subjective judgment from experimenters or participants. At the same time, most speech emotion research assumes the sparsity of emotions in speech information, and most databases label emotion tags based on the entire speech segment. Therefore, using EEG signals to reflect emotional changes objectively can be a possible direction of research. This project aims to combine EEG signal features with the traditional models for speech emotion recognition, exploring methods to improve the model's accuracy and better match the actual emotional response in the human brain.

Intelligent Computing Based on Acoustic Signals

Sentiment Classification Model

In discrete emotion models, researchers simplify the analysis by labelling and discretizing each emotion. The most common basic categories of emotions used in this model are happiness, anger, sadness, and fear, which are similar to the classification of emotions in human language expression. This classification method is intuitive and easy to understand and identify, and it also distinguishes emotions with significant differences, making it suitable for classification algorithms. However, this model also has obvious shortcomings, such as the difficulty in measuring the intensity of emotions, the possibility that human emotions may be composed of multiple emotions, and the inability of a single discrete label to fully describe a particular emotion.

Researchers have different definitions and classifications of emotions. The most widely used one is the six basic

emotions proposed by the American psychologist Ekman: anger, disgust, fear, joy, sadness, and surprise.

In continuous emotion models, human emotions are dimensionalized into continuous axes, and different coordinates in two-dimensional or three-dimensional coordinate systems represent different emotional states respectively. The most common continuous models are the PAD three-dimensional model and the VA two-dimensional model.[2] Unlike discrete emotion models, continuous emotion models are more specific and quantify emotions from multiple dimensions, theoretically covering all human emotions.

However, the continuous emotion model also comes with some problems. Some dimensions' contents are hard to understand, such as the information contained in the "Dominance" dimension exceeding traditional cognition. Furthermore, determining the number of dimensions to describe an emotion is challenging. Supporters of this model find it hard to provide convincing reasons to determine the proper number of dimensions to use. In addition, continuous emotions are difficult to be accurately evaluated and calculated because the human experience of emotions always features significant ambiguity and individual differences.

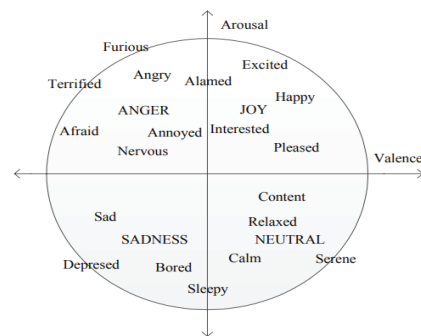


Fig.2 Arousal-Valence emotional space

Figure 1 – Arousal-Valence emotional space

Training Dataset

To explore the important parameters in the intelligent computation for speech emotion, we use CASIA dataset as the training dataset. The CASIA dataset is recorded by the Institute of Automation, Chinese Academy of Sciences. The dataset includes 1,200 recordings from 4 professional speakers, who pronounce each sentence under six different emotions – angry, fear, happy, neutral, sad and surprise. The recordings are labelled with 0-5 sequentially.

We chose one of the sentences as an example and visualized the audio by spectral analysis as shown in Figure 2. From Figure 1, we can see that each emotion has a different visual outcome. However, it is hard to tell the differences directly. Therefore, it is necessary to construct relative features and models for emotion classification.

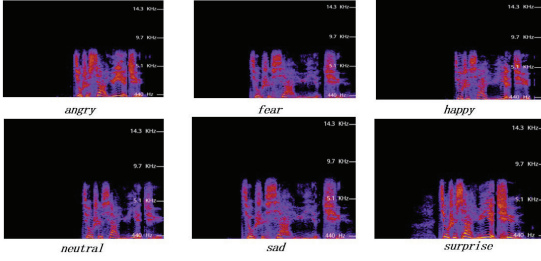


Figure 2 – Spectral Analysis

Speech Features

Speech features can be divided into two categories – linguistic features and acoustic features – the former refers to the linguistic information contained in the audio, and the latter includes the tune, frequency, etc., of the speech. Psychological researchers have revealed a significant correlation between a person’s speech emotion and the acoustic changes of the speech[3]. For example, people with positive emotions speak faster and louder, while those with negative emotions show the opposite.

In this research, we use two types of acoustic features – LLDs (Low Level Descriptors) and HSFs (High Level Statistics Functions) as shown in Table 1. LLDs are calculated directly from the original audio, while HSFs are calculated from LLDs by applying statistical functions. We use 16 LLDs and 384 HSFs in total.

Table 1 – Acoustic Features

ZCR	The Zero-Crossing Rate is the rate at which a signal changes from positive to zero to negative or from negative to zero to positive.
RMSE	The Root Mean Squared Energy measures the average loudness of the audio.
F0	The Fundamental Frequency, often referred to simply as the fundamental, is the lowest frequency of a periodic waveform.
MFCC	The Mel Frequency Cepstral Coefficients of an audio signal are a small set of features (usually about 10–20) describing the spectral envelope’s overall shape.
VAD	Voice activity detection is a technique in which the presence or absence of human speech is detected.

Model Training

Considering the fact that we are using a dataset with high dimensions and of a large scale, we chose to use Gradient-Boosted Decision Tree (GBDT) as our computational model.

The prediction method used by GBDT can be represented as Equation (1), where $F_i(x)$ is defined as the linear function that the algorithm should learn and $\hat{y}_i$ is defined as the probability of the event that the given sample

belongs to class L.

$$\hat{y}_i = \frac{e^{F_i(x)}}{\sum_{i=1}^k e^{F_i(x)}} \quad (1)$$

Further, the loss function of the GBDT algorithm is defined as in Equation (2). The GBDT will minimize the loss function by learning the linear function $F_i(x)$.

$$L(y, \hat{y}) = -\sum_{i=1}^k y_i * \log(\hat{y}_i) \quad (2)$$

Then the statistical model with the sentiment classification model and the acoustic features introduced earlier are combined to create our computational model for speech emotion classification.

To validate the model’s effectiveness, we performed 5 folds Cross-Validation on the CASIA dataset, and the outcome shows a 73.08% accuracy.

To further analyze the model’s performance, we used 80% of the dataset for training and the rest for prediction to give the confusion matrix of the predictive outcome. As shown in Table 2 (0-Angry, 1-Fear, 2-Happy, 3-Neutral, 4-Sad, 5-Surprise), the two sentiments – sad and fear – are most likely to be misclassified. The accuracies for these two sentiments are only 77.19% and 52.78% respectively. Meanwhile, the accuracy for neutral and angry are as high as 83.78% and 86.84%. It is also noticeable that fear is likely to be misclassified as sad. The observation suggests that there may be some acoustic similarities between these two negative sentiments.

Table 2 – Confusion Matrix

	0	1	2	3	4	5
0	33	1	1	2	0	5
1	0	19	5	3	9	0
2	3	1	27	1	3	3
3	0	5	1	31	0	0
4	0	7	1	0	34	0
5	2	3	7	0	1	32

Model Application -

Static Analysis

We used our classification model to conduct static analysis clips from the TV series – ‘The People v. O. J. Simpson: American Crime Story’. The process can be divided into the following two steps:

1. Classify the clips manually by the speaker. (Simpson, Defense Counsel, Public Prosecutor or Judge)
2. Analyze the speech emotion of each speaker by using our classification model.

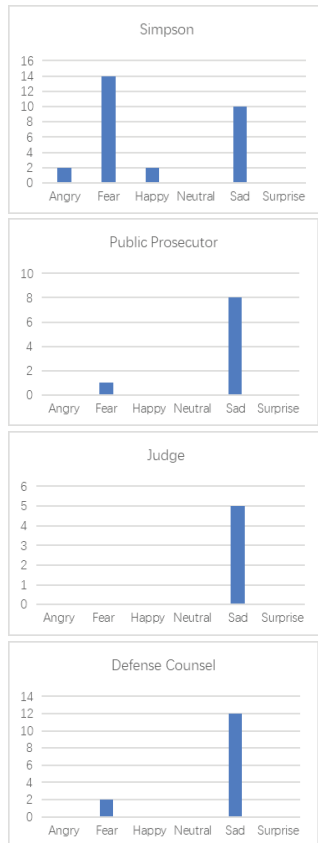


Figure 3 – Static Analysis

Analysis shows that their emotions are predominantly focused on the negative emotions of fear and sadness. Unlike the others, Simpson occasionally expresses anger and happiness. Based on this, we speculate that people tend to express negative emotions in a courtroom setting where the individuals involved are expected to maintain seriousness and professionalism. However, since he is not a trained professional, Simpson also shows other emotions like anger and happiness. These emotions are potentially attributable to Simpson's fear of being punished.

Dynamic Analysis

To conduct dynamic analysis, we divided the defense counsel's speech into six periods and calculated the emotion probability distribution for each period as in Figure 4. The outcome shows that the defense counsel's emotions stayed negative during the speech. We speculate that the counsel did so to demonstrate seriousness and professionalism during the trial.

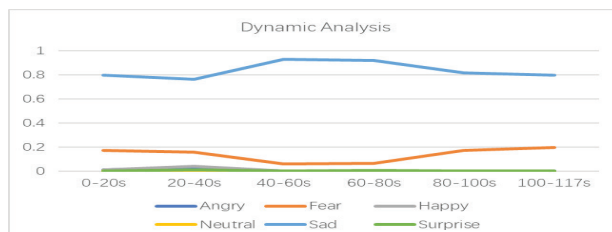


Figure 4 – Dynamic Analysis

Acoustic Feature Analysis

We extracted the acoustic feature of each speech and grouped the data by the speaker to calculate the average of each feature parameter. The result shows the following as in Figure 5: (1) The judge and Simpson are lower on RMSE; (2) The public prosecutor is higher on F0; and (3) Simpson has the lowest average MFCC parameter

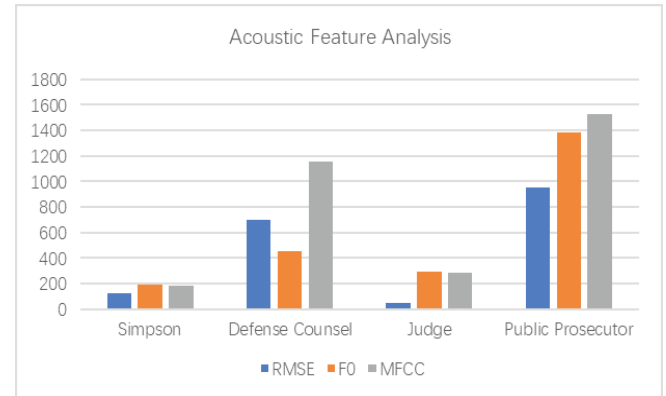


Figure 5 – Acoustic Feature Analysis

We speculate that the defense counsel and the public prosecutor's high RMSE is a result of the adversarial nature of the courtroom. They may have unconsciously raised the volume of their voices to ensure that everyone at present hears them.

Additionally, we believe that the unusually high fundamental frequency in the public prosecutor's case can be attributed to her being the only female, since women tend to have higher F0 due to their unique biological structure.

Speech Emotion in EEG Signals

Neural Mechanism in Speech Emotion Cognition

Different disciplines have their own understanding of the relationship between emotion, cognition, and language. According to generative linguistics, language is an independent entity not influenced by emotions or cognition. In other words, emotions and cognition do not affect language.

From the perspective of philosophical epistemology, emotions and cognition are seen as binary and opposed to each other[3]. Rationality is considered superior to emotion, and rational cognition is supposed to dominate emotion.

However, according to psychoanalysis, subconsciousness occupies the main part of the whole spiritual activities in comparison with consciousness, as the consciousness is determined by the subconsciousness. Consciousness is the prerequisite of rationality, while rational cognition is the major part of consciousness. Nevertheless, emotions can

occur in both consciousness and subconsciousness. So, in terms of subjective feelings, rationality can be influenced by emotions imperceptibly.[5]

Besides, the latest neuroscience research indicates that though the neural mechanisms of emotion and cognition have different effects, they interact with and influence each other in the brain.

From a static structural point of view, researchers found that the spatial arrangement of human cortical areas shows a sensorimotor-to-transmodal gradient in cortical micro-structure, macro-scale connectivity, and gene expression, which overlaps with the spatial distribution of global functional processing hierarchies. Relevant empirical studies that focus on the principal gradients of semantic category[6] and functional connectivity[7] support the validity of this conclusion. A potential link between brain structure and function is the temporal processing hierarchy, which emerges from micro-structural features and long-range connections, and gives rise to distributed functional specialization. In other words, there is a hierarchical structure in the brain. For a new sensory input, the signal first travels quickly and subconsciously up that hierarchy (probably the pre-cortex) and then down. Thus, the first step in forming consciousness occurs at a higher level. This means that the main flow of information in the subconscious condition is likely to be feed-forward, whereas the flow of information in the conscious mode is bidirectional. Thus, on one hand, the consciousness, which is responsible for processing a wider range of more unusual external sensory inputs (or imagery within the brain), processes information more slowly than the subconsciousness, which processes many external sensory inputs quickly, briefly, and schematically. It is also for this reason that, when considered from the point of view of external manifestation, emotions will, under normal circumstances, be manifested before rationality. On the other hand, from the point of view of internal interaction, emotions are able to have some influence on the rationality in the consciousness reasoning as a part of the subconsciousness. Neuroimaging methods reveal that the vast majority of brain areas can be activated subconsciously, which proves the dominant position of subconsciousness compared with consciousness. This is similar to the viewpoint derived from psychoanalysis, which indirectly supports the assertion that "rationality can be disturbed by emotions".

From a dynamic functional point of view, in a state of enlightened awareness, information is accessible to numerous cognitive processors. Dehaene's global neuronal workspace (GNW) hypothesis states that consciousness is the sharing of information across the brain, and that the "global neuronal workspace" is the specific communication system that enables the flexible sharing of information with a set of specialized and modularized perceptual, motor, memory, appraisal and attentional cognitive processing modules as shown in

Figure 6.[12] As for specific brain regions, Dehaene believes that the prefrontal cortex may be the key region, but it is not the only area where access consciousness occurs. At the same time, studies have shown that in comparison with consciousness, subconsciousness has obviously weaker signal intensity, faster decay rate and narrower activation region (in contrast, consciousness has global availability in the whole brain). Therefore, in competition, consciousness has a significant advantage over subconsciousness, for consciousness contents will mask subconsciousness contents. Thus on one hand, rationality can play a role in controlling emotions in the process of access consciousness; on the other hand, rationality is dominant over emotions from the perspective of one's subjective feelings. Language, as an essential part of cognition, can affect emotions.

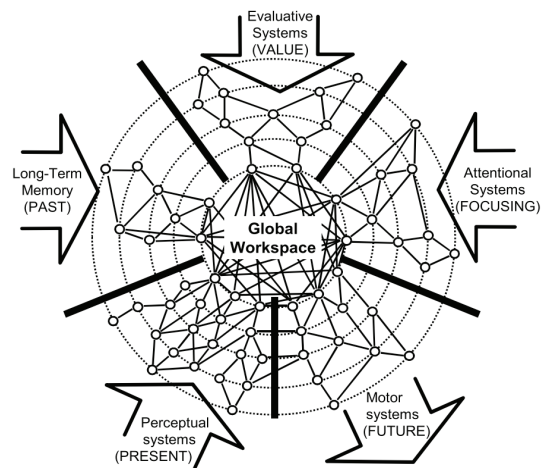


Figure 6 – global neuronal workspace (GNW) hypothesis

EEG is the electric current formed in the extracellular space of the brain cortex by the potential differences originating from brain activities. EEG signals originate from the central nervous system, which is highly related to emotions, with a high temporal resolution. They are commonly described in terms of rhythmic activity and can be classified into five usually used brain waves based on their frequency: delta waves, theta waves, alpha waves, beta waves, and gamma waves.

The information is encoded by a small number of activated, synchronized neurons (concentrated negative potentials) and a large number of suppressed neurons (scattered positive potentials) through brain oscillation frequencies. Research reveals that brain oscillations, which should be considered as neural mechanisms underlying cognitive processes instead of simple correlates, have three main functions: (1) coding specific information, (2) setting and modulating brain attentional states, and (3) assuring the communication among neuronal ensembles. Experiments discovered that gamma-rhythm is a signature of feedforward processing whereas alpha-rhythm indicates

feedback effects in the monkey's visual cortex.[17] As for information encoding, alpha oscillations function as the inhibition of task-irrelevant brain regions, while gamma oscillations function as neuron selection, activation and synchronization. Investigation found that a signature of engaged cortex is a reduction in the power of alpha/theta (perhaps with frequency lowering), modulation of gamma amplitude by the remaining alpha/theta oscillations, and an increase of the gamma duty cycle.[18] Moreover, the information maintenance involves the alpha-gamma neural code, whereas the encoding of ordered information relies on the theta/gamma-band oscillations. Figure 7 shows the interactive mechanism of language and emotion.

In the studies conducted by Gyanendra et al[23]., Tripathi S, Acharya S et al.[24] and Xin Hu, Jiangwen Yu et al[25]., different classification algorithms such as SVM and CNN were used to recognize emotions based on EEG signals, and all achieved high accuracy.

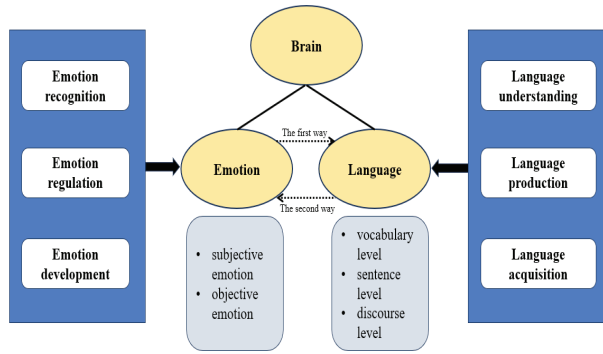


Figure 7 – The interaction of language and emotion

Experiment Design

We use the CUB and from CUSOFT as our EEG acquisition device for the experiment as Figure 8. The device transmits data using wireless technology, with a sampling frequency of $\geq 512\text{Hz}$, a signal accuracy of $\leq 0.25\mu\text{V}$ and an internal noise level of $\leq 0.2\mu\text{V}$. The device can collaborate with the MindXP Bio-Feedback System, which enables the real-time monitoring of EEG signals.



Figure 8 - CUBand

We designed four phases for the experiment, as is shown in Figure 9:

1. The Instruction and Adaptation phase primarily involves adjusting the equipment and familiarizing the participants with the experiment environment.
2. The participants will watch two movie clips in a quiet environment during the Clip 1 and Clip 2 phases. The EEG signals of the participants will be recorded during these two phases.

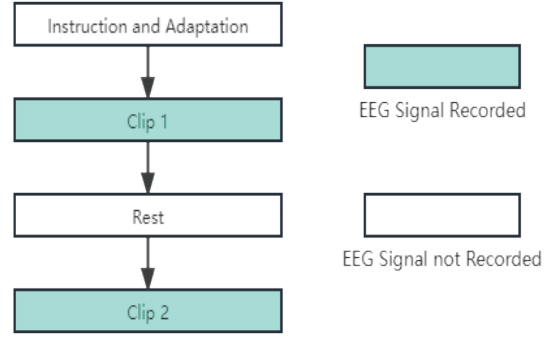


Figure 9 – Experiment Pipeline

The two clips are subtracted from the TV series 'The People v. O. J. Simpson: American Crime Story': Clip 1 lasts 117 seconds and features the defense counsel presenting the opening statement; Clip 2 lasts 87 seconds and involves the public prosecutor refuting the defense counsel's arguments.

Data Process and Feature Extraction

Sutton et al. proposed the use of Event-Related Potentials (ERPs) as a technique to study brain cognitive processes. They argued that single stimuli have a relatively low impact on the brain's electrical activity and are often accompanied by a high noise level. Therefore, researchers should magnify the event-related wave magnitude by repeating the stimuli multiple times and averaging the waveforms.

Based on this theory, we performed waveform averaging on the EEG data of the four participants. Additionally, since each individual has a different baseline EEG waveform, we standardized the data by calculating the standard deviation prior to averaging. The formula used for standard deviation normalization is as follows:

$$Z = \frac{x - \mu}{\sigma} \quad (3)$$

In conventional ERP data processing, researchers focus on ERP components such as N100, P200, and N300. However, analyzing such components requires millisecond-level sampling frequencies, whereas the CUB and EEG device used in the experiment only generates EEG signals at 1Hz. Therefore, in this study, ERP data was processed as

time series. The processing steps are as follow:
We discretize the data into three categories (Low, Mid, High) using Equation (4), where Q_i stands for the $i/3$ quantile:

$$f(x) = \begin{cases} Low'(x < Q_1) \\ Mid'(Q_1 \leq x \leq Q_2) \\ High'(x > Q_2) \end{cases} \quad (4)$$

Based on the discrete time series calculated from the equation above, the empirical Markov probability transition matrix is calculated, and we treat the matrix as a feature that represents the transition pattern of the time series.

Outcomes

Based on the previous calculations, we obtained the transition pattern feature of eight EEG parameters for the two stimuli, as shown in Table 3 and Figure 10. Comparing the transition pattern features of the two clips, we found that the most significant differences were observed in Alpha and Gamma waves.

Specifically, in the scene featuring the defense counsel, the Alpha1 wave maintained a high energy state in the middle to high energy range. In contrast, in the scene featuring the prosecutor, the high energy state underwent a smoother transition across the three states, while the middle energy state tended to switch between the high and low energy states. As for the Gamma2 wave, the situation was reversed. In the scene featuring the defense counsel, there were transitions between the low and middle energy states. In contrast, in the scene featuring the prosecutor, each state tended to maintain its original state.

Table 3 – Empirical Markov Transition Matrix

	Defense Counsel											
	Delta			Theta			Alpha1			Alpha2		
Low	0.46	0.28	0.26	0.475	0.275	0.25	0.45	0.32	0.23	0.38	0.38	0.24
Mid	0.29	0.37	0.34	0.32	0.22	0.46	0.41	0.28	0.31	0.34	0.24	0.42
High	0.225	0.35	0.425	0.225	0.475	0.3	0.15	0.4	0.45	0.3	0.325	0.375
	Beta1			Beta2			Gamma1			Gamma2		
Low	0.28	0.38	0.34	0.26	0.45	0.29	0.34	0.32	0.34	0.31	0.41	0.28
Mid	0.39	0.26	0.35	0.33	0.28	0.39	0.23	0.33	0.44	0.39	0.24	0.37
High	0.3	0.35	0.35	0.375	0.275	0.35	0.425	0.325	0.25	0.3	0.325	0.375
	Public Prosecutor											
	Delta			Theta			Alpha1			Alpha2		
Low	0.39	0.43	0.18	0.39	0.36	0.25	0.19	0.56	0.25	0.32	0.32	0.36
Mid	0.37	0.26	0.37	0.3	0.3	0.4	0.5	0.11	0.39	0.29	0.43	0.28
High	0.25	0.32	0.43	0.32	0.36	0.32	0.32	0.36	0.32	0.41	0.26	0.33
	Beta1			Beta2			Gamma1			Gamma2		
Low	0.37	0.3	0.33	0.29	0.36	0.35	0.36	0.25	0.39	0.44	0.33	0.23
Mid	0.39	0.36	0.25	0.43	0.36	0.21	0.36	0.32	0.32	0.29	0.46	0.25
High	0.25	0.36	0.39	0.3	0.3	0.4	0.3	0.44	0.26	0.29	0.21	0.5

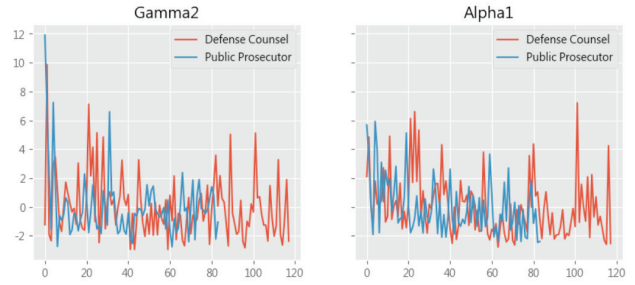


Figure 10 – EEG Signals

Conclusion

Our research investigates the impact of different speech stimuli on human cognitive processes using intelligent emotion computation and EEG brainwave data. Based on our analysis and experiments, the following conclusions are drawn:

- (1) In a courtroom setting, trained lawyers and judges can better control their expression of speech emotions, resulting in fewer and more neutral emotions.
- (2) Speakers exhibit different acoustic features even when expressing the same emotion. Factors causing these differences may include specific contexts of the speech, physiological characteristics of the speakers, etc.
- (3) Speech stimuli have different effects on the brain's EEG transition pattern. The influence is most significant on Alpha and Gamma waves.

Acknowledgements

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Utilizing the n-back task to investigate working memory and extending gerontological educational tools for applicability in school-aged children

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Abstract

In this research, a cohort of two children, aged 7-8 years, was selected to participate in a specialized three-week training program aimed at enhancing their working memory. The program consisted of three sessions, each lasting approximately 30 minutes. The primary goal was to investigate the impact and developmental trajectory of working memory in school-aged children.

Working memory plays a significant role in young children's learning and daily activities. To address the needs of this demographic, products should offer both educational and enjoyable activities that engage working memory. Digital educational tools, known for their flexibility, are suitable for both older individuals and young children. By updating software or modifying content, these tools can be effectively repurposed for young learners without extensive hardware changes, making them both cost-effective and practical. For example, memory training games initially designed for older adults can be adapted for young children by altering images, music, or storylines. Furthermore, incorporating elements familiar to children, like animals, toys, or fairy tales, can increase their engagement in these activities.

Historically, working memory capabilities have been assessed predominantly through traditional intelligence tests. However, recent research questions the adequacy of these behavioral measures in accurately detecting changes in working memory.

To bridge this gap, the current study utilized electroencephalography (EEG) as a more sophisticated and precise tool for monitoring potential changes in working memory after the training.

The research findings were revealing. Participants showed marked improvement in their performance on n-back tasks, a standard measure for evaluating working memory. This improvement post-training strongly supports the effectiveness of the training program. The results indicate that such targeted and structured training programs can significantly enhance the working memory abilities of children in this age group, providing promising implications for educational strategies and cognitive development interventions.

Keywords

Students, working, memorize, training, Electroencephalography (EEG), n-back task

Introduction

The current study aims to investigate the impact of working memory training on the cognitive abilities of school-aged children, with a special focus on the development of their working memory component. In recent years, there has been an increase in the development of products and tools aimed at enhancing working memory (Morrison & Chein, 2011), a trend largely attributed to the growing awareness of its importance.

However, the majority of these tools are designed for

adults or the elderly, leaving a significant yet untapped market for tools specifically tailored for young children. Given the significance of working memory as a fundamental cognitive ability, it is important to note that working memory is a critical cognitive skill. It is essential for processing and managing information during complex cognitive tasks and plays a crucial role in the academic achievements of children. Previous research has demonstrated that working memory can more accurately predict academic success, thereby highlighting that

enhancing working memory capacity has a significant impact on children's cognitive development.

Historically, intelligence tests have been commonly used to assess working memory capabilities. However, it has been noted that changes in working memory are not always detectable through behavioral measures alone. Therefore, this study examines changes in working memory capacity post-training using electroencephalography (EEG). Utilizing a true experimental design with an equivalent-groups posttest-only approach, participants were randomly assigned to evaluate the effects of n-back tasks, a working memory training exercise, on cognitive development and working memory in school-aged children.

In this research, school-aged children participated in working memory training. Following this, their brain responses during n-back tasks were monitored using EEG to assess the changes in working memory capabilities post-training. The results of this study are expected to support previous findings that working memory training can enhance the working memory capacities of school-aged children and positively influence their cognitive development. The use of EEG for monitoring changes in working memory capabilities facilitates a more accurate evaluation of the improvements in cognitive abilities post-training and provides a deeper insight into the effects of working memory training on brain activity. The EEG experiments were conducted using the St.EEGTM Altaire instrument, as depicted in the accompanying figure.

Literature Review

Gerontological educational tools

Working memory, as a core element of cognitive development, significantly impacts the learning and everyday activities of young children (Baddeley, 2003). To cater to the needs of this age group, products should focus on providing activities that are both educational and enjoyable, while also engaging working memory. Modern educational tools, particularly digital ones, offer considerable flexibility. Products initially designed for the elderly, known for their simple and intuitive interfaces, are also beneficial for young children. By updating software or changing content, these tools can be repurposed for young learners without extensive hardware changes, making this approach both cost-effective and practical. For instance, memory training games designed for the elderly can be adapted for young children by modifying in-game images, music, or storylines to better suit their interests and cognitive levels. Additionally, integrating elements from children's daily lives, such as animals, toys, or fairy tales, into these activities can enhance their engagement.

Recent years have seen a surge in products and tools aimed at enhancing working memory (Morrison & Chein, 2011), largely due to increasing awareness of its importance. However, most of these tools target adults or the elderly, leaving a substantial untapped market for young children.

Businesses can leverage existing technologies to develop working memory training programs specifically designed for young children. This not only satisfies market demand but also significantly lowers the costs of development and production, effectively extending gerontological educational tools to meet the developmental needs of school-aged children.

Working Memory

Working memory refers to an individual's cognitive ability to manipulate and process information during complex cognitive activities. It is also considered a crucial element for executing complex cognitive behaviors in daily life (Baddeley, 2003).

Working memory encompasses both the capacity for information processing and the temporary storage of information. The information processing capacity is directly related to the attentional capacity governed by the central executive and increases with the complexity of the task sequence. The memory span, representing the capacity of working memory, is dependent on the rehearsal rate within the phonological loop (Baddeley et al., 1975) and is not merely limited to the quantity or integration of information units. However, this capacity varies among individuals and can exceed the traditional limit of 7 ± 2 items. On the other hand, the temporary storage time is contingent upon the episodic buffer, which acts as a bridge between long-term memory and the central executive. The information integrated and processed in working memory dissipates upon task completion, existing in a transient state. This underscores the role of working memory as a platform for information processing operations."

N-back

The N-back working memory task is one of the most widely applied working memory training tasks in recent years (Jones et al., 2020; Chen et al., 2019; Pergher et al., 2018; Linares et al., 2019; Soveri et al., 2017; Au et al., 2015; Melby-Lervag et al., 2016; Melby-Lervag & Hulme, 2016; Forns et al., 2014) (refer to Table 4). Its popularity stems not only from its proven training effectiveness but also from its ability to transfer these gains to other untrained cognitive functions.

In the N-back task, participants are presented with a series of stimuli (such as numbers, letters, words, spatial locations, shapes, or faces) sequentially. The task is to determine whether the current stimulus matches the one presented N steps earlier in the sequence (Owen et al., 2005). For instance, in a 2-back task with the sequence "5, 7, 1, 7", the third stimulus "1" is a non-target, as it does not match "5" (two steps back); however, the fourth stimulus "7" is a target, matching the "7" presented two steps earlier. This task engages the working memory system for temporary storage, monitoring, manipulation, and updating of representations (Chen, Mitra, & Schlaghecken, 2008), allowing for the observation of neural mechanisms

associated with working memory (Owen et al., 2005).

The N-back task is an effective method to test control, maintenance, update, and process working memory tasks (Miyake et al., 2001). It has been shown to significantly enhance working memory capacity in both young and older adults (Dahlin et al., 2008). Studies by Au et al. (2015, 2016) indicate improvements in reasoning and working memory capacities in typically developing young individuals after N-back training. Jaeggi et al. (2011) demonstrated that healthy elementary school children improved their fluid intelligence through spatial N-back tasks, with training effects lasting for three months post-training. Similarly, Li et al. (2008) reported significant task performance improvements in healthy adults and older adults, with effects extending to other untrained working memory tasks and lasting up to three months post-training. However, some studies (Chooi& Thompson, 2012; Linares et al., 2019) have indicated that N-back training may not enhance certain untrained cognitive abilities, suggesting that the efficacy of N-back training in enhancing cognitive abilities warrants further investigation. Domestic research on working memory training has primarily focused on theoretical issues often employing a single indicator to measure training outcomes, which may overstate the interpretive power of this single indicator. For instance, some studies claim that working memory training enhances reading comprehension, yet only a specific reading skill was measured. To address this, the current study will employ a multifaceted assessment approach to measure the effects of training, aiming to explore various methods of assessing working memory and to investigate the impact of working memory training on school-aged children.

Working Memory and Physiological Signal Changes in EEG Studies

The assessment of cognitive functions has traditionally relied on behavioral measurement scales, such as the Wechsler Memory Scale (WMS), which is a significant and standardized indicator. This scale has been validated across various populations in numerous studies. However, the results from the Wechsler Intelligence Scale for Children can be influenced by the educational level of the participants. Currently, measurement tools based on physiological signals, like Electroencephalography (EEG), are employed to assess changes in working memory. The use of EEG technology enhances our understanding of the impact of working memory training on the cognitive development of children. Therefore, this study evaluates working memory using physiological signals through EEG, providing a direct and objective assessment method.

In terms of working memory application, changes are noted in vital signals. Brainwaves, or rhythmic electrical potential changes, are produced by neurons and nerve fibers in the brain during neural impulse transmission. The electrical potential data generated during brain activity, once amplified, form the curves observed in EEG readings (Farwell et al., 2013). EEG involves the collection of faint bioelectricity produced at the scalp through EEG instruments. The recorded brainwave patterns primarily reflect the electrical responses of the cerebral cortex and are categorized into different frequency bands: Delta (δ), Theta (θ), Alpha (α), Beta (β), and Gamma (γ) waves. An introduction to each of these brainwave patterns is provided below (as shown in Table 1)

Table 1 Brainwave Pattern Chart

Band	Frequency	Explain
δ (Delta band)	0.5-3Hz	Delta Waves (δ Waves) are characterized by their slower activity and are classified as low-frequency, high-amplitude brainwaves. They predominantly occur during the deep sleep phases in adults. Thus, the quality of sleep can be observed through the presence and characteristics of Delta Waves. These waves serve as crucial indicators of the depth and restorative nature of sleep, making them a valuable focus in sleep research, particularly in studies exploring the relationship between sleep patterns and overall health.
θ (Theta band)	3.5-7Hz	Theta Waves (θ Waves) are also categorized as low-frequency, high-amplitude slow brainwaves. They commonly emerge during periods when consciousness is interrupted and the body is deeply relaxed, such as during daydreaming, and are primarily observed in adults in states of semi-sleep. These waves are instrumental in measuring sustained attention in conditions of low anxiety and fear. Notably, Theta Wave activity is expected to increase slightly under cognitive load. This attribute of Theta Waves renders them a crucial subject in neurocognitive research, particularly in investigations exploring the correlation between brainwave patterns and mental states related to relaxation and focused attention

α (Alpha band)	8-13Hz	Alpha Waves (α Waves) are characterized as high-frequency, fast brainwaves with low amplitude. They typically occur when an individual is conscious but in a relaxed state. These waves are indicative of a lively brain, denoting an optimal state for learning and thinking. During periods of cognitive load, a slight reduction in Alpha Wave activity is generally observed. This property of Alpha Waves is crucial in cognitive neuroscience, particularly in research exploring how the brain responds to learning, cognitive engagement, and how these waves are modulated under varying cognitive demands.
β (Beta band)	13-30 Hz	Beta Waves (β Waves), identified by their high frequency, rapid nature, and low amplitude, correspond to a state of wakefulness and heightened alertness. These waves represent an active mental state wherein individuals engage in active thought and concentrated focus. An escalation in Beta Wave activity indicates the body's preparedness to react to external environmental stimuli. In daily life, people often find themselves in a state of readiness, poised to respond to changes in their surroundings. During these states of heightened focus and alertness, an increase in Beta Wave activity is commonly observed. This characteristic of Beta Waves is particularly significant in cognitive and behavioral neuroscience, underscoring the brain's adaptive response to attention-demanding tasks and environmental interactions
γ (gamma band)	30-70Hz	This refers to a mental state that exists between deep sleep and the verge of wakefulness.

Synthesizing the findings of prior scholarly work, this study proposes to utilize Theta (θ), Alpha (α), and Beta (β) brainwaves as instruments for measuring changes in working memory capacity. Neuroimaging studies in humans have revealed that working memory is linked with the prefrontal cortex of the brain. Given that working memory is a system with limited capacity, everyone's working memory capacity varies with age. Previous research indicates that training in working memory can significantly influence it, suggesting that through proper assessment and training, enhancement of working memory capacity is feasible.

Prevailing studies on working memory, in the context of advancements in cognitive neuroscience, have identified that cognitive training might induce alterations in neural-related components (Kelly & Garavan, 2005; Jones et al., 2006). Research focusing on cognitive and neural plasticity highlights that training development outcomes are more pronounced in typically developing children aged 4-6 years compared to other age groups. Moreover, the brain, as the most vital organ in the human body, manages all bodily reactions and sensory perceptions. Its structure is incredibly intricate, with each area performing specific functions. It is primarily divided into four parts: the Cerebrum, Diencephalon, Brain Stem, and Cerebellum. The cerebral cortex further subdivides into four lobes: the Frontal Lobe, Temporal Lobe, Parietal Lobe, and Occipital Lobe (as shown in Table 2).

Table2-The functions of the brain lobes

Brain lobes	Function
Frontal Lobe	Responsible for functions such as emotion, thinking, problem-solving, and attention.
Temporal Lobe	Controls memory, auditory processing, and some aspects of visual perception.
Parietal Lobe	Responsible for central processing, pain perception, and mathematical calculation abilities.
Occipital Lobe	Responsible for visual processing and integrating received stimuli.

(Source: Compiled by This Study)

As children's working memory develops, the activity in brain regions associated with memory tasks, such as the parietal sulcus and prefrontal cortex, intensifies. Working memory training can amplify the activation levels in these relevant brain areas. Prior research has demonstrated the crucial role of neurons in the frontal cortex, parietal cortex, and basal ganglia in the functioning of working memory (Constalltinidis et al., 2016). Training in working memory not only enhances memory capacity related to the trained tasks but also improves other cognitive processing abilities. Training working memory using domain-specific tasks activates certain cortical areas in the brain, facilitating the completion of tasks based on the same neural network. Furthermore, the more complex the activated cortical areas are, the greater the transfer effects of the working memory training will be. Based on this, the current study aims to observe Theta (θ), Alpha (α), and Beta (β) brainwaves in the frontal regions of the targeted children.

Methods

In this research, the study aims to explore the effectiveness of short-term N-back memory training intervention on working memory capacity in school-age children through electroencephalogram (EEG) analysis. Previous literature has indicated the plasticity of working memory in the brain, and this study presents the following hypotheses:

H1: Compared to pre-training, working memory training will enhance the EEG responses of the experimental group of school-age children.

This experiment was designed as a within-subject study, allowing participants to undergo the complete n-back training scenario, enabling an effective response to the experimental outcomes. Before the experiment, participants were required to undertake a pre-test to prevent potential experimental errors. The pre-test utilized the Chinese-adapted version of the Coloured Progressive Matrices (CPM) questionnaire, revised by Yu Xiaojun in 1993, to assess the working memory capabilities of the subjects. The CPM questionnaire primarily measures reasoning abilities, specifically those related to visual patterns. Due to the original version being in English and other considerations, this study employed Yu Xiaojun's (1993) Chinese translation to assess the working memory capabilities of the subjects, ensuring its appropriateness for the standards of this research.

The study incorporated the classic N-back working memory task for training, concurrently recording the participants' EEG signals for brainwave assessment, to investigate the impact of the working memory training task on brain activity. The objective was to observe any significant differences in brainwave patterns before and after receiving working memory training. Data were collected using an 8-channel EEG device (shown in Figure 1), with dry cotton, short needles, and long needles used to place electrodes on the scalp of the participants.

Electrode placement reference points were determined by installing electrodes behind both ears.



Figure 1-channel EEG device

The "N-back" task in this experiment was presented in a game format for training purposes, with game elements extracted and adapted from materials provided by New Oriental Biotechnology Limited Company. The training game for the experimental group was developed using E-prime (psychological experiment software). Following the N-back task design used in the study by Hotton et al. (2018), the screen display was based on a grid of 9 squares against a black background. At the center of the grid was a fixation cross "+", which could be influenced by the participant's eye movements during the task. Throughout the experiment, a white square would randomly appear in one of eight different positions surrounding a fixed point. Only one stimulus appeared at a time, each displayed for 500 milliseconds. After participants responded and answered, there was a rest period of 2500 milliseconds. The "N-back" task in this experiment had two levels of difficulty, ranging from easy to hard, specifically "0-back" and "1-back". In the "0-back" task, subjects needed to compare the position of the stimulus with the position of the first stimulus that appeared in the sequence. A correct response could be made by pressing the "mouse key" if the positions matched; no response was required if they did not. In the "1-back" task, participants had to compare the position of the stimulus with that of the immediately preceding stimulus in the sequence.

Results

Experiment Results

In this study, participants' brainwave data were subjected to a two-group independent sample non-parametric test (Mann-Whitney U test) to observe any significant effects on the α ,

β , and θ brainwaves at N-BACK levels of 0 and 1, pre- and post-training. The analysis results, as displayed in the following table, indicate that for both participants at N=0, there were significant impacts on the ALPHA, BETA, and THETA waves, suggesting that N-BACK training can influence changes in brainwave patterns, thereby affecting the capabilities of working memory. When the difficulty level was increased to N=1, a significant effect

was observed only on the BETA waves for both participants, indicating that the level of difficulty does affect changes in brainwave patterns(as shown in Table 3).

Table 3 - Analysis of Decision-Making Brainwaves in Participants Following N-Back Training for Working Memory Capacity.

Participant ID	N-BACK	Band	Z-value	p-value	Mann-Whitney U Statistic
S1	0	α	-3.468	0.001***	0.300
		β	-5.376	0.000***	0.000
		θ	-3.681	0.000***	0.228
	1	α	-1.191	0.233	0.315
		β	-8.040	0.000***	0.321
		θ	-0.291	0.771	0.305
S2	0	α	-3.191	0.001***	0.003
		β	-7.489	0.000***	0.000
		θ	-6.706	0.000***	0.001
	1	α	-0.908	0.364	0.943
		β	-2.126	0.034**	0.146
		θ	-2.000	0.046**	0.359

Note:***p-value < 0.01; ** p-value < 0.05; * p-value < 0.10

The research findings demonstrate that the n-back training program influences the working memory abilities of participants, thus supporting hypothesis H1. Therefore, the results of this study are consistent with previous research in this domain.

Conclusion

In this study, electrophysiological changes in participants were observed through electroencephalogram (EEG) experiments, focusing on variations in their physiological signals. The experimental results showed significant effects post-training in both 1-back and 0-back tasks. Notable changes in the amplitudes of ALPHA, BETA, and THETA brainwaves were observed during the 0-back task following a training period. Similarly, in the 1-back task, variations in BETA wave responses were detected. These findings suggest that participating in an n-back training regimen can influence working memory task performance, demonstrating a measurable impact of such cognitive training on brain activity.

The results of this study provide compelling evidence for the future applicability of these tools in interventions aimed at enhancing working memory capabilities in young children. The significant improvement in working memory, as evidenced by the children's performance in n-back tasks, underscores the effectiveness of the training program and the employed methodologies. The ability to adapt and effectively repurpose digital educational tools, initially designed for older demographics, for younger children highlights a versatile approach that can be utilized in future educational and cognitive development strategies.

However, it is important to acknowledge a limitation of this study: the small sample size. While the results are promising, they are based on a cohort of only two children. This sample size may not adequately represent the broader population of school-aged children. Therefore, future studies are recommended to recruit a larger number of participants to enhance the generalizability of the findings.

Working memory is recognized as a complex system, and future research may develop a more comprehensive EEG systems to better capture its intricacies. Acknowledging the need for improvements in our experimental design and procedures, future studies could adopt a multi-indicator approach. This approach would involve incorporating various measures, such as reading skills and academic performance, to better understand the effects of working memory training. Additionally, future research should explore the use of advanced neurophysiological techniques, like eye-tracking methods. These techniques could provide more precise and objective metrics for eye movement activities related to working memory training. By expanding the range of indicators and methodologies used, subsequent research could significantly enhance our understanding of the neural correlates of working memory training and its impact on cognitive functions.

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The Effects of Entrepreneurs' Personal Characteristics on Business Management and Performance: Focused on Food and Beverage (F&B) Industry

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Abstract

The food and beverage(F&B) industry, which shrank sharply after the outbreak of Corona-19 in 2019, has shown a slight increase in sales compared to the previous year as quarantine tensions eased in 2021. Although there are differences by industry, the production index of restaurants and bars is also showing an upward trend compared to the previous year, starting in the first quarter of 2021. In this regard, this study aimed at F&B business founders in the Gyeongsangnam-do region to figure out how the founder's psychological characteristics(desire for achievement, risk-taking propensity, creativity) and behavioral characteristics(reliability, self-efficacy, coping ability) affect business management and performance. The specific research methods of this study are as follows. First, a frequency analysis was conducted to confirm the general characteristics of restaurant founders and the characteristics of the sample. Second, reliability analysis, exploratory factor analysis, primary confirmatory factor analysis, and secondary confirmatory factor analysis are performed to confirm the reliability and validity of the items. In addition, correlation analysis was conducted to confirm the discriminant validity of the items. Third, path analysis was conducted to verify the hypotheses of the study.

Keywords

Characteristics of Entrepreneurs, Business Management, Operation Management, Service Management, Management Performance.

1. Introduction

The food and beverage(F&B) industry, which shrank sharply after the outbreak of Corona-19 in 2019, has shown a slight increase in sales compared to the previous year as quarantine tensions eased in 2021. Although there are differences by industry, the production index of restaurants and bars is also showing an upward trend compared to the previous year, starting in the first quarter of 2021.

According to the 2021 report by the Korea Rural Economic Institute (KREI), sales in the food and beverage industry showed an average annual increase of 3% between 2017 and 2019, but due to the impact of social distancing caused by the outbreak of COVID-19, the actual sales of F&B industry in 2020 are estimated at approximately KRW 108 trillion, 17% decrease compared to 2019. The actual sales of the F&B industry in 2021 are estimated to be KRW 110 trillion, 1% increase from 2020, indicating

a slight recovery from the impact of COVID-19, but still lower than in 2019. The number of licensed F&B business in 2021 was 1,074, 3% decrease compared to 2019 and 1% decrease compared to 2020, but the number of closed business in the same year was 466, 33% increase compared to 2019(Korea Rural Economic Institute, 2021).

Domestic F&B business startups are severely lacking in information infrastructure that represents their qualitative level, compared to its quantitative scale. As a result, their inefficiency is relatively greater compared to other startups. In order to minimize inefficient investment and startup failure in F&B business startups, stakeholders need practical and timely information on management performance. Even though it is easy to initially enter the market, it is not easy for a start-up to achieve successful results. In order to carry out sustainable management in the F&B industry market, efforts and research must be continuously supported.

Looking at previous research trends on restaurant startups, there are mostly studies on entrepreneurship education, such as entrepreneurship education programs, entrepreneurship education characteristics, and entrepreneurship education quality. In addition, there are studies related to F&B management, such as management activities, management performance, and management style of F&B business startups, and studies on self-efficacy, motivation for starting a business, and satisfaction with starting a business. In addition, various F&B business startups studies are being conducted on the entrepreneurial behavior of F&B business startups, such as entrepreneurs' attitude, and entrepreneurial intention.

As described above, researches are being conducted on F&B business startups in various fields, but more specific and systematic research and practical suggestions are needed. In this regard, this study aimed at F&B business founders in the Gyeongsangnam-do region. The founder's psychological characteristics (desire for achievement, risk-taking propensity, creativity) and behavioral characteristics (reliability, self-efficacy, coping ability) were found to be related to operation and service management. We will analyze its impact and how this business management affects business performance. Unlike existing studies that analyze whether F&B business start-up characteristics directly affect business performance, this study first analyzes the relationship between the founder's psychological and behavioral characteristics and business management, then it accordingly analyzes how these influences affect business performance. The study is expected to present academic and practical implications for successful business management and performance.

2.Theoretical Background & hypotheses Development

2.1Entrepreneurs' Personal Characteristics & Business Management

Prospective entrepreneurs who want to start a business or are preparing to start a business show different attitudes toward starting a business depending on their personal characteristics, and this has a significant impact on business management and management performance when starting a business. Looking at a number of previous studies, we can see that many studies have been conducted on the impact of entrepreneurs' characteristics on management performance, but the business management aspect has been overlooked.

Taehoon Kim et al. (2014) analyzed the relationship between entrepreneurs characteristics and business management. According to the research results, it was sequentially established that entrepreneurs characteristics affect business management factors, and business management factors in turn affect management performance. Operation management, revenue management, customer management, and service

management were presented as sub-factors of business management.

Based on the above prior researches, the following hypotheses have been established assuming that the personal characteristics of entrepreneurs can have a positive impact on business management.

H1: The psychological characteristics of entrepreneurs will have a positive influence on business management.

H1a: The psychological characteristics of entrepreneurs will have a positive influence on operation management

H1b: The psychological characteristics of entrepreneurs will have a positive influence on service management

H2: The behavioral characteristics of entrepreneurs will have a positive influence on business management.

H2a: The behavioral characteristics of entrepreneurs will have a positive influence on operation management.

H2b: The behavioral characteristics of entrepreneurs will have a positive influence on service management.

2.2Business Management and Management

Performance

Most studies related to the management performance of start-up companies target the characteristics of entrepreneurs or their relationship with the start-up environment. However, this study seeks to analyze the relationship between the management activities and the management performance of start-up companies. In F&B business, business management refers to the technology of achieving goals by effectively utilizing the people, products, and capital necessary to run a restaurant. This is not limited to cost management, but also contributes to society and realizes management efficiency (Shin Jae-yong and Park Ki-yong, 1999).

According to Daeyong Jeong (2007), the biggest reason for bankruptcy is a lack of management system, and failed businessmen did not know how to manage expenses, inventory, cash, and manpower. In other words, business management capabilities are an important criterion for business success and were viewed as an important factor for success (Kim Yang-ju, 2006). Seong Ok-seok and Park Seung-rak (2015) verified the impact of small business start-up characteristics on management mindset improvement, capability enhancement, and performance, and analyzed the impact of business management on management performance using mindset improvement and capability enhancement as mediating factors. As a result of the analysis, business management showed a

significant effect on improving mindset and enhancing competency, which also appeared to affect performance. F&B business management fundamentally believes that differentiated and focused factors have a significant impact on the performance of startup companies. Assuming that the business management element of F&B business start-up, as a differentiated and focused element, can have a positive impact on management performance, the following hypotheses have been hired.

H3: Operation management will have a positive influence on management performance.

H4: Service management will have a positive influence on management performance.

3. Methodology

3.1 Research Model

This study seeks to verify the impact of F&B business entrepreneurs' personal characteristics on business management and performance. For this purpose, personal characteristics were composed of sub-dimensions of psychological characteristics (Desire for Achievement, Risk-taking Propensity, Creativity) and behavioral characteristics (Reliability, Self-efficacy, Coping Ability) and set as independent variables. Variables of operation management, service management and management performance were selected and set as dependent variables. Based on previous research, a research model has been established as shown in Figure 1.

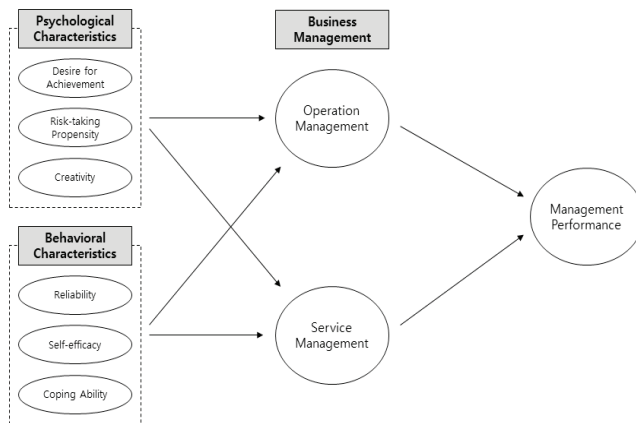


Figure 1 – Research Model

3.2 Measurement

Based on previous studies by Slevin (1989), Lumpkin & Dess (1996), and Stevenson & Jarillo (1990), the psychological characteristics of entrepreneurs, including Desire for Achievement, Risk-taking Propensity, and Creativity, were selected. Next, based on previous studies by Sandberg & Hofer (1987), Herron & Robinson (1993), and Collins & Lazier (1992), the Reliability, Self-efficacy, and Coping Ability factors of the behavioral characteristics of entrepreneurs were selected. In addition, operation

management and service management factors of business management were selected based on previous studies by Davidsson & Wiklund (2001), Minsoo Kim et al. (2010), and Jinsoo Kim et al. (2011). Lastly, management performance factors were selected based on previous studies by Lee Chung-seop et al. (2009), Jang Seong-hee (2012), and Kim Dae-eop and Seong Chang-soo (2013). The self-administered questionnaire included nine constructs. The constructs in the study were measured using multi-item scales adapted from the existing literatures. The survey instrument was developed by adopting existing validated questions wherever possible. All of the questions were measured by Likert scale (1 = strongly disagree, 5 = strongly agree).

3.3 Data Collection

This study targeted restaurant entrepreneurs who run a food business in the Gyeongnam region. In this study, questionnaire collection was conducted in two formats using 1:1 offline and online Google questionnaires, and the survey was conducted from December 04, 2023, to December 22, 2023. A total of 342 questionnaires were collected, and 287 questionnaires were finally applied to the empirical analysis.

4. Results

4.1 Demographic Characteristics

A total of 342 questionnaires were collected for empirical analysis, and after excluding inappropriate samples, 287 questionnaires were finally applied. Frequency analysis was conducted to present the demographic characteristics of the sample in this study, and the results are shown in Table 1. First, regarding the gender of the respondents, 127 (44.3%) were men and 160 (55.7%) were women. And regarding the age of respondents, those in their 50s were the highest at 116 (40.4%), while those in their 40s were 84 (29.3%). Subsequently, 37 (11.8%) were in their 60s or older, 30 (10.5%) were in their 30s, and 23 (8.0%) were in their 20s.

4.2 Reliability and Validity

Before testing the structural model, the measurement model should exhibit satisfactory levels of reliability and validity. Confirmatory factor analysis was performed to assess the overall model fit of the measurement model using analysis of moment structure. The model fit indices showed that $\chi^2 = 636.082$, $DF=288$, $P=.000$, $CMIN/DF=2.209$, $GFI=.855$, $AGFI=.810$, $NFI=.824$, $IFI=.896$, $TLI=.870$, $CFI=.894$, $RMR=.042$, $RMSEA=.065$, which suggests that the measurement model reasonably fits the current data.

In the Table 2, the results of the reliability test showed that the composite reliability's values of all the constructs exceeded the minimum requirement for reliability of 0.70, indicating that multiple measurement items were highly reliable for measuring each construct. The AVE of each

latent factor ranged from 0.500 to 0.704, more than the recommended value of 0.5, suggesting that the constructs are distinct.

And in Table 3, the results of second-order CFA are presented.

Further, in order to test discriminant validity, the square root of AVE should be greater than the correlation between every construct. As indicated in Table 4, the square root of the AVE of each construct was larger than the correlation of the specific construct with any of the other constructs in the model.

4.2 Hypotheses Testing

Following measurement purification, the path relationships within the research model were analyzed by structural equation modeling using the maximum likelihood method. The overall fit indices of the structural model was acceptable ($\chi^2 = 671.466$, $df=311$, $P=.000$, $CMIN/DF=2.159$, $GFI=.845$, $AGFI=.812$, $NFI=.815$, $IFI=.891$, $TLI=.876$, $CFI=.890$, $RMR=.045$, $RMSEA=.064$). The results are as below in Table 5.

The analysis results of this study are as follows. First, hypothesis1a that psychological characteristics significantly affect operation management was adopted (Std. Estimate=.408, $t=4.060$, $p=.0030$). Hypothesis1b that psychological characteristics significantly affect service management were accepted (Std. Estimate=.139, $t=2.016$, $p=.044$). These results show that restaurant start-up departments' operational and service management is more formed due to psychological characteristics, such as the desire for achievement, risk-taking propensity, and creativity.

Second, hypothesis2a that behavioral characteristics significantly affect operation management was adopted (Std. Estimate =.609, $t=4.289$, $p=.000$).

□. Hypothesis2b that behavioral characteristics significantly affect service management was adopted (Std. Estimate=.791, $t=5.745$, $p=.000$). These results show that restaurant start-ups' operation and service management are further formed due to behavioral characteristics, reliability, self-efficiency, and coping ability.

Third, hypothesis3 that operation management significantly affects business performance was adopted (Std. Estimate=.214, $t=3.145$, $p=.000$). And hypothesis4 that service management significantly affects business performance was adopted (Std. Estimate =.429, $t =4.869$, $p=.000$). These results indicate that business performance is further formed due to operational and service management.

5. Results

The results of this study are summarized as follows. First, H1a, which states that psychological characteristics have a significant effect on operation management, was adopted. In addition, H1b, which states that psychological characteristics have a significant effect on service management, was adopted. These results suggest that

the operation management and service management of F&B business start-up are further formed due to the psychological characteristics of Desire for Achievement, Risk-taking Propensity, and Creativity. Second, H2a, which states that behavioral characteristics have a significant impact on operation management, was adopted. In addition, H2b, which states that behavioral characteristics have a significant impact on service management, was also adopted. These results mean that the operation management and service management of F&B business start-up are further formed due to the behavioral characteristics of factors such as Reliability, Self-efficacy, and Coping Ability. Third, H3, which states that operation management has a significant effect on management performance, was adopted. These results mean that management performance is further developed due to operation management. Fourth, H4, which states that service management has a significant impact on management performance, was adopted. These results suggest that management performance is further formed due to service management.

The theoretical implications of the study are as follows. First, in existing studies, psychological characteristics and behavioral characteristics were studied separately, but in this study, both psychological characteristics (Lumpkin and Dess, 1996) and behavioral characteristics (Mitchellmore and Rowley, 2013) were studied. By constructing psychological characteristics and behavioral characteristics into multiple dimensions and studying them together, a theoretical framework was laid for the business management of F&B business entrepreneurs that affects operation management, service management, and management performance.

Second, in this study, a structural model of psychological characteristics and behavioral characteristics, operation management, service management, and management performance was presented. In a situation where there is a lack of research on the impact of psychological characteristics and behavioral characteristics on operation management and service management, and subsequently on management performance, this study is differentiated from existing studies and can be said to be more advanced. Third, second-order factors of psychological characteristics and behavioral characteristics were measured. Creativity among psychological characteristics and self-efficacy among behavioral characteristics were measured to have greater influence than other factors, indicating that they are critical factors in each higher dimension factors.

Lastly, in the hypothesis testing, it was found that psychological characteristics had a greater influence on operation management than service management, while behavioral characteristics had a greater influence on service management than operation management. Additionally, this study found that service management has a greater impact on management performance than operation management.

References

Provided upon the request. **Appendix**

Table 1. –Demographic Characteristics of Respondents

Measure		Frequen- cy	%
Gender	Male	127	44.3
	Female	160	55.7
Age	20s	23	8.0
	30s	30	10.5
	40s	84	29.3
	50s	116	40.4
	60s or over	37	11.8
Type of Start-up	Independent Start-up	171	59.6
	Franchise Start-up	69	24.0
	Acquisition Start-up	47	16.4
Total		287	100%

Table 2. – Results of Confirmatory Factor Analysis

Factor		Std. Estimate	S.E.	t-Value	Composite Reliability	AVE
Psychologi- cal Charac- teristics	Desire for Achievement	1 .764			.854	.595
		2 .725	.086	12.059		
		3 .826	.083	13.777		
		4 .769	.081	12.826		
	Risk-taking Propensity	1 .692			.799	.500
		2 .763	.114	10.646		
		3 .650	.104	9.400		
		4 .718	.117	10.205		
	Creativity	1 .675			.811	.518
		2 .696	.103	10.038		
		3 .722	.090	10.337		
		4 .783	.102	10.982		
Behavioral Characteris- tics	Reliability	1 .853			.826	.704
		2 .825	.091	10.214		
	Self-efficacy	1 .711			.700	.533
		2 .750	.171	8.073		
	Coping Ability	1 .721			.700	.529
		2 .734	.161	8.206		
Operation Management		1 .703			.734	.581
		2 .818	.107	8.443		
Service Management		1 .741			.762	.517
		2 .716	.160	7.149		
		3 .700	.192	7.090		
Management Performance		1 .674			.846	.579
		2 .771	.104	11.017		
		3 .794	.108	11.248		
		4 .800	.111	11.308		

CMIN=636.082, DF=288, P=.000, CMIN/DF=2.209, GFI=.855, AGFI=.810, NFI=.824, IFI=.896, TLI=.870, CFI=.894, RMR=.042, RMSEA=.065

Table 3. – Results of Second-order Confirmatory Factor Analysis

	Factor	Std. Estimate	S.E.	t-Value	Composite Reliability	AVE
Psychological Characteristics	→ Desire for Achievement	.687	.108	6.533	.815	.598
	→ Risk-taking Propensity	.721	.128	6.331		
	→ Creativity	.897				
Behavioral Characteristics	→ Reliability	.524	.201	5.367	.894	.753
	→ Self-efficacy	1.096	.232	5.115		
	→ Coping Ability	.886				

CMIN=369.127, DF=128, P=.000, CMIN/DF=2.884, GFI=.874, AGFI=.832, NFI=.843, IFI=.891, TLI=.868, CFI=.890, RMR=.051, RMSEA=.081

Table 4. Results of Correlation Analysis

Factor	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Desire for Achievement	.595								
(2) Risk-taking Propensity	.246	.500							
(3) Creativity	.379	.421	.518						
(4) Reliability	.245	.123	.164	.704					
(5) Self-efficacy	.361	.219	.314	.226	.533				
(6) Coping Ability	.089	.077	.091	.077	.189	.529			
(7) operation management	.225	.090	.142	.191	.267	.281	.581		
(8) service management	.516	.395	.421	.326	.422	.467	.175	.517	
(9) management performance	.173	.164	.224	.171	.231	.274	.197	.258	.579

Notes : The average variance extracted(AVE) values are presented on the diagonal and the square of correlations are presented below diagonal.

Table 5. Results of Hypotheses Testing

Hypothesis	Independent Variable	Dependent Variable	Std. Estimate	S.E.	t-Value	p-Value	Result
H1a	Psychological Characteristics	Operation Management	.408	.101	4.060	.000	Accepted
H1b		Service Management	.139	.069	2.016	.044	Accepted
H2a	Behavioral Characteristics	Operation Management	.609	.142	4.289	.000	Accepted
H2b		Service Management	.791	.138	5.745	.000	Accepted
H3	Operation Management	Management Performance	.214	.068	3.145	.002	Accepted
H4	Service Management	Management Performance	.429	.088	4.869	.000	Accepted

CMIN=671.466, df=311, P=.000, CMIN/DF=2.159, GFI=.845, AGFI=.812, NFI=.815, IFI=.891, TLI=.876, CFI=.890, RMR=.045, RMSEA=.064

Multivariate Analysis of Covariance on Characteristics Influencing Technological and Managerial Barriers of Technology Startups

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Abstract

This study investigated technological and managerial barriers in technology startups through a survey of 151 companies, yielding 118 responses (78.1% response rate). Factor and multivariate analyses identified two distinct barriers: technological and managerial. Reliability analysis validated the measurement tool. Using MANCOVA, 12 hypotheses were tested, incorporating six independent variables. Results revealed significant disparities in technological and managerial barriers based on establishment type, commercialization goals, growth stage, and commercialization stage, with 5 hypotheses supported. This study highlights the crucial role of these variables in understanding barriers within technology-based startups.

Keywords

Technology Startups, Technological and Managerial Barriers, MANCOVA

Introduction

Previous research on established startup companies has primarily focused on analyzing performance outcomes based on individual influencing factors, emphasizing specific directions for research. However, the operational structure of general startups is not extensive or complex, allowing for the attainment of operational efficiency through the analysis of representative quantitative and qualitative factors. In contrast, for technology-based startup companies, external influences, such as the technological environment and social structure, become more intricate. Beyond typical operational elements, various internal and external variables interact in a compound manner, introducing multiple barriers that inevitably impact technology startup management. Furthermore, the proposed solutions may be deemed inadequate. In light of this, the present study aims to analyze variations in technological and managerial barriers based on the characteristics of technology startup companies, considering factors such as startup form, commercialization goals, key technology introduction methods, growth stages, commercialization phases, and research organization types.

Backgrounds

In the scope of this study, the conceptualization of corporate barriers encompasses diverse terms, including success factors, failure factors, obstacles, and impediments. The literal definition of corporate

barriers refers to the difficulties and hindrances arising from the scarcity of production factors in the process of expanding production. Production activities are reliant on factors such as labor, capital equipment, raw materials, and finances. If any of these production factors is insufficient, it is defined as a 'challenge,' thereby constraining the production process. In international contexts, the pre-existing terminology for barriers utilizes a variety of terms, such as Bottleneck, Difficulty, Barrier, Problem, signifying analogous conceptualizations. Since the 1970s, discussions on the transfer of 'public technology' derived from national R&D projects and the subsequent success or failure of commercialization have initiated various research studies examining the 'influencing factors' expressed through success factors, failure factors, and barriers. Numerous studies have been conducted in this area. Some researchers, intrigued by the effectiveness of public development technologies and factors contributing to successful commercialization based on the outcomes of federal projects in the United States, conducted surveys targeting technology developers to identify key influencing factors in related papers. Existing paper proposed factors such as technical problem-solving, commercialization costs, a robust industrial infrastructure, participation opportunities in research and development planning, and resolution of time constraints as elements contributing to commercialization success. As advocated for market-oriented research and

development outcomes, effective communication and collaboration between technology adopters and providers.

Technology Startups

Before delving into the definition of technology entrepreneurship, this chapter aims to precisely define the concept of entrepreneurship. The literal definition of entrepreneurship is articulated as 'the act of initiating a business or the like for the first time.' Generally, the commonly accepted notion of entrepreneurship in society is understood as the creation of a new business entity. Similarly, as defined in Korean law, the concept of entrepreneurship involves 'establishing a new small and medium-sized enterprise and commencing business activities.' In a similar context, domestic entrepreneurial institutions in Korea often define entrepreneurship as the act of 'creating a new individual or corporate entity for profit' or 'an entrepreneur combining resources with a business idea to initiate business activities.' As seen in the table below, researchers abroad are also providing various definitions for technology entrepreneurship. Similar to the preceding domestic studies on technology entrepreneurship, there is a diverse range of definitions for the concept of technology entrepreneurship. While many researchers define the concept of technology entrepreneurship in a similar manner, slight conceptual differences exist depending on the purpose and context of the research.

Table 1 – Literature review of Technology Startup

Authors	Description
Cooper (1971)	Companies with a strong emphasis on R&D or a high tendency to pursue new technological knowledge
Sheaman&Bur-rel(1988)	Independent startups that contribute to the development of new industries
Butchart (1987)	Small and medium-sized enterprises (SMEs) active in the high-tech sector
Jones-Ev-ans(1995)	Establishment of new technology ventures
Maula (2001)	Enterprises with less than 6 years of history in industries such as biotechnology, medical science, IT, computer, software, and services
Nicholas & Armstrong (2003)	Organizations involved in technology-based business with considerations for organization, management, and associated risks

Technology Commercialization

Cooper (1986) and Lester (1998) argued that the commercialization of technology, from the perspective of the technological innovation process, involves the execution of the 'new product development process.' Jolly (1997) stated that it encompasses the overall process of

'idea proposal, research and development, prototyping/ market entry, mass production, and sustained growth,' while Farrukh et al. (2004) defined it as a process including manufacturing and market supply after research and development. Kimura (2010) described technology commercialization as the evolution of technology, under an R&D program, beyond the prototype level to function as a crucial part of the commercial product entering the market. Thus, the commercialization of technology cannot be separated from the ultimate goals of successful product development and market supply. It seems only natural to trace whether the introduced technology is effectively utilized by the company. Therefore, recent research has focused on the success of commercialization, aligning with this purpose.

On the other hand, the most crucial aspect lies in establishing the criteria for the success of technology commercialization. Spann et al. (1993) summarized previous studies, indicating that judgments about the success of technology commercialization can vary based on different perspectives such as progress achievement as a measure of commercialization success for the company, performance metrics relative to inputs such as financial gains, competitiveness metrics like market share, the number of new product developments, and the number of patents generated. In other words, the success of technology transfer and commercialization is closely tied to various meanings associated with commercialization. This conceptualization of technology commercialization in Korea is also organized as mentioned above. It is evident from most of the definitions that the specific outputs corresponding to each stage, such as 'prototype' and 'product,' are mentioned.

In this study, we determined that the discussion on technology commercialization goals and success, as perceived by technology startup companies, is an inseparable factor in understanding technological and managerial barriers. The results of the research indicate that each startup company has different goals and criteria for success. Some express success as achieving product completeness, while others define it based on revenue generation.

Technology and Managerial Barriers

In this study, the concept of business barriers, also referred to as success factors, failure factors, obstacles, and challenges, is characterized by various terms. The preconceived notion of business barriers refers to the difficulties or obstacles arising from the scarcity of production factors in the process of expanding production. Production activities rely on factors such as labor, capital equipment, raw materials, and funding. If any of these production factors is insufficient, it becomes a 'challenge,' constraining the production process. The terminology in overseas contexts uses various terms interchangeably, including Bottleneck, Difficulty, Barrier, Problem,

indicating similar concepts

Technology Commercialization with Barriers

This study started with Cooper's (1986) three-stage model and restructured the stages to align with the commercialization situation of domestic technology startups. In other words, we applied the criteria for stage construction by dividing the process into four stages: technology acquisition, prototype testing, product manufacturing, and market testing, using 'prototype' and 'commercial product' as intermediate metrics for commercialization following technology adoption.

However, Cooper's (1986) stage model, constructed as a model for the commercialization process utilizing internally developed technology, broadly includes early stages such as idea formulation and business planning. Since this study focuses on situations where technology startups use both internally developed technologies and externally transferred technologies for commercialization, we applied a narrower definition of the commercialization stage, starting from the development stage.

Meanwhile, with growing interest in the commercialization process after technology transfer, research has emerged on phenomena occurring at various commercialization stages described earlier, and on key success factors for commercialization success at each stage or specific stages. Benedetto (1999) emphasized that high-level sales efforts, advertising, technical support, and optimal release timing considering customers and competitors are critical success factors for a successful product launch. Kiriata (2007) divided the commercialization stage into three stages: basic research, product development, and commercial product sales, researching barriers at each stage such as financial condition and lack of research personnel. While there is no definitive answer to stage-specific barriers faced by companies in various commercialization conditions, this study outlines common experiences in stages and major barriers in the industry, contributing to a better understanding of commercialization conditions.

Methods and Data Collection

In this study, a survey was conducted among 151 technology-based startup companies in Korea, resulting in the acquisition of 118 valid responses (a response rate of 78.1%). Empirical analyses, including factor analysis and multivariate analysis of covariance, were performed utilizing these 118 survey responses. Exploratory and confirmatory factor analyses were conducted based on the 118 valid survey results, leading to the identification of two factors: technological barriers and managerial barriers. Through reliability analysis, the study ensured the validity and reliability of the measurement tool. Additionally, the two identified challenge factors (technological barriers and managerial barriers) were designated as dependent variables.

To analyze potential significant differences based on six

independent variables (startup form, commercialization goals, key technology introduction methods, growth stages, commercialization phases, and research organization types), 12 specific hypotheses were formulated. Subsequently, Multivariate Analysis of Covariance (MANCOVA) was employed for the analysis. To substantively control for variables, the revenue, number of employees, and business tenure of technology-based startup companies were introduced as covariates

Research Model and Hypotheses

The objective of this research is to analyze differences in technological and managerial barriers among technology startup enterprises based on their entrepreneurial forms, commercialization goals, key technology adoption forms, growth stages, commercialization stages, and research organizational structures, grounded in previous literature. Therefore, this study formulates hypotheses and establishes a research model regarding the barriers faced by technology startup enterprises. The research model and hypotheses are as follows

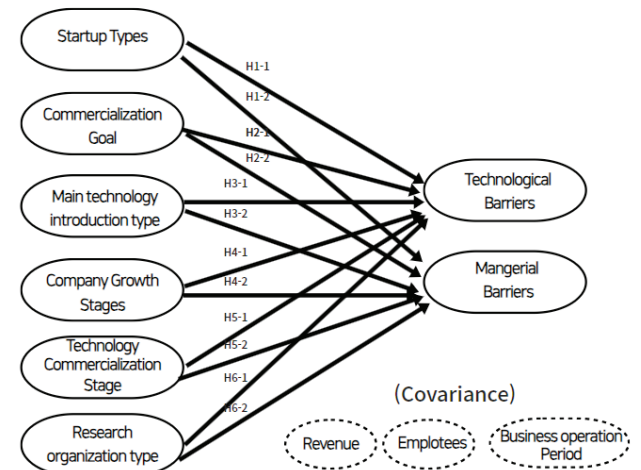


Figure 1 – Research Model

H1-1. There will be significant differences in Technological Barriers depending on Startup Types.

H1-2. There will be significant differences in Managerial Barriers depending on Startup Types.

H2-1. There will be significant differences in Technological Barriers depending on Commercialization Goals.

H2-2. There will be significant differences in Managerial Barriers depending on Commercialization Goals,

H3-1. There will be significant differences in Technological Barriers depending on Main technology introduction types.

H3-2. There will be significant differences in Managerial Barriers depending on Main technology introduction types.

H4-1. There will be significant differences in Technological Barriers depending on Company Growth Stages.

H4-2. There will be significant differences in Managerial Barriers depending on Company Growth Stages

H5-1. There will be significant differences in Technological Barriers depending on Technology Commercialization Stages

H5-2. There will be significant differences in Managerial Barriers depending on Technology Commercialization Stages.

H6-1. There will be significant differences in Technological Barriers depending on Research Organization Types

H6-2. There will be significant differences in Managerial Barriers depending on Research Organization Types

Variables and Measurements

In this study, six independent variables and two dependent variables were established based on previous research. The operational definitions of the independent and dependent variables are as follows

Table 2–Definition of Independent Variables

Variables	Operational Definition	Measurement
Startup Types	Initial type of startup	General startups, Researcher startups, Technology-based joint ventures
Commercialization Goals	Goal through the commercialization of technology.	Technology Sales, Technology, Acquisition, Business Rights Sale, Revenue Increase
Main Technology introduction-types	Form of introducing main technologies for technology commercialization	External adoption, In-house Development, Collaborative Development
Company Growth Stages	Current growth stage in terms of technological and managerial aspects of the company	Startup Stage, Early Growth Stage, High Growth Stage, Mature Stage, Stagnant Stage

Technology Commercialization Stages	Present stage of technology commercialization	Technology Adoption, Prototype Production, Commercial Product Development, Market Validation
Research Organization Types	Phase of establishing a research organization within the company for the purpose of technology research	Corporate Research Institute, Dedicated Research Department, Unauthorized Research Organization, No Research Organization

Table 3 - Definition of Dependent Variables

Variables	Operational Definition
Technological Barriers (TB)	Degree to which individual companies experience technical difficulties during the process of technology commercialization
Managerial Barriers (BB)	Degree to which individual enterprises encounter managerial difficulties in the process of technology commercialization

Results

Reliability and Validity Analysis

In this study, exploratory factor analysis (EFA) was conducted to extract the factors associated with barriers in technology-based startups. Out of the 16 scale items used in the factor analysis, two technological challenge measurement items (T6, T7) and one managerial challenge item (B8) with factor loading values below 0.5 were excluded. A total of 13 items were utilized for factor analysis to extract latent factors. Principal component analysis was employed as the factor extraction method, and Varimax rotation with Kaiser normalization was applied.

The results of the factor analysis indicated a sample adequacy (MSA) Kaiser-Meyer-Olkin (KMO) measure of 0.870, suggesting that the data is suitable for factor analysis. Additionally, Bartlett's test of sphericity yielded an approximate chi-square value of 894.550 with a p-value of 0.000, indicating that the correlation between variables is significant at the 0.05 significance level and validating the appropriateness of factor analysis. The cumulative explained variance of the two extracted factors was 29.836% for technological barriers and 32.002% for managerial barriers, totaling 61.838% of variance explained, supporting the extraction of two factors. The results revealed two factors, with Factor 1 labeled as 'Technological barriers' and Factor 2 as 'Managerial barriers.'

To assess the reliability of the measurement tool for the two extracted factors, a reliability analysis was conducted. The results indicated a Cronbach's alpha value of 0.876 for Factor 1 (Technological barriers) and 0.879 for Factor 2 (Managerial barriers), both surpassing the threshold of 0.6, confirming the reliability of the measurement tool. This analysis ensures the validity and reliability of the study's findings. The results of Exploratory Factor Analysis (EFA) are presented in Table 4 as follows:

Table 4 - Results of Exploratory Factor Analysis

Factor	Mesurement	Factor Loading
Techno-logical Barriers (TB)	Insufficient additional technology for technology commercializa-tion(T2)	.911
	Lack of optimization technology for technology commercializa-tion(T3)	.899
	Inadequate initial technology completeness(T1)	.833
	Lack of technology management skills in technology development projects(T4)	.718
	Shortage of technical personnel in research and development(T5)	.631
	Inadequate securing of intellectu-al property rights(T8)	.523
Manageri-al Barriers (BB)	Lack of financial management capabilities(B1)	.891
	Insufficient expertise in legal, taxation, and labor-related mat-ters(B2)	.865
	Inadequate marketing capabili-ties(B4)	.730
	Deficiencies in organizational management capabilities(B6)	.726
	Insufficient production capacities and workforce(B5)	.669
	barriers in fund procurement(B3)	.650
	Deficient management of domes-tic and international standards and certifications(B7)	.613
* Extraction Method: Principal Component Analysis **Rotation Method: Varimax with Kaiser Normalization		

To examine the correlation between variables of barriers factors, a correlation analysis using Pearson correlation coefficient was conducted. Correlation analysis is a statistical method to test the degree of linear relationship between two variables. In this study, correlation analysis

was performed to investigate the correlation between two factors derived from exploratory factor analysis: technological barriers and managerial barriers. The technological barriers factor showed a mean of 3.1012 and a standard deviation of 0.77617, while the managerial barriers factor exhibited a mean of 3.1307 and a standard deviation of 0.77418.

The Pearson correlation coefficient, calculated to understand the correlation between the two factors, was 0.488, indicating a significant correlation at the 0.01 significance level. However, it was deemed that there were no issues affecting the progress of this study despite the observed correlation between the variables, and thus the analysis proceeded.

Additionally, Confirmatory Factor Analysis (CFA) was conducted by excluding three variables (T6, T7, B8) from the initial measurement model to assess its fit. The final model for technological and managerial barriers in technology startups demonstrated good overall fit ($\chi^2=148.615$, $p<0.001$), incremental fit indices (TLI=0.880, CFI=0.901), and an RMSEA of 0.106. Standardized regression weights for the measurement variables were all above 0.4, significant at the 0.001 level. Latent variables TB and BB showed good AVE values (0.558286 and 0.517744), concept reliability above 0.7, and a correlation of 0.343. Although some variables had lower explanatory power, the high model fit justified proceeding with the study.

Multivariate Analysis of Covariance (MANCOVA)

To understand the impact of technological and managerial barriers on technology startups, this study conducted Multivariate Analysis of Covariance (MANCOVA). Covariance analysis is a method used to control for the influence of continuous variables and identify the pure effects of independent variables on dependent variables. In this study, three continuous variables (revenue, number of employees, tenure) were set as covariates to control for their effects, and six independent variables (startup type, commercialization goal, technology adoption type, growth stage, commercialization stage, research organization type) were set as predictors. The dependent variables were technological barriers and managerial barriers. The MANCOVA was performed to analyze the multivariate effects.

Initially, a test for the homogeneity of covariance matrices was conducted to ensure that the analyzed data possessed a structure suitable for covariance analysis. Upon examining the results of Box's test for the equality of covariance matrices below, the significance level was determined to be 0.100, with a p-value exceeding 0.05. Consequently, it was observed that there was no significant difference in the covariance matrices, affirming the consistency of the matrix structure in explaining the dependent variables by the independent variables. This substantiates the appropriateness of the data for covariance analysis.

Table 5 - Results of Box's test for the equality of covariance matrices

Box's M	F	df1	df2	P value
19.063	1.783	6	661.596	0.100

Additionally, a Levene test for the equality of error variances was conducted. The results indicated that the significance level for all dependent variables (technological barriers and managerial barriers) was above 0.05. With the covariates (revenue, number of employees, tenure) controlled and considering six independent variables (startup type, commercialization goal, technology adoption type, growth stage, commercialization stage, research organization type), it can be interpreted that the error variances of all dependent variables are homogenous (homoscedasticity). In conclusion, there were no structural issues in the data that could impede the validity of the Multivariate Analysis of Covariance (MANCOVA)

Table 6 - Levene's test for the equality of error variance

Dependent Variables	F	df1	df2	P value
TB	1.620	96	21	.103
BB	.822	96	21	.744

In this study, we sought to examine whether there are significant differences in the dependent variables (technological barriers and managerial barriers) based on six fixed independent variables (startup type, commercialization goal, technology adoption type, growth stage, commercialization stage, research organization type). As previously mentioned, revenue, number of employees, and tenure were set as covariates and treated as controlled variables in the analysis. Additionally, the analysis model exclusively addresses main effects analysis, excluding interaction effects among independent variables.

Upon reviewing the analysis results, the covariance analysis model with the six independent variables and technological barriers as the dependent variable yielded an R-squared value of .665 and an adjusted R-squared value of .595. This suggests that the covariance analysis model explains 59.5% of the variance in technological barriers. Similarly, when the six independent variables were used with managerial barriers as the dependent variable, the model's R-squared value was .630, and the adjusted R-squared value was .554, indicating that the covariance analysis model accounts for 55.4% of the variance in managerial barriers.

Table 7 - Results of Multivariate Analysis of Covariance Model (Main Effects)

Dependent Variables	Sum of Squares	R ²	P value
TB ^a	1.620	.665	.000****
BB ^b	.822	.630	.000****
a. R-squared = 0.665 (Adjusted R-squared = 0.595)			
b. R-squared = 0.630 (Adjusted R-squared = 0.554)			

*p<.1, **p<.05, ***p<.01, ****p<.001

To assess the significance of discriminant power of the fixed independent variables used in the analysis and determine whether an appropriate function for covariance analysis was employed, multivariate tests were conducted.

The multivariate tests were performed using Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root. A significance level of $p < 0.05$ was applied for measurement. According to the results of multivariate tests, for the variable 'startup type,' excluding Roy's Largest Root, other methods did not show significant results; however, the outcome by Roy's Largest Root was found to be significant at the 0.05 level, suggesting the suitability of the function for covariance analysis. Variables such as 'commercialization goal,' 'company growth stage,' and 'technological commercialization stage' were found to be significant ($p < 0.05$) across all test methods (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root). Furthermore, 'main technology adoption type' and 'research organization type' showed non-significant results across all test method.

Also, We conducted tests to examine whether there were differences in the dependent variables, technological barriers, and managerial barriers, based on the six independent variables. The analysis results indicated that there was no significant difference in technological barriers based on 'startup type,' whereas a significant difference was observed in managerial barriers according to 'startup type' ($F=2.581, p<0.1$). Additionally, significant differences were found in technological barriers ($F=2.217, p<0.1$) and managerial barriers ($F=2.421, p<0.05$) based on 'commercialization goal.' Although no significant difference was observed in technological barriers based on 'company growth stage,' a significant difference was noted in managerial barriers ($F=3.263, p<0.05$). Regarding 'technological commercialization stage,' a significant difference was observed in technological barriers ($F=4.207, p<0.01$), while no significant difference was found in managerial barriers. Finally, there were no significant differences in technological and managerial barriers based on 'main technology adoption type' and 'research organization type.'

Table 8 - Main Effects of Technological and Managerial barriers Based on Independent Variables

Independent variables	Dependent Variables	F	R ²	P value
Startup type	TB	1.646	.033	.198
	BB	2.581	.051	.081*
Commercialization goal	TB	2.217	.064	.091*
	BB	3.017	.085	.034**
Main technology adoption type	TB	.273	.006	.762
	BB	.490	.010	.614
Company growth stage	TB	.721	.029	.580
	BB	3.263	.119	.015**
Technological Commercialization Stage	TB	4.207	.115	.008***
	BB	1.497	.044	.220
Research organization type	TB	1.226	.037	.305
	BB	.456	.014	.713

*p<.1, **p<.05, ***p<.01, ****p<.001

Results of post-hoc test

Following the significant differences identified in the preceding multivariate analysis of covariance results, post-hoc tests were conducted. The Bonferroni multiple comparison method was utilized for the post-hoc tests, with consistent control of covariates including revenue, number of employees, and tenure. Examining the estimated mean values of managerial barriers based on 'startup type,' it was revealed that, in the case of general startups, managerial barriers was higher compared to researcher startups. However, no significant difference was observed in managerial barriers for technology-based joint ventures

Table 9 - Multiple Comparisons of Estimated Mean Managerial Barriers Based on Startup Type

Dependent Variables	Startup type	Sample size	Mean	SE
BB	General startups	47	2.976^b	.135
	Researcher startups	46	2.671^a	.134
	Technology-based joint ventures	25	2.841 ^{ab}	.167
Bonferroni's Multiple Comparison: a < b Covariates: Revenue, Number of Employees, Tenure				

Next, when examining the estimated mean values of technological barriers and managerial barriers based on commercialization goals, it was found that technological barriers differed significantly between groups aiming for business rights sale and those with the goal of technology sales as a means of commercialization.

Furthermore, managerial barriers was higher in the group targeting technology acquisition and revenue increase as commercialization goals compared to the group targeting technological sales.

Table 10 - Multiple Comparisons of Estimated Mean Technological and Managerial Barriers Based on Commercialization Goals

Dependent Variables	Commercialization Goals	Sample size	Mean	SE
TB	Technology Sales	6	2.562^a	.231
	Technology Acquisition	28	3.026 ^{ab}	.142
	Business Rights Sale	9	3.292^b	.201
	Revenue Increase	75	3.037 ^{ab}	.105
BB	Technology Sales	6	2.469^a	.242
	Technology Acquisition	28	3.109^b	.149
	Business Rights Sale	9	2.700 ^{ab}	.210
	Revenue Increase	75	3.040^b	.110
Bonferroni's Multiple Comparison: a < b Covariates: Revenue, Number of Employees, Tenure				

The following post-hoc analysis results present an estimated mean comparison table of managerial barriers based on growth stages. The high-growth and stagnant groups did not show significant differences. However, the startup and early startup groups exhibited a significant difference in post-hoc testing when compared to the group in the mature growth stage. It was found that the startup and early startup groups had higher managerial barriers in the mature growth stage than the group in the growth stage

Table 11 - Multiple Comparisons of Estimated Mean Managerial Barriers Based on Growth Stages

Dependent Variables	Growth Stages	Sample size	Mean	SE
BB	Startup Stage	21	3.209^b	.152
	Early Growth Stage	50	3.137^b	.124
	High Growth Stage	34	2.808 ^{ab}	.143
	Mature Stage	6	2.340^a	.288
	Stagnant Stage	7	2.653^{ab}	.231
Bonferroni's Multiple Comparison: a < b Covariates: Revenue, Number of Employees, Tenure				

Finally, here are the post-hoc test results for technological barriers based on the stage of technological commercialization. In the case of market validation, no significant differences were observed. However, the groups involved in technology adoption and prototype development showed a significant difference compared to the group involved in commercial product development. Specifically, the group in the technology introduction and prototype development stages exhibited higher technological barriers compared to the group engaged in commercial product development.

Table 12 - Multiple Comparisons of Estimated Mean Technological Barriers Based on Technological Commercialization Stages

Dependent Variables	Technological Commercialization Stages	Sample size	Mean	SE
TB	Technology Introduction	27	3.277 ^b	.136
	Prototype Development	48	3.174 ^b	.129
	Commercial Product Development	31	2.750 ^a	.157
	Market Validation	12	2.717 ^{ab}	.210
Bonferroni's Multiple Comparison: a < b Covariates: Revenue, Number of Employees, Tenure				

Hypothesis Verification

Multivariate Analysis of Covariance (MANCOVA) was conducted, including tests for the homogeneity of covariance matrices and error variance, discriminant power of independent variables, analysis of multivariate covariance model effects, and post-hoc testing (Bonferroni's multiple comparisons) to derive the results. The determination of the acceptance or rejection of hypotheses indicating significant differences is as follows.

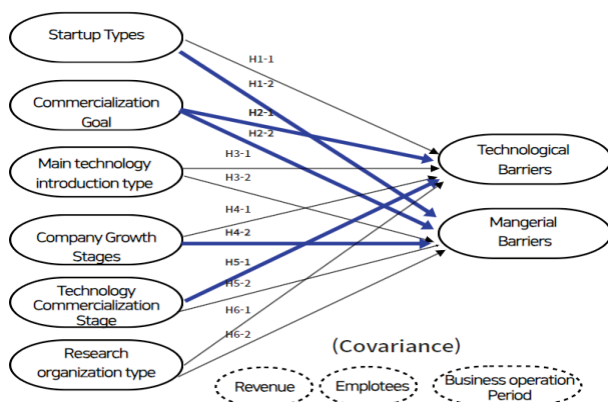


Figure 2 – Hypothesis Verification for Research Model

H1-1. There will be significant differences in Technological Barriers depending on Startup Types. (Rejected)

H1-2. There will be significant differences in Managerial Barriers depending on Startup Types. (Accepted)

H2-1. There will be significant differences in Technological Barriers depending on Commercialization Goals. (Accepted)

H2-2. There will be significant differences in Managerial Barriers depending on Commercialization Goals (Accepted)

H3-1. There will be significant differences in Technological Barriers depending on Main technology introduction types. (Rejected)

H3-2. There will be significant differences in Managerial Barriers depending on Main technology introduction types. (Rejected)

H4-1. There will be significant differences in Technological Barriers depending on Company Growth Stages. (Rejected)

H4-2. There will be significant differences in Managerial Barriers depending on Company Growth Stages (Accepted)

H5-1. There will be significant differences in Technological Barriers depending on Technology Commercialization Stages. (Accepted)

H5-2. There will be significant differences in Managerial Barriers depending on Technology Commercialization Stages. (Rejected)

H6-1. There will be significant differences in Technological Barriers depending on Research Organization Types (Rejected)

H6-2. There will be significant differences in Managerial Barriers depending on Research Organization Types (Rejected)

Conclusions and implications

This study conducted exploratory and confirmatory factor analyses based on 118 survey responses to analyze the types of technological and managerial barriers faced by technology startups. Two factors, technological barriers and managerial barriers, were identified, and the reliability analysis ensured the validity and reliability of the measurement tool. Subsequently, 12 hypotheses were formulated to investigate significant differences in the two

derived challenge factors (technological and managerial) based on six independent variables (entrepreneurial type, commercialization goal, dominant technology adoption, growth stage, commercialization stage, and research organization type). Multivariate Analysis of Covariance (MANCOVA) was employed, with revenue, number of employees, and company tenure as covariates to control for practical variations among technology startups.

Statistically significant results were obtained, and Bonferroni's post-hoc tests were conducted to validate the accepted hypotheses. Out of the 12 hypotheses, 5 were accepted (Hypotheses 1-2, 2-1, 2-2, 4-2, 5-1), while 7 were rejected. Notably, one accepted hypothesis verified that there is a significant difference in managerial barriers faced by technology startups based on their entrepreneurial type (Hypothesis 1-2). Conversely, no significant difference in technological barriers based on entrepreneurial type was observed and, therefore, was rejected (Hypothesis 1-1). Furthermore, hypotheses testing the significant differences in technological and managerial barriers based on the commercialization goal of technology startups (Hypotheses 2-1, 2-2) were accepted. This suggests that companies with goals beyond simple revenue increase, such as prioritizing technology sales or business rights acquisition, face different barriers based on their objectives and factors. Additionally, the accepted hypothesis about the significant differences in managerial barriers based on the growth stage of the company (Hypothesis 4-2) indicates that, in contrast to technological barriers, managerial factors become increasingly crucial as companies progress quantitatively. However, no significant difference in technological barriers based on growth stage was observed, suggesting that technological barriers are more likely associated with individual products or the commercialization process. Finally, all hypotheses related to the organizational type were rejected (Hypotheses 6-1, 6-2), emphasizing that the company's research organization is more likely a result rather than a precursor to technological and managerial barriers, requiring a different perspective for interpretation.

Acknowledgments

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Construct Scientific Company Business Ecosystem- Taking B Scientific Company as an Example

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Abstract

Biopesticides are very important substances to ensure agricultural production. The introduction of apple snails to several Asian countries such as Taiwan, has led to infestation of water bodies including rice fields and they have unexpectedly developed into a serious pest of rice. As this species causes considerable damage in rice fields by eating the rice seedlings materials, they become an impediment to the production as well as the rice farmers' incomes. Therefore, the control of this species is essential to safeguard yields and income of rice farmers. The object of this research is B scientific corp, a biopesticide company that is intensively searching for solutions to this increasing problem. It provides effective products without negative impacts on the environment or human health, to farmers against this species. This paper also discusses the emergence of this company's ecosystem and how it can expand its presence in the rapidly growing markets and becomes more active.

Keyword

Business Ecosystem, Case study

1. Introduction

The increasing need to improve agricultural productivity and enhance its sustainability is one of the most significant challenges facing humanity. Across the world, farmers, growers, and other in the food supply chain need to make a fair living from agriculture without damaging the social and the environmental prospects of the society. However, with the pest-related problems that decrease agricultural production, farmers are resorted to chemical control, with implications for human health and the environment. Therefore, for the integration of pest management methods, biopesticides are an important component and are considerable as effective and ecofriendly compared to synthetic materials. Because consumer markets are becoming more aware of the environmental concerns and are making demands on the industry to move towards a more ecologically rational approach to pest management. Apple snails are considered a serious pest to rice fields as they destroy the entire plants when they get attached on them. In Asia, especially in Taiwan, its introduction has created a ravage in the natural ecology and has generated huge losses in local agricultural production (rice). Though, their presence in the rice fields is a threat for the economic growth of the farm. The estimated results

show that the annual impact of golden apple snails control and management is \$US 175.6 million (Yang, Chen, Lee & Chen, 2006). To cope with the increasing issues created by the apple snails among rice fields, B scientific company have worked on an effective product against this viscous species and therefore improve the rice production in Taiwan. This biological pesticide product is known to be safe to the environment and also to the human health.

The objective of this paper is to address the needs of the farmers regarding the apple snails- related issues, while focuses on the emergence of the company's ecosystem. This paper also discusses the challenges of the company in reaching the global markets and also its targets. The challenges associated with biopesticide are part of the wider set of issues facing global agriculture, including improving livelihood and social welfare for people, increasing food productivity while minimizing the negative effect of farm activities, and also finding effective ways to manage the spread of information. So, the need for B scientific company to build strong relationships with the stakeholders is necessary for the development of the business, the achievement of a greater uptake of its products in the market, and its expansion in the global market.

2. About B Scientific Corp

B scientific company is a biopesticide company operating in Taiwan. It has been a strong component in agriculture science and technology. The company has emerged as one of the players in the biochemical pesticides market and has been strategically bolstering its presence in the market and building a strong portfolio of biopesticide solutions against apple snails that are attached on rice and eventually caused serious damaged to the young rice plants. The company aims at deepening its footprint in Taiwan and helping farmers to eradicate apple snails more efficiently without any toxic chemicals and enhance rice productivity while protecting the environment.

This company started as one-man enterprise and it is actually growing really fast to meet the daily and emergency needs of the target customers in the market. The company has only 20 employees and also separate companies used for manufacturing the products. Those companies are mainly located in United States for research and development which provides great facilities to innovate and introduce new products and services to the market. The company makes its successful products by using tabaco, tea seed, wheat and soap bark tree, which are the key materials used in the production process of the biopesticide for the eradication of the apple snails. In addition to its beneficial products, this company is promoting organic agriculture and environmental awareness.

3. The importance of using biopesticide against applesnail

Apple snails are invasive aquatic snails. There are more than 100 species of apple snail that exists and two of them such as *Pomacea canaliculata* and *Pomacea maculate* commonly known as Golden Apple Snails, are highly invasive and cause damage to rice crops (Rice Knowledge Bank, n.d.). They were introduced to Asia, from South America, in the 1980s as potential food for people but it unfortunately became a major pest of rice (Rice Knowledge Bank, n.d.). Therefore, rice systems represent a high-quality habitat for these apple snails because of similarities in the environmental conditions (water temperature, salinity, pH, water flow velocity) necessary for both rice production and for snail survival and development (Horgan, 2018).

Apple snails have heavy golden-yellow to dark brown shells which can grow up to 6 inches across but are more often in the range of 2 to 4 inches. They can be easily found due to their bright pink egg clusters, usually clumps of 200-600 tiny eggs attached to the rice seedlings above the waterline. When they invade a rice growing field, they start to overpopulate and spread through irrigation canals,

natural water distribution pathways etc... and eventually steal resources away from native species, disturbing natural ecological processes. They consume large amount of rice plant material and cut its stem at the base which destroy the entire plant. If no management measure is taken, the apple snails can completely destroy a major part of the field overnight. This damage could lead to more than 50 percent yield loss (Rice Knowledge Bank, n.d.). Therefore, judicious use of biopesticide plays an important role in rice plants protection.

In Taiwan, rice is considered as the most valuable cash crop. 240,000 of nearly 30 percent of the nation's farm households are growing rice, and the average cultivated area of each household is only 0.6 hectares. An estimated 1,348,000 tons of brown rice equivalent crops is harvested each year, valuing TWD 37.9 billion, which contributes to roughly eight percent of the agricultural GDP (Agriculture and Food Agency, Council of Agriculture, 2018). Therefore, farmers are always looking for the best way to enhance and increase rice productivity. As apple snails create an obstacle that impedes the productivity and decrease the income of the farmers, B scientific company brings to the farmers an effective biopesticide as a remedy for this problem which help increasing the rice productivity in Taiwan and also several South Asian countries.

4. Emergence of the company's ecosystem (Business development)

4.1. Address Farmers' Needs

In the biopesticide markets, farmers represent the main target, they are very important for the company because they are most attracted by the company's value proposition, they drive revenues and without them the biopesticide companies cannot continue to exist. Thus, knowing what farmers need to take their farms to the next level is a strong point for the company.

First of all, B scientific company understanding the farmers and their decisions drivers by developing customers' metrics. And the company can use surveys, interviews, panels, internet and so forth to get access to gain this knowledge. Second of all, the company can social media to display its products and show their importance (mostly about the quality and the effectiveness of the products which can be done by using a sample) and how to use them in the rice production process. And this will not only increase the target customers that are geographically localizable, but also widely dispersed online communities with common characteristics. Thirdly, the company needs to be aware of the competitive price of those kind

of products, in order to set a reasonable price for the customers.

4.2. Having strong co-operations

Product's validation is one of the most important steps for a company to take in order to grow successfully in the market industries. Therefore, B scientific company needs to have strong co-operations with universities both in Taiwan and outside in order to validate the product quality and to speed up market entry. That can help the company to make innovations at every phase such as; agricultural operation, production, management and marketing. Hence, innovative research and development at universities and government agencies have resulted in the establishment of operational ideas for applications in sustainable agriculture management, marketing of eco-friendly biopesticide products, new product development, and the establishment of alternative supply chains for profitable product distribution. Using the product in the educational field would give a rise to the company business development in the global biopesticide market.

4.3. Government operating in multiple roles

The government plays multiple roles in the business system. they gives the companies permission to form and operate, which is why most businesses need forms of registration that define the financial liability of the businesses' owners. So, when the product causes harm to people the courts may hold the company responsible. To make sure of the food safety, the government imposes many requirements on marketers, especially for the pesticides products that have some negative impacts on the environment and also on people's health if not well managed.

Though, biopesticide companies are facing many requirements in Taiwan due to the adverse effect cause by the pesticides to environment and health. When the farmers apply the crop protection agents, the residues would most likely to get into our food chain and expose more people to the risky food residues which may negatively affect their health. According to the regulations act of pesticide in Taiwan, no matter it is classified as chemical pesticides or biopesticides, data required for registration include studies of physicochemical properties, toxicities, and field trials of efficacy, residue, and phytotoxicity. All of these studies should in compliance with good laboratory practice (GLP) guideline (Taiwan Agricultural Research Institute Council of Agriculture, 2019). Consequently, B scientific company needs to make sure that it follows all the requirements regarding Taiwan government regulations on pesticides products.

Another key factor for B scientific company to consider in emerging its ecosystem is creating positive interactions with the farmers associations in Taiwan. They formed the core of the colonial government's agricultural extension program, which is involved in standardizing seed varieties, introducing new farming methods, and other development activities (The View from Taiwan, 2007). In addition, the farmers' associations system in Taiwan provides a structural pattern which makes it possible to increase agricultural production and promote the well-being of rural families (Taiwan Today, 2021). Embracing the idea behind the farmers' associations can help the company finding new perspectives to ensure food safety and increase agricultural production(rice).

5. Targets customers

B scientific company focus on building personal relations with universities that can help in the research and development of new products. In addition, its interaction with the famers' associations are essential to achieve ecosystem targets. Having a co-operation with local experts on distribution and product development, help strengthening the network. With the different challenges created by the competitors in the market, B scientific company needs to develop as a fast reacting company and a well surrounding in order to address these challenges. Another key target is the expansion of the business to global markets with university and private distributors partners.

6. Challenges

Despite their benefits to soil, human health, and ecosystems, biopesticides ae facing significant challenges and competition regarding synthetic pesticides for a variety of reasons. Therefore, the development of biopesticides must overcome the problems of poorquality products, short shelf life, delayed action, high market cost, and legal/registration issues (Arjjumend, Koutouki, & Donets, 2020). The major challenges of B scientific company are mainly revolved around the sales development which is a critical task, the inventory control that has a substantial meaning when developing the partnering network and also the price competition.Hence, the relationship between operational feasibility, utility of effective inventory control management in the customer related issues of the company and cost effectiveness technique are implemented to enhance the return on investment in the company. The price competition from the global market such as Bayer company remains one of the challenges of B scientific company.Because the price of the natural materials is high with suppliers.

Bethesda Scientific Corp

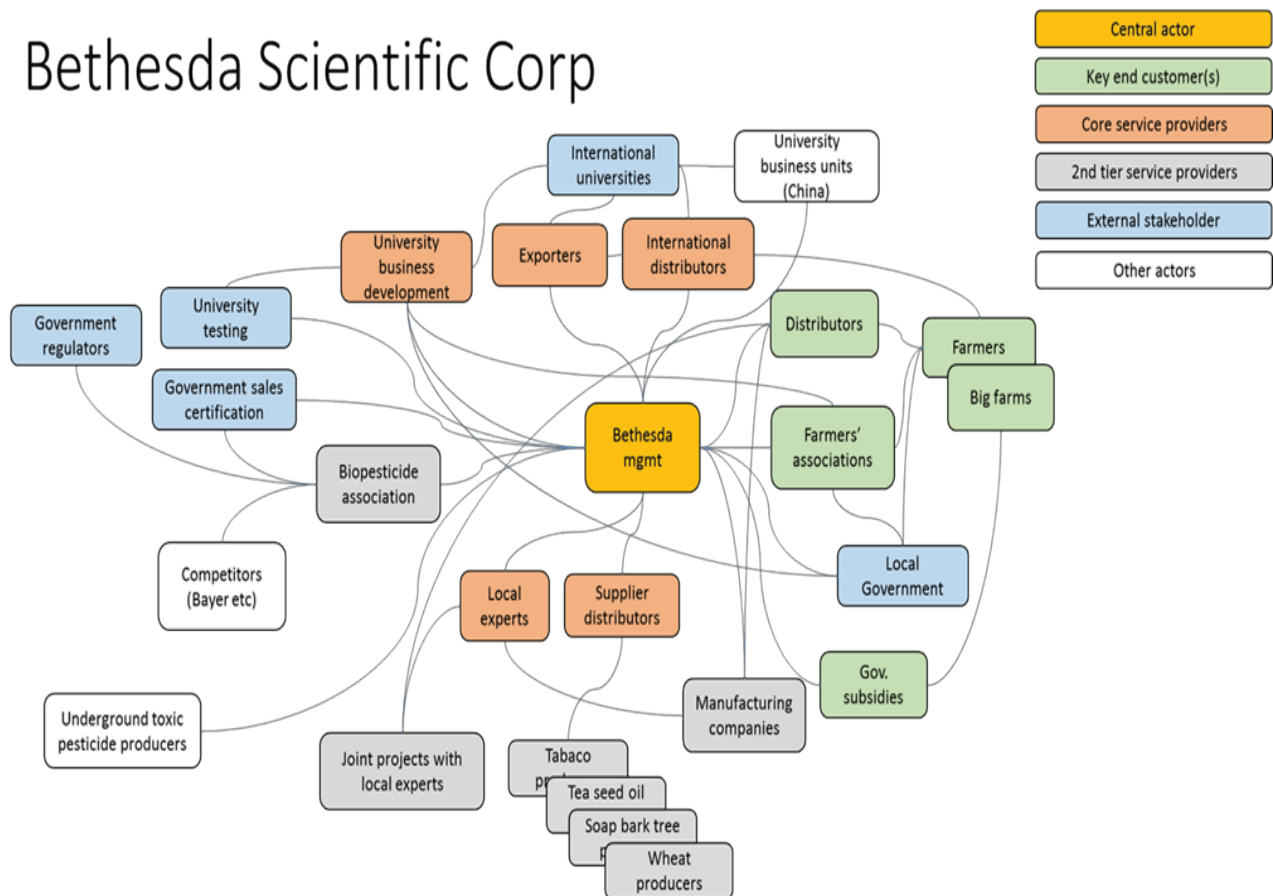


Figure 1. Business ecosystem description of B scientific company

7. Network of indirect actors

The network of indirect actors like universities provide new ecosystems opportunities for the company to enter to new markets, test the company's products and develop new sales channels. The public sector actors like the government office can also have different roles in a same way as the service providers or customers in the ecosystem. Therefore, a firm's network-oriented behaviors positively affect the development of customer-oriented and competitor-oriented behaviors. They also foster relationship coordination with the important business partners within the network. Though, the effective management of the company's portfolio of relationships is found to mediate the positive impact of net-working-oriented behaviors on the company profitability.

8. Conclusion

According to the purpose of this paper, B scientific company has the potential to develop further into biopesticides that will help increasing agricultural productions to ensure the effectiveness of its products while promoting food safety. So, the collaboration between stakeholders remains crucial and it is necessary that B scientific company work closely in partnership with other companies, universities, farmers' associations, policymakers, government and other relevant stakeholders. And that can speed up the company's entry in the markets and contributes greatly to the development of the business. Many methods have been made for ensuring the integration of biopesticides against apple snails into existing farming systems which allow the targets customers to increase. In order to promote greater uptake of biopesticides, addressing farmers' awareness and their perceptions of effectiveness is important, as well as increasing the knowledge of those ensuring registered products are locally available at competitive prices.

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The Information Content between Stock Return and Revenue Growth Rate: Evidence from Excellent Governance Companies in Taiwan

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Abstract

This study selects 16 Taiwanese companies with excellent corporate governance ranked among the top 5% from the first session of the corporate governance evaluation system in 2014 to the ninth session in 2022 as the research objects. The data period is from January 2014 to May 2023. After studying the relationship between stock return and revenue growth rate through a rigorous empirical process, We obtained the following conclusions:

First of all, in terms of stock return on the revenue growth rate, the stock returns of Win Semiconductors and Coretronic had a significant positive impact on the revenue growth, and the stock price had information content; that is, investors could predict the increase or decrease of the monthly revenue growth in subsequent announcements based on the increase or decrease in the stock returns.

In addition, in terms of the leadership of revenue growth on stock returns, the revenue growth of China Motor, Sinyi Realty, Sino-American Silicon, and Ecove Environment had a significant positive correlation with the stock returns, that is, investors could subsequently buy or sell stocks based on the results of monthly revenue announcements (growth or decline).

Keywords

Corporate Governance, Information Content, Evaluation System, Stock Return, Revenue Growth Rate

Introduction

International organizations such as the World Bank, International Monetary Fund (IMF), and World Trade Organization (WTO) regard good corporate governance as essential for economic development and financial stability. Taiwan Financial Supervisory Commission announced the five-year “Blueprint for Strengthening Taiwan’s Corporate Governance” to align with international standards in 2013, which included a “corporate governance assessment” for all listed companies, hoping to deepen the concept of corporate governance through the assessment mechanism and advocate corporate social responsibility to safeguard the rights and interests of the investor.

To strengthen corporate governance and enhance the sustainable development of enterprises, the Financial Supervisory Commission successively promoted the Corporate Governance 3.0: Sustainable Development Blueprint in August 2020. It released the Sustainable Development Action Plan for Listed Overseas Companies in March 2023, including Governance evaluation indicators in corporate sustainable governance issues.

The Taiwan Corporate Governance 100 Index and Taipei Exchange Corporate Governance Index use the evaluation results of the corporate governance evaluation system as a reference for selecting constituent stocks. At the same time, the evaluation results have also attracted increasing attention from investors. Therefore, the company hopes to enhance its corporate image and reputation and increase investor confidence by actively participating in self-assessment exercises. This trend reflects market demands for corporate governance transparency and quality and encourages companies to establish more effective governance structures. Taiwanese listed companies are paying more and more attention to this evaluation, which is the fact that the ninth self-evaluation companies accounted for 99% of the overall evaluated companies.

In addition, monthly revenue information is more timely than quarterly earnings information and can provide the latest information on the company’s most recent operating conditions. After a company announces its monthly revenue, it will impact its stock price and trading volume. Generally speaking, investors usually buy stocks when a

company's monthly revenue increases, leading to good stock price performance. Therefore, the rise and fall of the stock price is closely related to the monthly revenue performance.

Of course, companies with better corporate governance are more likely to be held by corporate governance ETF funds. There should be a close relationship between stock return and revenue growth rate. This study is deeply interested in this issue, which also triggered the motivation for the research. Then, this paper builds a leadership model to study whether the monthly stock return of companies with excellent corporate governance leads the monthly revenue growth rate or the monthly revenue growth rate leads the monthly stock return; that is, this paper is deeply interested in whether it exists information content between them.

In addition, the data period of this study includes the outbreak of the COVID-19 epidemic. Subsequently, this paper will set the dummy variable during the COVID-19 pandemic period (from March 2020) to 1 and set the previous period to 0 to explore the impact of this event further. This study believes its results should provide investors with a more robust investment reference.

Literature Review

We will explain the following two parts: Taiwan's corporate governance evaluation system and the information content of revenue growth rate and stock return rate.

1. Taiwan's Corporate Governance Evaluation System is in its ninth session in 2022 since the first session in 2014. The evaluation projects mainly have four aspects and 78 indicators to assess companies. The evaluation aims to review the implementation of corporate governance-related matters by each company and promptly reward companies with outstanding performance to function as leaders in the industry. Enhance the quality of the capital market through information disclosure and broad participation. To help the investor, the Corporate Governance Center divided the assessed companies into three categories: electronics with a market value of more than 10 billion NT dollars, non-finance and non-tech companies with a market value of more than 10 billion NT dollars, and Finance and Insurance. According to their scores, they divided into five grades, including the top 10%, 11%~20%, 21%~40%, 41%~60%, and 61%~100%; in addition, the market value of more than 5 billion NT dollars to 10 billion NT dollars category will be divided into six levels according to the level of performance, according to the top 5%, 6%~10%, 11%~20%, 21%~40%, 41%~60%, 61%~100%, etc.

2. Information content of stock return and revenue growth rate:

Taiwan Stock Exchange stipulates that listed companies must announce the previous month's revenue before the

10th of each month. Investors will pay special attention to whether the company's monthly revenue is growing or declining, which will affect the performance of the subsequent stock return; that is, the monthly revenue growth rate has a leading role in the monthly stock return, and the monthly revenue growth rate has information content. Some scholars explain this argument from the perspective of information asymmetry. For example, Verdi (2005) pointed out that company insiders (such as employees or managers) generally have more internal information than external investors. LaFond and Watts (2008) and Brown and Hillegeist (2007) pointed out that in the case of information asymmetry, investors can only obtain part of the information and cannot understand the company's future value. Usually, information about the quality of monthly revenue can provide a quicker understanding of the company's operating conditions than quarterly, half-year, or annual revenue.

On the contrary, monthly stock return leads the monthly revenue growth rate of subsequent announcements; that is, monthly stock return contains information content. However, there is little literature on this argument, which is where this study contributes. The following is a summary of the information content on revenue growth rate and stock return by scholars.

Except for Saputra (2022), all the following papers support the idea that revenue significantly impacts stock prices. Benston (1985) proposed that changes in revenue are closely related to stock return, and Natarajan et al. (2020) pointed out a significant positive correlation between stock returns and financial performance. Boesso and Kumar (2007) and Pinto et al. (2013) pointed out that revenue growth has a direct and significant impact on stock return, while Jegadeesh and Livnat (2006) also pointed out that when a US company's revenue announcement exceeds expectations, the subsequent stock return has a significant impact. Aghion and Stein (2008) also pointed out that when company managers care about the current stock price, they will work harder to increase sales. The above literature supports that revenue significantly impacts stock prices. However, Saputra (2022) pointed out that no significant relationship exists between the stock prices and revenue of Indonesian-listed food and beverage companies from 2018 to 2021.

In addition to the threat to personal life and health, the COVID-19 epidemic has also brought unprecedented challenges to the world at the economic and social levels. According to research by Cheema-Fox et al. (2022), the COVID-19 epidemic has forced many companies to adjust their business management strategies to cope with the new economic and social environment. For example, it strengthened its risk management strategies and revisited its supply chain management to ensure that business continuity can be maintained despite many uncertain environments.

Generally speaking, according to the studies by the

scholars mentioned above, most focus on the informational content of revenue growth rate on stock return. Still, the stock return rarely has information content on the revenue growth rate of the month of subsequent announcements. It is also the contribution of this study. In addition, this study also considers the impact of the COVID-19 epidemic.

Methods

We will explain the following three parts: The unit root test of Ng and Perron (2001), the Optimal lag periods of the SC criterion, and the Leadership model.

1. Unit root test of Ng and Perron (2001)

Granger and Newbold (1974) pointed out that spurious regression will occur when performing regression analysis if the time series is non-stationary. The data analysis results will have no economic implications. The unit root test is an essential concept in time series analysis. Assuming that the sequence has a unit root, the sequence exhibits random characteristics in the long term; that is, the values in the sequence cannot tend to a fixed average. Ng and Perron (2001) proposed a single root test to remove the trend term and established four test statistics such as MZ_a , MZ_t , MSB , and MP_t .

Besides, MZ_a and MZ_t of Ng and Perron (2001)

modified the Z_a and MZ_t statistics of Phillips (1987). The following are test statistics:

$$MZ_a = (T^{-1}(Y_t^d)^2 - f_0) \left[2T^{-2} \sum_{t=1}^T (Y_{t-1}^d)^2 \right]^{-1} \quad (1)$$

$$MZ_t = MZ_a \times MSB \quad (2)$$

$$MSB = \left[T^{-2} \sum_{t=1}^T (Y_{t-1}^d)^2 / f_0 \right]^{1/2} \quad (3)$$

$$MP_t = \begin{cases} \left[\bar{c}^2 T^{-2} \sum_{t=1}^T (Y_{t-1}^d)^2 - \bar{c} T^{-1} (Y_T^d)^2 \right] / f_0, & \text{if } x_t = \{1\} \\ \left[\bar{c}^2 T^{-2} \sum_{t=1}^T (Y_{t-1}^d)^2 + (1 - \bar{c}) T^{-1} (Y_T^d)^2 \right] / f_0, & \text{if } x_t = \{1, t\} \end{cases}$$

Among them $\bar{c} = \begin{cases} -7, & \text{if } x_t = \{1\} \\ -13.5, & \text{if } x_t = \{1, t\} \end{cases}$, the NP unit root test has limited x_t scope and the selection method to estimate f_0 .

The null hypothesis of the Ng and Perron (2001) unit root test is non-stationary; the opposite hypothesis is

stationary. This study uses MZ_t and MP_t statistics to test whether the time series is stationary.

2. Optimal lag periods of SC criterion

This study discusses whether the monthly stock return leads to the monthly revenue growth rate or the monthly revenue growth rate leads to the monthly stock return.

Adding the lag term of the dependent variable to the leadership model can prevent the linear model from missing important variables and make the residual more like white noise. This study uses the SC criterion to select the optimal lag periods.

$$SC = S \ln(SSE) + P \ln(S) \quad (5)$$

Where S is the number of samples, $\ln(SSE)$ is the sum of squared residuals taking the natural logarithm, $\ln(S)$ is the number of samples taking the natural logarithm, and P is the number of parameters to be estimated. Here, we take the leading model that adds the contingency number two periods later as an example, and the explanation is as follows:

3. Leadership model

(1) The stock returns leadership (taking the lag two as an example)

$$y_{1t} = a_0 + b_1 y_{1t-1} + b_2 y_{1t-2} + b_3 y_{2t} + \varepsilon_t \quad (6)$$

Formula (6), y_{2t} is the stock return at the end of last month. y_{1t} is the monthly revenue growth rate, which t ' refers to the monthly report announcement on the 10th of the subsequent month. When the stock returns positive and contains information content, the subsequent monthly revenue growth rate announcement will also be positive. However, when the stock return is negative, the subsequent announcement of the monthly revenue growth rate will be negative.

In particular, Liu and Tsai (2006) pointed out that when companies have better corporate governance and are without information content, investors weigh investment risks and conduct "risk-off trades." As a result, the stock price performance before the monthly revenue announcement usually shows a significant negative correlation. The stock price falls in advance due to "risk-off trades," but the monthly revenue announcement is good.

(2) Monthly revenue growth rate is leadership (taking the lag two as an example):

$$y_{2t+1} = a_0 + b_1 y_{1t} + b_2 y_{2t} + b_3 y_{2t-1} + \varepsilon_{t+1} \quad (7)$$

Formula (7), y_{1t} is the monthly revenue announcement on the 10th of the month. y_{2t+1} is the stock return at the end of the revenue announcement month. If it contains information content, the subsequent stock return will be positive when the monthly revenue growth rate announcement is positive. However, the subsequent stock return will be negative when the monthly revenue growth rate announcement is negative.

This paper can rewrite Formula (7) into the following empirical model.

$$y_{2t} = a_0 + b_1 y_{1t-1} + b_2 y_{2t-1} + b_3 y_{2t-2} + \varepsilon_t \quad (8)$$

Results

This study selects 16 Taiwanese companies with excellent corporate governance ranked among the top 5% from the corporate governance evaluation system. They are Yulon Motor, China Motor, United Microelectronics, Taiwan Semiconductor Manufacturing, President Chain Store, Taiwan Mobile, Far EasTone, Sinyi Realty, Win Semiconductors, CTCI Advanced Systems, Vanguard International Semiconductor, Coretronic, Sino-American Silicon, Yuanta Futures, Chipmore Holding, and ECOVE Environment. The research period of this study is from January 2014 to May 2023.

We can see from the results in Tables 1 and 2 that the revenue growth rates and stock returns of 16 companies.

Both MZ_t and MP_t tests of Ng and Perron (2001) reject the null hypothesis that the time series has a unit root. So, we can use linearity in the follow-up. The linear model can explore the correlation between stock return and revenue growth rate.

Table 1. The revenue growth rate of Ng and Perron (2001) unit root test

Company	Equation	MZ_t	MP_t
Yulon Motor	Intercept	-1.906(1)*	3.373(1)*
China Motor	Intercept	-4.320(0)***	1.059(0)***
United Micro-electronics	Intercept	-4.41 (4)***	0.941(4)***
Taiwan Semiconductor Manufacturing	Intercept	-3.296(3)***	1.196(3)***
President Chain Store	Intercept	-2.802(1)***	1.640(1)***
Taiwan Mobile	Intercept	-2.878(1)***	1.483(1)***
Far EasTone	Intercept	-3.552(0)***	0.971(0)***
Sinyi Realty	Intercept	-3.656(1)***	0.956(1)***
Win Semiconductors	Intercept	-1.891(1)*	3.427(1)*
CTCI Advanced Systems	Intercept	-2.901(0)***	1.820(0)**
Vanguard International Semiconductor	Intercept	-3.776(3)***	1.484(3)***
Coretronic	Intercept	-2.353(0)**	2.529(0)**
Sino-American Silicon	Intercept	-3.319(12)***	1.160(12)***
Yuanta Futures	Intercept	-3.171(0)***	1.229(0)***
Chipmore Holding	Intercept	-2.696(0)***	1.779(0)***
ECOVE Environment	Intercept	-5.136(0)***	0.466(0)***

Notes: *, **, and *** represent significant levels of 0.1, 0.05, and 0.01, respectively; the numbers in parentheses represent the optimal number of lag periods selected by

the Schwarz info criterion; the Spectral estimation method is AR spectral-OLS

Table 2. Stock return of Ng and Perron (2001) unit root test

Company	Equation	MZ_t	MP_t
Yulon Motor	Intercept	-5.0879 (0)***	0.5341 (0)***
China Motor	Intercept	-5.1349 (0)***	0.6733 (0)***
United Micro-electronics	Intercept	-3.9049 (1)***	0.8260 (1)***
Taiwan Semiconductor Manufacturing	Intercept	-5.1397 (0)***	0.5791 (0)***
President Chain Store	Intercept	-5.1110 (0)***	0.5186 (0)***
Taiwan Mobile	Intercept	-2.4887 (0)**	2.0625 (0)**
Far EasTone	Intercept	-2.8149 (0)***	1.5693 (0)***
Sinyi Realty	Intercept	-5.0042 (0)***	0.5228 (0)***
Win Semiconductors	Intercept	-5.0662 (0)***	0.4773 (0)***
CTCI Advanced Systems	Intercept	-4.2364 (0)***	1.3257 (0)***
Vanguard International Semiconductor	Intercept	-4.8487 (0)***	0.5384 (0)***
Coretronic	Intercept	-5.0004 (0)**	0.4948 (0)**
Sino-American Silicon	Intercept	-4.7924 (0)***	0.5336 (0)***
Yuanta Futures	Intercept	-6.3463 (1)***	0.3042 (1)***
Chipmore Holding	Intercept	-5.2834 (0)***	0.4397 (0)***
ECOVE Environment	Intercept	-3.3913 (0)***	1.5083 (0)***

Notes: ** and *** represent significant levels of 0.05 and 0.01, respectively; the numbers in parentheses represent the optimal number of lag periods selected by the Schwarz info criterion; the Spectral estimation method is AR spectral-OLS

Liu and Tsai (2006) pointed out that when there is information content, those with information advantages will significantly increase or decrease their shareholdings before the monthly revenue is announced, which will cause the stock price to rise or fall in advance. That is, the stock price performance before the monthly revenue announcement period. There is a significant positive correlation with the monthly revenue announcement results. However, for companies with better corporate

governance, when the stock price does not have information content, investors will engage in “risk-off trading” to balance the investment portfolio’s risk, resulting in a significant negative correlation between the stock return and the Subsequent monthly revenue announcement results. The stock price fell early due to “risk-off trading,” but the monthly revenue announcement results were good.

From Table 3, the coefficients of stock return of Win Semiconductors and Coretronic are both significantly positive. It means that the stock return is leadership in revenue growth, and the stock price has information content. However, the stock return coefficient of Yuanta Futures is significantly negative. When the stock price does not have information content, investors conduct “risk-off transactions” to balance the portfolio risk. The results show a significant negative relationship between the stock price performance before the monthly revenue announcement and the monthly revenue announcement results. The remaining 13 companies’ stock returns have no significant leading effect on revenue growth. In addition, observing from the COVID-19 dummy variable, Taiwan Mobile has a significant positive number, while Win Semiconductors has a significant negative number. It means that the COVID-19 period positively impacted the revenue growth rate of Taiwan Mobile. However, Win Semiconductors has suffered because the bullwhip effect of increased inventory has caused the revenue growth to decline.

Table 3. Research on the leadership of stock return on revenue growth rate

Company	y Optimal Lag	Coefficient of Stock Return	COVID-19 Dummy Variable
Yulon Motor	2	0.1580	0.0079
China Motor	1	0.1556	0.0193
United Microelectronics	5	0.0534	0.0240
Taiwan Semiconductor Manufacturing	1	0.0778	0.0277
President Chain Store	2	0.0636	0.0034
Taiwan Mobile	1	-0.0607	0.0388***
Far EasTone	1	0.0985	0.0183
Sinyi Realty	2	0.3808	0.0333
Win Semiconductors	2	0.1199*	-0.0453**
CTCI Advanced Systems	1	0.1015	0.1099
Vanguard International Semiconductor	4	-0.0530	-0.0008
Coretronic	1	0.2152**	0.0261
Sino-American Silicon	1	0.0980	-0.0090
Yuanta Futures	1	-1.1578*	-0.0105
Chipmore Holding	2	0.0566	-0.0168
ECOVE Environment	0	0.6428	0.0363

Note: *, **, and *** indicate significant levels of 0.1, 0.05, and 0.01, respectively.

From Table 4, the revenue growth rate coefficients of China Motor, Sinyi Realty, Sino-American Silicon, and ECOVE Environment are all significantly positive. It means that the revenue growth rate has leadership in the stock return, which means that investors can make stock investments in the same direction according to the growth or decline of revenue. However, the coefficient of revenue growth rate of Vanguard International Semiconductor is significantly negative. It also means that the revenue growth rate is leadership in stock return. However, investors can make reverse stock investments based on revenue growth (To sell all the good news) or decline (To buy all the bad news).

The stock returns of the remaining 11 companies have no significant leadership in revenue growth. In addition, we observe from the COVID-19 dummy variable that Yulon Motor and United Microelectronics have significant positive numbers, which means that during the COVID-19 period, the stock returns of these two companies increased significantly.

Table 4. Research on the leadership of revenue growth rate in stock return

Company	y Optimal Lag	Coefficient of Stock Return	COVID-19 Dummy Variable
Yulon Motor	0	0.0207	0.0504***
China Motor	0	0.1625***	0.0205
United Microelectronics	0	-0.0861	0.0405*
Taiwan Semiconductor Manufacturing	0	-0.0496	0.0057
President Chain Store	3	0.0396	-0.0077
Taiwan Mobile	0	0.0276	-0.0050
Far EasTone	0	0.0546	0.0005
Sinyi Realty	0	0.0333***	0.0072
Win Semiconductors	0	-0.0090	-0.0480
CTCI Advanced Systems	1	0.0158	0.0156
Vanguard International Semiconductor	2	-0.0819*	0.0054
Coretronic	0	0.0876	0.0097
Sino-American Silicon	1	0.0997*	0.0114
Yuanta Futures	2	0.0047	-0.0062
Chipmore Holding	0	0.0098	0.0009
ECOVE Environment	0	0.0385**	0.0054

Note: *, **, and *** indicate significant levels of 0.1, 0.05, and 0.01, respectively.

Conclusions

This study focuses on whether there is information content between monthly stock returns and monthly revenue of companies with excellent corporate governance.

The stock return coefficients of Win Semiconductors and Coretronic are both significant positive numbers, which means that the stock return has a leadership in revenue growth rate and the stock price has information content. In addition, the revenue growth rate coefficients of China

Motor, Sinyi Realty, Sino-American Silicon, and ECOVE Environment are all significant positive numbers, which means that revenue growth rate has a leadership in stock return, that is, investors can base on revenue growth or decline to invest stocks in the same direction. It is the same conclusion as Boesso and Kumar (2007), Pinto et al. (2013), Aghion and Stein (2008), and Jegadeesh and Livnat (2006) all support that revenue has informational content.

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The Effect of Absorptive Capacity on Technology Collaboration Performance : Focusing on the Moderating Roles of Innovation Intermediaries[blank line]

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Abstract

This study aims to analyze the effect of absorptive capacity on technology collaboration performance and the moderating effect of innovation intermediaries. We set absorptive capacity (potential, realized) as independent variables and technology collaboration performance (relative technology level, development period, cost savings, new product development, collaboration satisfaction) as dependent variables, with innovation intermediaries as a moderating variable. We conducted a survey of 145 ICT companies that experienced technology collaboration and analyzed the data using 101 valid responses. The results show that potential absorptive capacity has a significant effect on new product development and collaboration satisfaction, while realized absorptive capacity has a significant effect on relative technology level, cost savings, and new product development. Furthermore, innovation intermediaries have a moderating effect between realized absorptive capacity and new product development. The contribution of this study to academia and industry is that it highlights absorptive capacity as a key factor influencing technology collaboration performance. The limitations of this study include the lack of accurate measurement of absorptive capacity and innovation intermediaries, as well as a lack of control over external factors. These limitations should be addressed through more in-depth research by systematically defining and measuring them in future follow-up studies.

Keywords

Absorptive Capacity, Technology Collaboration Performance, Innovation Intermediaries

Introduction

In the upcoming era of the Fourth Industrial Revolution, Information and Communication Technologies (ICT) such as hyper-connectivity, intelligence and reality will converge with traditional industries, leading to the creation of new societal environments, the emergence of novel industries, market disruptions, and significant changes in individual lifestyles. In the industrial sector, awareness and significance of technological collaboration are growing more than ever, aligning with the rapidly changing technological landscape.

To effectively advance such technological collaborations, the absorptive capacity of companies engaging in collaboration is crucial. Inherently, the majority of companies find it challenging to independently develop all the technologies necessary for product and service development. Consequently, there is a need for reliance

on external technologies or collaboration with external companies for joint development. From this perspective, the capability to leverage external knowledge, rather than relying solely on internally developed technologies, can be considered a core element of innovation capacity (Cohen & Levinthal, 1990). Despite the importance of technological collaboration activities, effective communication among collaborating parties faces significant constraints. To address these challenges, the role of innovation intermediaries is crucial. However, there is a lack of research on whether they can effectively influence enhancing a company's absorptive capacity (Lee & Jung, 2017).

This study examines the role of absorptive capacity and innovation intermediaries in technological collaboration outcomes. Prior research commonly used absorptive capacity as a mediating or moderating variable, but this

study views it as an inherent capability within companies. It focuses on the impact of technological collaboration with public research institutions on technological performance, emphasizing outcomes like technological level and new product development. The study also explores whether innovation intermediaries play a moderating role in technological collaboration outcomes when not directly involved. Through this study, we aim to present implications on which companies are advantageous for technology collaboration and how innovation intermediaries should encourage and stimulate the Technology Collaboration.

Theoretical Background

Absorptive Capacity

In the digital transformation environment where traditional industries integrate with IT, companies are increasingly shifting towards dependence on external technology utilization to foster continuous innovation and generate performance.

However, despite the increasing ubiquity of the adoption and utilization of external technology, many companies find themselves unable to derive benefits from external technologies (Escribano et al., 2009). To enhance technological capabilities and gain a competitive advantage by leveraging external technologies, it is essential to have absorptive capacity.

Absorptive capacity is the ability of a company to recognize the value of new external technological information, absorb it, and apply it to commercialization (Cohen & Levinthal, 1990). The source of external knowledge becomes a source of corporate innovation. This absorptive capacity is considered a key driver in securing a competitive advantage for the company (Lichtenthaler, 2009).

Preceding studies on absorptive capacity have evolved from Cohen & Levinthal's (1990) research, branching into various streams of research. In the early stages, research focused on theoretical models regarding the essence of absorptive capacity, antecedents, and outcomes. However, empirical studies on these models were not as actively conducted (Lane et al., 2006).

Subsequent research has employed both quantitative and qualitative approaches to measure absorptive capacity (Konstantinos et al., 2011). Some researchers have used indicators such as R&D expenditure and R&D intensity (R&D expenditure/revenue) (Cohen & Levinthal, 1990; Tsai, 2001), science and technology-related educational expenses (Mowery & Oxley, 1995), the presence of in-house R&D departments (Cassiman & Veugelers, 2002), the number of graduates from universities (Grimpe & Sofka, 2009), and the ratio of R&D personnel to total employees (Spanos & Voudouris, 2009) as variables to measure absorptive capacity.

Zahra and George (2002) proposed a theoretical

framework, distinct from previous research, for structuring, measuring, and validating absorptive capacity. In their study, absorptive capacity was conceptualized as a series of four detailed capabilities based on the processes of acquiring, assimilating, transforming, and exploiting knowledge obtained through exploration. These capabilities were argued to be sequential and cumulative in nature, consisting of knowledge acquisition, assimilation, transformation, and exploitation.

Furthermore, Zahra and George (2002) categorized absorptive capacity into two factors: Potential Absorptive Capacity, and Realized Absorptive Capacity, based on the four components of absorptive capacity. Potential Absorptive Capacity was further divided into Acquisition and Assimilation, while Realized Absorptive Capacity was divided into Transformation and Application. Subsequently, Cesar & Beatriz (2010) conducted empirical research to validate both Potential and Realized Absorptive Capacities.

Table 1 – Components of Absorptive Capacity

Components		Authors
Potential Absorptive Capacity	Acquisition	Zahra and George(2002)
	Assimilation	
Realized Absorptive Capacity	Transformation	Cesar & Beatriz(2010)
	Application	

Jansen et al. (2005) expanded the scope of absorptive capacity by utilizing the concepts of potential and realized absorptive capacities, conducting research on coordination capability and socialization capability. Lane et al. (2006) conducted a comprehensive review of past research on absorptive capacity, proposing three related processes of absorptive capacity explained by the identification of knowledge, assimilation and transformation of knowledge, and application of knowledge.

Lane et al. (2001) argued for the importance of capabilities in understanding external knowledge, assimilating external knowledge, and applying external knowledge for the successful operation of International Joint Ventures (IJVs) with different languages, cultures, and competencies, through research on the technological absorptive capacity, learning, and performance necessary for the success of IJVs.

Lichtenthaler, U., & E. Lichtenthaler (2009) attempted to connect absorptive capacity and open innovation by proposing a framework for the open innovation process. They complemented the concept of absorptive capacity by merging research on knowledge management, absorptive capacity, and dynamic capabilities, considering internal and external knowledge exploration, possession, and utilization within companies.

Konstantinos et al. (2011) derived research results indicating a direct relationship between the inflow

of external knowledge and absorptive capacity, and demonstrated that absorptive capacity directly influences innovation and financial performance.

Technology Collaboration Performance

ICT companies, engaged in business based on technology, need to rapidly and efficiently acquire knowledge and technology in various fields compared to other companies in the fiercely competitive environment to secure technological competitiveness. At times, they also engage in benchmarking and integrate acquired knowledge and technology in a manner suitable for their internal capabilities. However, since it is not practically easy for individual companies to possess diverse technologies in various fields to maintain technological competitiveness, various forms of technological collaboration have been increasingly employed as a strategic means to overcome such limitations (Kim, 2005).

Technology collaboration can be considered a form of strategic technological alliance, wherein participating companies form collaborative relationships between or among organizations through activities such as joint research and development and technology transfer with the aim of strengthening their product-market positions (Hagedoorn & Schakernraad, 1994). Inter-firm technological collaboration provides advantages such as sharing technical resources, exchanging technological information, improving investment efficiency, and enhancing the effectiveness of product development timelines. These factors positively impact competitive advantages (Park, 2016).

Due to differences in the level and scope of technology held by companies, as well as variations in methods or know-how for technology development, technological collaboration can take various forms. Furthermore, companies pursuing technological collaboration require mutual trust for successful outcomes in technological collaboration (Barnir& Smith, 2002). Research on technological collaboration outcomes can be broadly categorized into two streams. One stream focuses on the acquisition of technological knowledge from the collaborative partner, while the other stream concentrates on the results of a company's new product development (Hans, 2016).

Table 2 – Prior research on Technology Collaboration

Authors	Description
Belderboset al (2018)	Companies that work together with universities and research institutions in R&D are more likely to continue collaborating with industry partners.
Stephanie & Patrick(2003)	Imitative firms gain from adopting existing technologies, while radical innovators find greater collaboration effects in joint research with universities.

Xuemei et at (2023)	R&D collaboration has a reverse U-shaped impact on new product innovation, and absorptive capacity moderates this effect
Hans (2016)	Knowledge acquired through technological collaboration positively influences the number of new product developments
Kim (2013)	Technological collaboration with external partner positively impact technological innovation outcomes, with absorptive capacity exhibiting a moderating effect.
Hwang (2014)	Technological collaboration with customers and affiliates has a positive impact on product innovation
Hwang &Seong (2018)	Technological collaboration between companies and research institute has a positive impact on technological outcomes, but not on economic outcomes.
Park (2016)	Companies with a higher level of technological collaboration demonstrate higher managerial performance

Another outcome of technological collaboration is Collaboration satisfaction. When collaboration is perceived as successful, the collaborating parties feel satisfied, establishing a mutual customer relationship. Regarding the measurement of customer satisfaction, Giese and Cote (2000) suggested that by studying and understanding various types of customers and contexts, satisfaction scales can be customized.

Oliver (1980)'s Expectation Confirmation Theory (ECT) is widely utilized in consumer behavior literature to study consumer satisfaction, post-purchase behavior (e.g., repurchase, dissatisfaction), and general service marketing related to customer satisfaction.

Locke (1976) defined satisfaction in the context of performance as "a pleasurable or positive emotional state resulting from the appraisal of one's job." Later, Oliver (1981) expanded this definition in the consumer context as "a summary psychological state that occurs when emotions surrounding unconfirmed expectations become combined with prior emotions about the consumer experience." Both definitions emphasize cognitive assessments of expectation-performance discrepancies, resulting in psychological or emotional states. Higher performance than low expectations leads to increased confidence, ultimately positively influencing customer satisfaction and intention to continue. Conversely, dissatisfaction and intent to discontinue arise if expectations are not met.

Bhattacharjee (2001) proposed the Post-Acceptance Model (PAM) based on the Expectation Confirmation Theory (ECT) and the Technology Acceptance Model (TAM). In the Post-Acceptance Model, perceived usefulness directly influences the intention to continue using, and indirectly affects the intention to continue use through user satisfaction. Bhattacharjee also argued that

expectation confirmation influences perceived usefulness and satisfaction.

Table 3 – Post Acceptance Model(Bhattacharjee, 2001)

Components	Description
Continuance Intention	User's intention to continue service usage
Satisfaction	Overall satisfaction derived from service usage
Perceived Usefulness	User perception of the effects and contributions of service usage
Confirmation	User satisfaction with the alignment between expectations and actual performance

Innovation Intermediaries

Innovation Intermediaries is a specialized organization or individual that facilitates business, contracts, programs, etc., necessary for technology innovation and successful technology commercialization within or between specific organizations. Innovation intermediaries play a crucial role in the innovation ecosystem, contributing significantly to various disciplines and industries such as technological innovation, technology commercialization, knowledge management, and open innovation.

In the context of innovation intermediaries, numerous prior studies have been conducted; however, there is no consensus on distinguishing roles and functions. The roles often overlap, leading to occasional confusion (Lee & Jung, 2018). Howells (2006) defined innovation intermediaries as "organizations or institutions acting as agents or brokers in the innovation process between two or more parties." Dalziel (2010) expanded on Howells' definition, characterizing innovation intermediaries as organizations or groups within organizations that directly enable innovation in one or more companies and indirectly enhance the innovation capabilities of industries, regions, or nations based on organizational goals.

Innovation intermediaries need to share knowledge based on their expertise. To achieve this, they must possess in-depth expertise in specific industries or technological fields. They provide valuable knowledge on new technologies, market trends, legal aspects, and more, assisting companies in addressing challenges that may arise during the pursuit of innovation (Bakici et al., 2013). Howells (2006) was the first to categorize various roles and functions performed by innovation intermediaries in the technological innovation process. These include prediction and diagnosis, information search and analysis, knowledge processing, creation and recombination, technology selection, mediation and negotiation, technological assessment, testing and validation of technology, technological standard certification, technology-related regulations, intellectual property rights, and licensing protection. Subsequent research by

Lopez-Vega (2009) classified the roles and functions of innovation intermediaries into three categories: facilitating collaboration, connecting actors involved in innovation, and providing services for stakeholders.

Table 4 – Role of Innovation Intermediaries(Howells, 2006)

Role	Function
facilitating collaboration	Prediction and diagnosis
	Information search and analysis
	Knowledge processing, creation, and recombination
	Business development
connecting actors	Selection, technology mediation, and negotiation
	Technological assessment
providing services for stakeholders	Testing and validation
	Standard certification
	Verification and regulation
	Intellectual property rights and performance protection

Various studies have been conducted in diverse fields related to innovation intermediaries, primarily focusing on the role of innovation intermediaries in facilitating collaboration and improving a firm's performance through external partnerships. Notably, research has delved into the mediating role of innovation intermediaries. Leal et al. (2014) analyzed the mediating role of potential absorptive capacity and realized absorptive capacity, as proposed by Zahra & George (2002), on the impact of individual innovation performance. Lau & Lo (2015) explored the effects of regional innovation institutions, knowledge management services, and value chain networks on a firm's technological absorptive capacity and innovation performance from a regional innovation perspective. Lin et al. (2016) examined the relationship between innovation intermediaries and firm innovation performance, verifying the mediating effects of absorptive capacity. They found that higher absorptive capacity expands the scope of external technological exploration and simultaneously reduces the costs associated with exploration, influencing a firm's absorptive capacity and innovation. Liu et al. (2013) analyzed the mediating effects of absorptive capacity and supply chain agility on the relationship between a firm's information technology level and its performance. Shou et al. (2013) studied the impact of innovation intermediaries on the innovation process of small and medium-sized enterprises (SMEs), revealing that innovation intermediaries and resource- and information-based collaboration affect performance through absorptive capacity. Gassmann et al. (2011) highlighted the role of innovation intermediaries in industrial convergence and process innovation. Ferreras et al. (2015) investigated performance differences based

on the depth and breadth of external technological exploration and identified the mediating effect of technological absorptive capacity in this process. In prior research, the predominant focus has been on utilizing innovation intermediaries as independent or mediating variables. However, considering that many companies successfully engage in technological collaborations even without innovation intermediaries, there is a need to view innovation intermediaries as moderating variables. Research should be conducted to verify which counterpart or context exhibits a more significant moderating effect when innovation intermediaries are absent.

Research Model and Hypotheses

In this study, we established the following research model through a literature review of prior studies. The independent variable is technology absorptive capacity, which consists of two sub-factors: potential absorptive capacity and realized absorptive capacity. The dependent variable is technology collaboration performance, composed of five sub-factors: relative technological level, development period, cost saving, new product development, and collaboration satisfaction. Additionally, to examine the moderating effect of innovation intermediaries between technology absorptive capacity and technology collaboration performance, we utilize innovation intermediaries as a moderating variable.

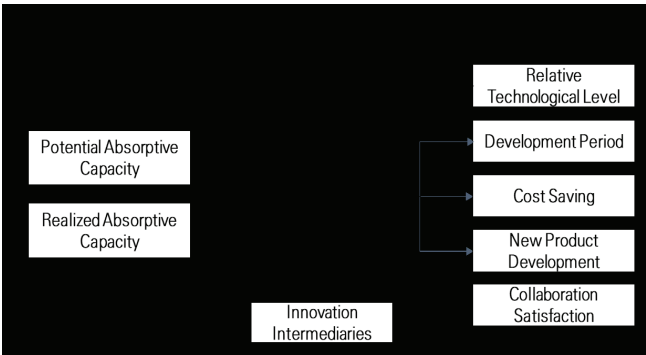


Figure 1 – Research Model

The relationship between absorptive capacity and technology collaboration performance

- H1-1: Potential absorptive capacity will have a positive and significant impact on relative technological level.
- H1-2: Potential absorptive capacity will have a positive and significant impact on development period.
- H1-3: Potential absorptive capacity will have a positive and significant impact on cost saving.
- H1-4: Potential absorptive capacity will have a positive and significant impact on new product development.
- H1-5: Potential absorptive capacity will have a positive and significant impact on collaboration satisfaction.

- H2-1: Realized absorptive capacity will have a positive and significant impact on relative technological level.
- H2-2: Realized absorptive capacity will have a positive and significant impact on development period.
- H2-3: Realized absorptive capacity will have a positive and significant impact on cost saving.
- H2-4: Realized absorptive capacity will have a positive and significant impact on new product development.
- H2-5: Realized absorptive capacity will have a positive and significant impact on collaboration satisfaction.

The relationship between absorptive capacity and technology collaboration performance

- H3-1: Innovation intermediaries will have a moderating effect between potential absorptive capacity and relative technological level.
- H3-2: Innovation intermediaries will have a moderating effect between potential absorptive capacity and development period.
- H3-3: Innovation intermediaries will have a moderating effect between potential absorptive capacity and cost saving.
- H3-4: Innovation intermediaries will have a moderating effect between potential absorptive capacity and new product development.
- H3-5: Innovation intermediaries will have a moderating effect between potential absorptive capacity and collaboration satisfaction.
- H4-1: Innovation intermediaries will have a moderating effect between realized absorptive capacity and relative technological level.
- H4-2: Innovation intermediaries will have a moderating effect between realized absorptive capacity and development period.
- H4-3: Innovation intermediaries will have a moderating effect between realized absorptive capacity and cost saving.
- H4-4: Innovation intermediaries will have a moderating effect between realized absorptive capacity and new product development.
- H4-5: Innovation intermediaries will have a moderating effect between realized absorptive capacity and collaboration satisfaction.

Operational definition and Measurement of variables

In this study, two independent variables, five dependent variables and one moderating variable were established based on previous research. The operational definitions and measurement of the variables are as follows

Table 5 – Operational definition of Independent Variables

Table 6 – Operational definition of Dependent Variables

Table 7 – Operational definition of Moderating Variable

Variables	Operational Definition	Measurement
Relative Technological Level	Technological level compared to the highest technology country due to technological cooperation	Technological level after technical cooperation compared to the highest technology country (%)
Development Period	Shortened technology development period through technological cooperation	Shortening effect compared to expected development period (%)
New Product Development	Contribution to new product development through technological cooperation	Contribution to new product development (%)
Cost Saving	Technology/product development costs reduced through technological cooperation	Savings effect compared to expected cost (%)
Collaboration Satisfaction	<u>- Overall satisfaction</u> <u>- Contribution</u> <u>- Sufficiency</u> <u>- Continuous use</u> <u>- Recommendation</u>	L i k e r t Scale(1-5)
Variables	Operational Definition	
Innovation Intermediaries	Support technology collaboration between suppliers and consumers (coordinating)	

Variables	Operational Definition	Measurement
Potential Absorptive Capacity	<u>- Know competitors' technologies</u> <u>- Catch external environment change</u> <u>- Collaborate with external partners</u> <u>- Internal technology development</u> <u>- Utilizing internal resources</u> <u>- Benchmarking in the same industry</u> <u>- External technology diffusion</u>	Likert Scale (1-5)
Realized Absorptive Capacity	<u>- Have knowledge delivery system</u> <u>- Can replace existing technology</u> <u>- Can apply external technologies</u> <u>- Share information among employees</u> <u>- Can utilize experience to product</u> <u>- Can create Intellectual property</u> <u>- Can expand new product portfolio</u>	Likert Scale (1-5)

Methods and Data Collection

In this study, data were collected through a survey targeting 145 ICT companies in Korea that transferred technologies from government-funded research institutions. The survey was conducted from October 4 to 20, 2023, using methods such as email and postal distribution, and a total of 105 surveys were collected (response rate of 72.4%). For accuracy and reliability in empirical analysis, 4 surveys that were deemed insincere or not properly filled out were excluded from the analysis, leaving a total of 101 valid datasets.

The collected data were statistically analyzed using SPSS 29. The analysis started with frequency analysis, followed by the analysis of the validity and reliability of variables related to independent variables (potential absorptive capacity, realized absorptive capacity) and the dependent variable (collaboration satisfaction). Subsequently, correlation analysis among independent variables, dependent variables, and moderating variables was conducted. After completing the verification of variables, multivariate analysis of variance (MANOVA) was conducted for 2 independent variables and 5 dependent variables (relative technological level, development period, cost saving, new product development, collaboration satisfaction). Multiple regression analysis was then performed to elucidate the causal relationships between independent and dependent variables. Finally, the analysis was concluded by verifying the moderating effect of the innovation intermediaries.

Results

Validity and Reliability Analysis

In this study, prior to hypothesis testing for the variables in the research model, a factor analysis was conducted to enhance the substantive validity of the research findings and evaluate the validity of survey items for each variable. The analysis method involved using principal component analysis, and Varimax was employed to maintain independence among the factors.

A factor analysis was conducted on the detailed measurement items of the independent variable, absorptive capacity (ACAP1-16), and the dependent variable, collaboration satisfaction (CSAT1-5), resulting in three groups. Factor 1 was extracted with a total of 8 items (ACAP11, 9, 16, 13, 10, 15, 14, 12), showing an eigenvalue of 5.485, and it was named 'Realized Absorptive Capacity'. Factor 2 was extracted with a total of 8 items (ACAP5, 6, 2, 7, 1, 8, 3, 4), showing an eigenvalue of 4.994, and it was named 'Latent Absorptive Capacity'. Factor 3 was extracted with a total of 5 items (CSAT2, 1, 3, 5, 4), showing an eigenvalue of 4.431, and it was named 'Collaboration Satisfaction'.

Next, a reliability analysis was conducted for the three variables derived through Factor Analysis. The reliability of Potential Absorptive Capacity was .906, Realized Absorptive Capacity was .933, and Collaboration

Satisfaction was .965. All variables demonstrated a high reliability with values exceeding 0.7. As there were no items undermining the reliability of any of the three factors, all factors will be utilized in the analysis.

Table 8 – Results of Validity and Reliability

Item	Factor 1	Factor 2	Factor 3	Cronbach's Alpha
ACAP11	.894	.091	-.096	Realized Absorptive Capacity .933
ACAP9	.856	-.014	-.037	
ACAP16	.826	.198	.059	
ACAP13	.808	.316	-.018	
ACAP10	.803	.162	-.040	
ACAP15	.799	.108	.035	
ACAP14	.762	.152	.094	
ACAP12	.746	.186	.014	
ACAP5	.088	.856	.061	Potential Absorptive Capacity .906
ACAP6	.190	.782	.143	
ACAP2	.195	.759	.178	
ACAP7	.230	.753	.065	
ACAP1	.154	.734	.183	
ACAP8	.148	.724	.137	
ACAP3	.088	.708	.270	
ACAP4	.065	.689	.213	
CSAT2	.040	.191	.928	Collaboration Satisfaction .965
CSAT1	-.002	.186	.925	
CSAT3	.008	.271	.924	
CSAT5	-.062	.129	.905	
CSAT4	.002	.250	.886	

Correlation analysis

To verify the correlation of the relationships between the scales, correlation analysis was conducted. The analysis results showed significant relationships among the variables overall, except for a relatively lower correlation between realized absorptive capacity and collaboration satisfaction, as well as between relative technological level and collaboration satisfaction. This indicates that the validity of the variables used in this study has been confirmed for their application.

Variable	1	2	3	4	5	6	7
PACAP	1						
RACAP	.355**	1					
TECH	.261**	.378**	1				
DEVEL	.230*	.211*	.248*	1			
COST	.254*	.358**	.219*	.517**	1		
NPD	.362**	.526**	.275**	.433**	.746**	1	
CSAT	.404**	.037	.105	.315**	.328**	.225*	1

Table 9 – Results of Correlation analysis

Multivariate Analysis of Variance (MANOVA)

To understand the impact of absorptive capacity on technology collaboration performance, this study conducted Multivariate Analysis of Variance (MANOVA). In the study, before conducting Multivariate Analysis of Variance (MANOVA), the assumption of homogeneity of covariance matrix for covariates is checked. The sample sizes for the intervals of the independent variables, latent absorptive capacity, and realized absorptive capacity, are different. As each variable is composed of the average values of 8 sub-factors, for the convenience of the study, the decimal points of each independent variable are truncated to form 5 groups with scores ranging from 1 to 5. As a result, latent absorptive capacity is classified into 4 groups (2, 3, 4, 5), and realized absorptive capacity is classified into 5 groups (1, 2, 3, 4, 5). Next, since the correlation between dependent variables should be similar in all groups, Box's test of homogeneity of covariance was employed. The homogeneity of covariance test results for dependent variables showed that Box's M was 66.915, the F-value was 1.298, and the significance level was greater than 0.05. Therefore, it indicates that there is a similarity in the correlation between dependent variables across all groups.

Results of Box's Test for Homogeneity of Covariance Matrices

Table 10 - Results of Box's Test for Homogeneity of covariance Matrices

Box's M	F	df1	df2	p
66.915	1.298	45	10091.610	0.87

Then, a Levene test for the equality of error variances was conducted. The results of the homogeneity test for error variance for each of the five dependent variables (Relative Technological Level, Development Period, Cost Savings, New Product Development, Collaboration Satisfaction) showed that the p-values for Relative Technological Level (.219), Development Period (.123), and Cost Savings (.339) are greater than 0.05. However, New Product Development (.046) and Collaboration Satisfaction (.046) yielded very small p-values less than 0.05, indicating that these samples can be considered as drawn from the same population.

Table 11 - Levene's test for the equality of error variance

Dependent Variables	F	df1	df2	p
Relative Technological Level	1.374	8	87	.219
Development Period	1.649	8	87	.123
Cost Saving	1.149	8	87	.339
New Product Development	2.080	8	87	.046
Collaboration Satisfaction	2.078	8	87	.046

Next, to examine the overall significance of the relationships between two independent variables (potential absorptive capacity with four groups and realized absorptive capacity with five groups) and five dependent variables (relative technological level, development period, cost saving, new product development, collaboration satisfaction), multivariate tests were conducted. Three different test methods, including Pillai's trace, Wilks' lambda, and Hotelling's trace, were employed for the multivariate tests. The MANOVA significance test results revealed that both potential absorptive capacity (Pillai's trace = 0.367, $F(15, 255) = 2.371$, $p = 0.003$ / Wilks' lambda = 0.646, $F(15, 229.528) = 2.628$, $p = 0.001$ / Hotelling's trace = 0.529, $F(5, 245) = 2.881$, $p = 0.001$) and realized absorptive capacity (Pillai's trace = 0.441, $F(20, 344) = 2.131$, $p = 0.004$ / Wilks' lambda = 0.612, $F(20, 276.230) = 2.202$, $p = 0.003$ / Hotelling's trace = 0.550, $F(20, 326) = 2.241$, $p = 0.002$) significantly influenced the dependent variables. Finally, the interaction between the two independent variables (potential absorptive capacity * realized absorptive capacity) also had a significant impact on the dependent variables (Pillai's trace = 0.541, $F(30, 435) = 1.761$, $p = 0.009$ / Wilks' lambda = 0.543, $F(30, 334) = 1.883$, $p = 0.006$ / Hotelling's trace = 0.693, $F(30, 407) = 1.879$, $p = 0.004$).

Table 12—Results of Multivariate analysis

Methods	value	F	df1	df2	p
Potential absorptive capacity					
Pillai's trace	.367	2.371	15	255	.003
Wilks' lambda	.646	2.628	15	230	.001
Hotelling's trace	.529	2.881	5	245	.001
Realized absorptive capacity					
Pillai's trace	.441	2.131	20	344	.004
Wilks' lambda	.612	2.202	20	276	.003
Hotelling's trace	.550	2.241	20	326	.002
Potential * Realized absorptive capacity					
Pillai's trace	.541	1.761	30	435	.009
Wilks' lambda	.543	1.883	30	334	.006
Hotelling's trace	.693	1.879	30	407	.004

Finally, the effects of independent variables (Potential Absorptive Capacity and Realized Absorptive Capacity) on inter-unit effects (main effects and interaction effects) were tested. For 'Potential Absorptive Capacity,' statistically significant main effects were observed in Relative Technology Level ($F=5.478$, $p=0.002$), Development Period ($F=2.999$, $p=0.035$), and Collaboration Satisfaction ($F=7.647$, $p=0.001$), while no significant effects were found in Cost Saving ($F=0.973$, $p=0.410$) and New Product Development ($F=1.802$, $p=0.153$). For 'Realized Absorptive Capacity,' statistically significant main effects were observed in Relative

Technology Level ($F=6.107$, $p=0.001$) and Collaboration Satisfaction ($F=3.379$, $p=0.013$), while no significant effects were found in Development Period ($F=0.719$, $p=0.581$), Cost Saving ($F=1.294$, $p=0.279$), and New Product Development ($F=1.035$, $p=0.394$).

The interaction effect of 'Potential Absorptive Capacity * Realized Absorptive Capacity' showed statistically significant interaction effects only in Relative Technology Level ($F=5.280$, $p=0.001$). There were no significant effects in Development Period ($F=1.284$, $p=0.273$), Cost Saving ($F=1.367$, $p=0.237$), New Product Development ($F=0.989$, $p=0.438$), and Collaboration Satisfaction ($F=2.132$, $p=0.058$).

Table 13 - Main Effects of Technology Collaboration Performance by Independent Variables

Independent variables	Dependent Variables	F	p	η^2
Potential Absorptive Capacity	Relative Technology Level	5.478	.002**	.159
	Development Period	2.999	.035*	.094
	Cost Saving	.973	.410	.032
	New Product Development	1.802	.153	.059
	Collaboration Satisfaction	7.647	.001***	.209
Realized Absorptive Capacity	Relative Technology Level	6.107	.001***	.219
	Development Period	.719	.581	.032
	Cost Saving	1.294	.279	.056
	New Product Development	1.035	.394	.045
	Collaboration Satisfaction	3.379	.013*	.134
Potential x Realized Absorptive Capacity	Relative Technology Level	5.280	.001***	.267
	Development Period	1.284	.273	.081
	Cost Saving	1.367	.237	.086
	New Product Development	.089	.438	.064
	Collaboration Satisfaction	2.132	.058	.128

* $p < .05$, ** $p < .01$, *** $p < .001$

Multiple Regression Analysis

To verify the hypotheses of this study, a multiple regression analysis was conducted to examine the impact of absorptive capacity (potential absorptive capacity, realized absorptive capacity) on technology collaboration performance (relative technological level, development period, cost saving, new product development, collaboration satisfaction). The R^2 values representing the explanatory power of the models ranged from .072 to

.312, indicating an explanatory power of 7.2% to 31.2%. The Durbin-Watson values ranged from 1.383 to 2.066, and as these values are close to 2 and not close to 0 or 4, it can be interpreted that there is no correlation among the residuals, making the regression model appropriate. The F-values ranged from 3.795 to 22.258, and the significance level was .001 to .026 ($p < .05$), indicating that the regression line model is suitable.

Table 14 – Results of Multiple Regression analysis

Dependent variables	Independent Variables	t	p	ϵ
Relative Technological Level	Constant	6.098	.001**	-
	Potential Absorptive Capacity	1.472	.144*	.874
	Realized Absorptive Capacity	3.295	.001***	.874
	R=.402, R ² =.161, Adjusted R ² =.144, F=9.423, p=.001, Durbin-Watson=1.752			
Development Period	Constant	.370	.713	-
	Potential Absorptive Capacity	1.669	.092	.874
	Realized Absorptive Capacity	1.424	.158	.874
	R=.268, R ² =.072, Adjusted R ² =.053, F=3.795, p=.026, Durbin-Watson=1.383			
Cost Saving	Constant	-2.157	.033*	-
	Potential Absorptive Capacity	1.452	.150	.874
	Realized Absorptive Capacity	3.067	.003**	.874
	R=.382, R ² =.146, Adjusted R ² =.129, F=8.396, p=.001, Durbin-Watson=1.754			
New Product Development	Constant	-3.476	.001***	-
	Potential Absorptive Capacity	2.241	.027*	.874
	Realized Absorptive Capacity	5.079	.001***	.874
	R=.559, R ² =.312, Adjusted R ² =.298, F=22.258, p=.001, Durbin-Watson=1.594			
Collaboration Satisfaction	Constant	4.673	.001***	-
	Potential Absorptive Capacity	4.555	.001***	.874
	Realized Absorptive Capacity	-1.235	.220	.874
	R=.419, R ² =.176, Adjusted R ² =.159, F=10.459, p=.001, Durbin-Watson=2.066			

* $p < .05$, ** $p < .01$, *** $p < .001$

Results for the impact on Relative Technological Level are as follows: the t-value for potential absorptive capacity is 1.472, with a significance level of .144, resulting in the rejection of hypothesis [H1-1]. On the other hand, the t-value for realized absorptive capacity is 3.295, with a significance level of .001, leading to the acceptance of hypothesis [H2-1]. The tolerance limits for collinearity statistics are all 0.874, indicating no issues with multicollinearity.

Results for the impact on Development Period are as follows: for potential absorptive capacity, the t-value is 1.699, with a significance level of .092, resulting in the rejection of hypothesis [H1-2]. Similarly, for realized absorptive capacity, the t-value is 1.424, with a significance level of .158, leading to the rejection of hypothesis [H2-2]. The tolerance limits for collinearity statistics are all 0.874, indicating no issues with multicollinearity.

Results for the impact on Cost Saving are as follows: regarding potential absorptive capacity, the t-value is 1.452, with a significance level of .150, resulting in the rejection of hypothesis [H1-3]. However, for realized absorptive capacity, the t-value is 3.067, with a significance level of .003, leading to the acceptance of hypothesis [H2-3]. The tolerance limits for collinearity statistics are all 0.874, indicating no issues with multicollinearity.

Results for the impact on New Product Development are as follows: the t-value for potential absorptive capacity is 2.241, with a significance level of .027, resulting in the acceptance of hypothesis [H1-4]. Additionally, for realized absorptive capacity, the t-value is 5.079, with a significance level of .001, leading to the acceptance of hypothesis [H2-4]. The tolerance limits for collinearity statistics are all 0.874, indicating no issues with multicollinearity.

Results for the impact on Collaboration Satisfaction are as follows: for potential absorptive capacity, the t-value is 4.555, with a significance level of .001, resulting in the acceptance of hypothesis [H1-1]. Conversely, for realized absorptive capacity, the t-value is -1.235, with a significance level of .220, leading to the rejection of hypothesis [H1-3]. The tolerance limits for collinearity statistics are all 0.874, indicating no issues with multicollinearity.

Moderating Effect Analysis

To verify the hypotheses of this study, moderating effect analysis was conducted to examine the impact of Innovation Intermediaries's moderating effect between absorptive capacity and technology collaboration performance.

In examining the moderating effects of innovation intermediaries on the relationship between absorptive capacity and relative technological level, the results indicated that the p-values for Potential ACAP moderation (potential absorptive capacity x innovation intermediaries) and Realized ACAP moderation (realized absorptive capacity x innovation intermediaries) were both 0.469 and 0.503, respectively, leading to the rejection of hypotheses [H3-1] and [H4-1].

Similarly, when investigating the relationship between absorptive capacity and development period with the moderating effects of innovation intermediaries, the p-values for Potential ACAP moderation and Realized ACAP moderation were both 0.662 and 0.885, respectively,

resulting in the rejection of hypotheses [H3-2] and [H4-2].

Furthermore, in exploring the impact of absorptive capacity on cost reduction with the moderating effects of innovation intermediaries, the p-values for Potential ACAP moderation and Realized ACAP moderation were both 0.538 and 0.152, respectively, leading to the rejection of hypotheses [H3-3] and [H4-3].

In the context of the relationship between absorptive capacity and new product development with the moderating effects of innovation intermediaries, the p-value for Potential ACAP moderation was 0.374, leading to the rejection of hypothesis [H3-4], while the p-value for Realized ACAP moderation was 0.001, resulting in the acceptance of hypothesis [H4-4].

Lastly, when investigating the impact of absorptive capacity on collaboration satisfaction with the moderating effects of innovation intermediaries, the p-values for Potential ACAP moderation and Realized ACAP moderation were both 0.538 and 0.152, respectively, leading to the rejection of hypotheses [H3-5] and [H4-5].

Table 15 – Results of Moderating Effect analysis

Dependent variables	Independent Variables	t	p	ε
Relative Technological Level	Constant	69.905	.001**	-
	Innovation Intermediaries	1.268	.208	.782
	Potential ACAP Moderation	.727	.469	.428
	Realized ACAP Moderation	-.672	.503	.430
Development Period	Constant	19.081	.001***	-
	Innovation Intermediaries	6.305	.001***	.782
	Potential ACAP Moderation	-.438	.662	.428
	Realized ACAP Moderation	-.145	.885	.430
Cost Saving	Constant	18.104	.001***	-
	Innovation Intermediaries	11.843	.001***	.782
	Potential ACAP Moderation	-.618	.538	.428
	Realized ACAP Moderation	1.445	.152	.430
New Product Development	Constant	28.472	.001***	-
	Innovation Intermediaries	11.188	.001***	.782
	Potential ACAP Moderation	-.893	.374	.428
	Realized ACAP Moderation	3.520	.001***	.430

Collaboration Satisfaction	Constant	52.396	.001***	-
	Innovation Intermediaries	1.904	.060	.782
	Potential ACAP Moderation	-.782	.436	.428
	Realized ACAP Moderation	1.450	.150	.430

*p<.05, **p<.01, ***p<.001

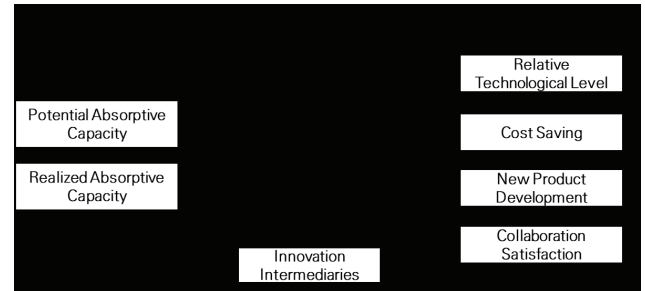


Figure 2 – Research Results

Conclusion

The conclusion and implications of this study are as follows. First, The higher the Absorptive Capacity of small and medium-sized enterprises (SMEs) in the ICT sector, the greater the success in new product development. New products achieve high levels of completeness when every stage, from the exploration and learning of technology to its utilization and transformation, is appropriately harmonized. Therefore, both potential absorptive capacity and realized absorptive capacity exert influence on the development of new products.

Second, Companies with high potential absorptive capacity tend to exhibit high satisfaction with technological collaboration. Companies with high Potential Absorptive Capacity typically excel in exploring and learning early-stage technologies. These companies, facing challenges in developing proprietary technologies on their own, find satisfaction in technological collaboration as it allows them to absorb technology at the initial stages through collaborative efforts.

Third, The higher the Realized Absorptive Capacity, the greater the Technological level, Cost savings, and success in new product development. And Forth, Companies with higher Realized Absorptive Capacity, when engaged in more innovation intermediaries activities, yield even greater success in new product development. Therefore, departments performing the role of innovation intermediaries should focus their efforts on identifying companies with high Realized Absorptive Capacity. By mediating technological collaborations with these companies, they can strive to generate productization outcomes with minimal resources and maximum impact. The limitations of this study include the difficulty in structurally measuring the absorptive capacity of ICT small and medium-sized enterprises (SMEs). Additionally, there are constraints in controlling external factors that may influence the outcomes of technological

collaboration. Lastly, the verification of the moderating effect was based on the presence or absence of innovation intermediaries activities (dummy measurement), highlighting the need for a more detailed measurement of innovation intermediation. These aspects should be addressed and improved in future research endeavors.

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Financial literacy: A bibliometric study, review, and direction for future research

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Abstract

In the present scenario, the role of financial literacy is increasing day by day and it is essential for individual well-being. Financial literacy builds confidence in people for saving, investment, and retirement planning. This study aims to analyze, summarize, and identify the extent of research on financial literacy and to reveal the study trends, growth, and evolution. The study comprises a review of 131 articles – published in peer-reviewed journals from 2013 to 2023. These data are taken from the Scopus database. The most prominent journals, authors, countries, themes, and articles have been identified using bibliometric analysis. In this paper citation analysis, citation network, page-rank analysis, and co-citation analysis have been employed to identify work and gaps. This bibliometric study will provide determinants, a model, a training and awareness program, and the most recognized theory in this domain. This study will help researchers, policymakers, and regulators to know the current status of financial literacy and identify the relevant areas that need investigation.

Keywords

Financial literacy, financial attitude, financial knowledge, and financial behaviour

Introduction

Today world economies are volatile and no one can predict how economies are run for a long time. In an increasingly globalized and risky marketplace people must be able to the knowledge of financial concepts and tools. Financial literacy has gained importance in recent years and is a major issue around the world. Financial literacy is defined as the “knowledge and understanding of financial concepts and skills, confidence and motivation to spread on such knowledge and understanding to make an effective decision and to enable participation in economic life”. (Atkinson & Messy, 2012). (Lusardi & Mitchell, 2006) define financial literacy as a concept of applying basic financial knowledge and capability to do simple calculations. (Goyal & Kumar, 2021) says that financial literacy and financial capability both are different. People can be financially literate when they have the knowledge, understanding, and skills to manage their finances, but they cannot be called financially competent unless that is reflected in their actual behavior. Financial literacy is a broad concept and the related research turns around analyzing results of financial literacy, factors affecting financial literacy, and the impact of financial

behavior and financial education on financial literacy. After studying various literature reviews and found that in 1787, Sir John Adams, the founding father of financial literacy in the United States known for the significance of financial literacy.(Lusardi & Mitchell, 2014) developed a Life cycle model that suggests that people who are financially literate perform better than those who don't have.(Beal & Delpachitra, 2003) found in their study and said that financial literacy improved with income and work experience and their lack of financial skills will tend to impact negatively on their future lives. Financial information is more operative when it is modified to the needs of specific groups. (Clark, 2023).

Literature review

It can be seen that now financial literacy is a broad aspect and recognized as an important factor for economic growth. There are vast works of literature on financial literacy. (Amagir et al., 2019)designed a “save wise” program for high school students in Nigeria and found that these programs improved the financial knowledge and awareness of students and their programs were helpful regarding spending decisions, purchasing, and savings.

(Rai et al., 2019) found three important factors to examine financial literacy that is – financial knowledge, financial attitude, and financial behavior, and also found that women have less knowledge. In concert findings of (Beal & Delpachitra, 2003) in Australia, students in Australia are risk averse and less knowledgeable and found that financial literacy increased with income and work experience and using regression modelling. (Mielitz et al., 2018) determined the helpfulness of a financial education course to improve financial knowledge and found that those who used financial tools were more financially knowledgeable than those who did not. (Sangeeta et al., 2022) examined the determinants of financial literacy and explained that financial behavior and financial attitude have noteworthy influence on financial knowledge and financial well-being and also suggested that schools, colleges, and governments should weigh on building the attitude and financial behavior for the security of society. (Lusardi, 2019) conducted research for financial education evidence and implication and to give suggestions that the big three questions should be revised and education program created a rigorous problem. (Akpene Akakpo et al., 2022) used a Biprobit model and their result explained that financial inclusion was improved by financial literacy and also recommended that financial institutions provide basic financial clients and help them to promote savings and investment behavior. (Xiao et al., 2022) analyzed a systematic review of financial capability and found that financial well-being is an essential component in financial capability and suggested various future directions on financial capability like differences in consumer's background, and new variables like financial behavior, knowledge, and opportunity. (Nuris et al., 2023) discussed in their topic and said that financial attitude, financial knowledge, financial socialization, and financial socialization are the factors that affect financial behavior. (Baker et al., 2019) examined behavioral biases in financial literacy and found that there is a difference in biases like emotional biases, disposition effect and self-attribution among Indian investors and this study revealed that disposition effect and herding biases have negative association with financial literacy and their evidence suggests that young investors are more secure about their returns. (Banthia & Dey, 2022) examined three variables on financial literacy using the structural equation modeling approach in Odisha and found that financial attitude and financial knowledge are the momentous displays of financial literacy levels but these two variables are negatively related. (N. Garg & Singh, 2018) discussed

financial literacy among youth and found that females hold less financial knowledge, financial behavior, and inclusive financial literacy than males. This study also found that there is an interrelationship between financial knowledge, financial behavior, and financial attitude. (Adil et al., 2023) study indicates that financial literacy helps investors trust which increases their behavior to participate in the stock market. Trust in financial institutions enhances individual intention to invest in the financial market. (Huang et al., 2023) The study indicated that underestimation in financial literacy has a negative influence on stock participation in the financial market and also suggested that government improve the stock market system and effort to safeguard small and medium-sized investors. (Heinberg et al., 2014) conducted five steps to planning success and found that videos can more strongly motivate action compared to written narratives. Their study also supports that financial education programs can change investor behavior. (Ergün, 2018) conducted a study in eight European countries and found that male students are more knowledgeable than female students about personal financial literacy. These findings are supported by realistic data through abundant data (Atkinson & Messy, 2012; Baker et al., 2019; N. Garg & Singh, 2018; Goyal et al., 2022; Klapper & Lusardi, 2020; Lusardi, 2019; Lusardi & Mitchell, 2011). (Kumar et al., 2023) studied focus on financial well-being and found that families' socio-economic status can improved by financial well-being and this study also reflects that financial well-being and financial literacy are positively related and also suggested that education programs, workshops, seminars, tutorials, and awareness camps may improve financial wellbeing of individuals and this study is supported by (Goyal et al., 2022; Iramani & Lutfi, 2021; Sangeeta et al., 2022; Vieira et al., 2021). (Stolper & Walter, 2017) conducted a study in Germany and found that there is a substantial difference in demographic allies and national economies and also found that most of the study and research on financial literacy has been conducted in U.S.

Section 2

Worldwide research on financial literacy

Worldwide research on financial literacy demonstrates the existence of the problem. Poor financial behavior is fatal not only for individuals but also for the global economies. (Klapper & Lusardi, 2020). (Stolper & Walter, 2017) examined The Big Three measure was used to assess financial literacy among individuals in 22 single-country studies. Although greater levels of competence were discovered in upper-income countries, only 35% of total

people answered all three questions correctly on average, compared to 13% in middle-income countries and 4% in transition countries. (Stolper & Walter, 2017). (de Clercq, 2019) examined financial literacy amongst adults across 30 countries using the big three questions that are prescribed by the OECD. They found that the highest education accomplishment of the majority of the respondents in Brazil, Croatia, South Africa, and Hungary and suggested that the current set of financial knowledge questions should be reconsidered. (OECD, 2022) examined financial education levels across 30 countries using three variables financial attitude, financial knowledge, and financial behavior as a mixed measure of financial literacy, and found that the overall financial literacy levels are low. (Hogarth & Hilgert, 2002) conducted a new survey on financial literacy in the US and asked a question covering savings and general financial management topics and found that consumers have more knowledge about mortgages and less knowledge about savings. According to data that are shared by the OECD INFE study, India's score average of 13.7 in financial literacy compared to 13.8 for countries in the OECD INFE study. In a survey carried out by the OECD INFE study, the average score of financial knowledge is 4.2, and unfortunately India's lies below the average score of 5.2 for the 14 countries in the OECD INFE study. (Beal & Delpachitra, 2003) survey among Australian university students and found that there is a lack of financial skill - education in school and he also found that financial literacy may improve with income and work experience.

Objective of the study:

The purpose of this study is to present the prevailing state of research on financial literacy, with the following question describing the scope of the study.

1. To identify the most current publication trends in financial literacy in terms of journals, authors, affiliated countries, and institutions.
2. To identify the most used keywords in the field of financial literacy of selected papers.
3. To identify the most used research tools.
4. To identify the Gap and discuss the future direction.

The rest of this paper is designed as follows: Section 3 covers the research methodology. Section 4 covers the bibliometric analysis of the papers. Section 5 shows the main findings and the conclusion and in the last section 6 covers the future scope.

Section 3

Research Methodology

Databases, keywords, and inclusion criteria

In this review paper, the data were retrieved in July 2023 from the Scopus database, which is the world's premier database for published articles and citations. It includes publication in top impact factor journals and is most suited for bibliometrics analysis (Goyal & Kumar, 2021). The search was conducted in July 2023 and data from the period 2013– 2023 were analyzed. In 2007 – 2008 the economic recession was spreading all over the world, especially in the United States. Millions of people lost their homes, savings, and jobs. The most interchangeably used terms in the literature are financial attitude, financial knowledge, and financial education (Goyal & Kumar, 2021). The term financial literacy was used for the first time in North America and the term financial capability was used in the British that are taken from Social and Enterprise development innovations (SEDI, 2004). A string of appropriate search terms (“financial literacy” and “financial knowledge” and “financial attitude” or “financial behavior”) was used to search the papers in title, abstract, or keywords, yielding 212 initial results. The articles were screened based on reading abstracts, titles, and keywords. To ensure the inclusion of relevant articles, those articles were shortlisted for final analyses which either focused on financial literacy or financial knowledge, financial attitude, and financial education, and articles related closely to concepts like financial capability, and subsequently duplicated articles were removed. The final database used for this review comprised 131 articles.

Analysis method:

After studying various review papers and journals, systematic review papers can be of several types, like structured review, framework-based, hybrid–narrative framework, theory-based review, and meta-analysis (Goyal et al., 2022; Kaiser et al., 2022; Nuris et al., 2023; Santini et al., 2019), bibliometric review (G. Garg et al., 2023; Goyal & Kumar, 2021; Paul & Bhukya, 2021; Vijay Kumar & Senthil Kumar, 2023) and review aiming for model/framework development. In this paper, we are using bibliometric analysis which is a highly used approach to trace the behavior of knowledge in the research field. In this paper tools such as citation network analysis and publication trend are used in this study. Additionally, we are using co-citation analysis bibliographic coupling, keyword analysis, and clustering. the software used for this analysis is VOS Viewer. The VOS viewer analyses are used for citation, co-citation, and keyword analysis.

Figure1. Data retrieval

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

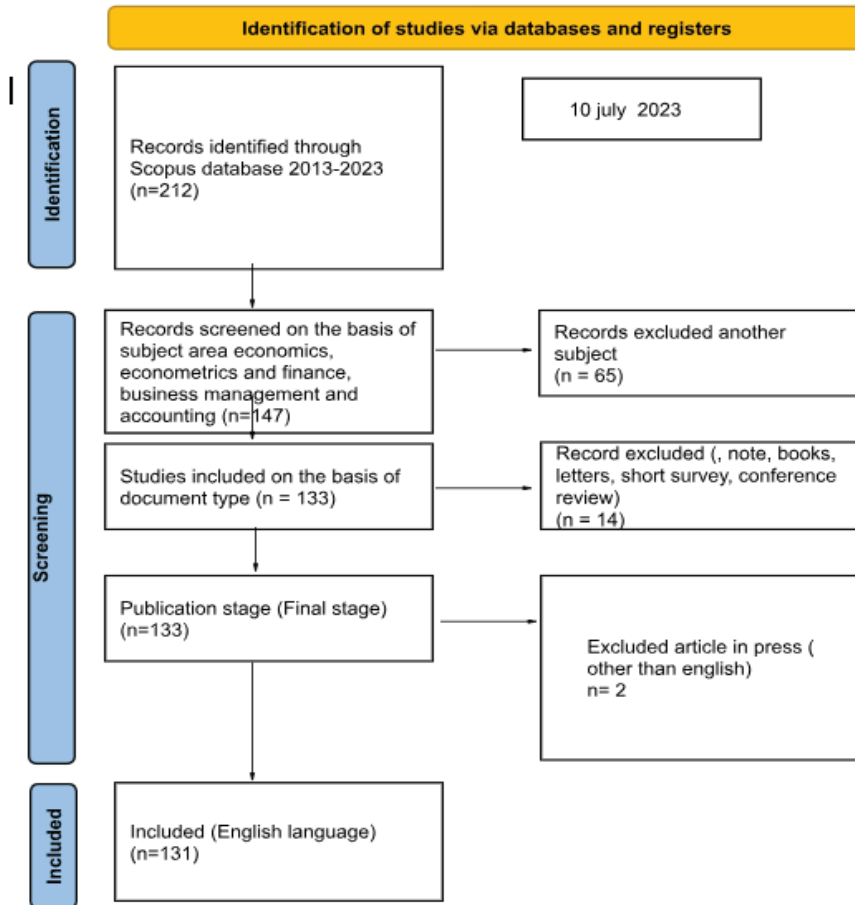


Figure 1.0 PRISMA flow chart

Table1. Summary of extent reviews in the financial literacy domain (2013- 2023)

Authors	Scope of the review	Findings	Type of Study
Goyal & Kumar, (2021)	Financial literacy: A systematic review and bibliometric analysis	The researchers conducted a systematic review and bibliometric analysis of 502 peer-reviewed journal papers published between 2000 and 2019 to identify influential work, intellectual structure, and research needs on the subject of financial literacy.	Review + bibliometric analysis
Goyal et al., (2022)	The psychological antecedents of personal financial management behavior: a meta-analysis	The findings emphasize the significance of self-control in PFMB and point to the necessity for additional investigation of the relationship between psychological characteristics and PFMB by subgroup meta-analysis.	Meta-analysis

Amagir et al., (2018)	A review of financial-literacy education programs for children and adolescents	This paper pointed out that financial literacy education programs can improve children and adolescents' financial education and attitude.	Review
Nuris et al., (2023)	Factors Influencing Financial Behavior of Undergraduate Students: A Systematic Review	This systematic literature review found that financial attitude, financial knowledge, financial socialization, financial self-efficacy, and financial threats affect the financial behavior of undergraduate students.	Systematic review
Arora &Chakraborty, (2023)	Role of financial literacy in investment choices of financial consumers: an insight from India	The result highlighted that financial literacy is positively associated with investment choices and people who have higher financial knowledge are more likely to invest.	Review
Ergün, (2018)	Financial literacy among university students: A study in eight European countries	This study supports that educational activity may improve the financial knowledge of students at university.	Review
Lusardi & Mitchell, (2011)	FINANCIAL LITERACY AROUND THE WORLD: AN OVERVIEW	This study found that the level of financial literacy is very low around the world and financial education programs can boost the attitude and behavior of investors.	Review + conceptual
Xu &Zia, (2012)	Financial Literacy around the World	Through an analysis and synthesis of current research, the study advances our understanding of financial literacy. It sheds light on how crucial financial literacy initiatives are to global financial policy reform.	Review
Lusardi, (2019)	Financial literacy and the need for financial education: evidence and implications	This review paper analyzed the big three questions that are developed by OECD, INFE and found that financial literacy is low among the young and there is a vast gender gap around the world.	Review + conceptual
Engels et al., (2020)	Financial literacy and fraud detection	This study found that there is a positive relationship between financial literacy and fraud detection. People have more financial knowledge and are more detect to fraud.	Empirical and conceptual
Carpena &Zia, (2020)	The causal mechanism of financial education: Evidence from mediation analysis	In this paper, the author found that financial education must increase financial knowledge.	Empirical approach

Morgan &Long, (2020)	Financial literacy, financial inclusion, and savings behavior in Laos	This study suggests that there is a positive effect of financial literacy on financial inclusion and savings.	Conceptual
Xiao et al., (2022)	Financial capability: a systematic conceptual review, extension and synthesis	In the contemporary context, when people have more choices and responsibilities for financial decisions, financial competence programs are becoming more and more significant. The study emphasizes the necessity of conducting primary research to comprehend how retail banking providers can help customers become more financially capable by offering them services and goods.	review
Cossa et al., (2022)	Financial Literacy Environment Scan in Mozambique	This study found that education level influences the financial attitude and financial behavior of a person and individuals who have higher financial knowledge are better able to manage their finances.	descriptive
Karakurum-Ozdemir et al., (2019)	Financial Literacy in Developing Countries	This study explained that financial literacy increases with income and income is correlated with income.	descriptive

Source: Author contribution

Table2. A summary list of models and methods in the financial literacy domain (2013– 2023)

Authors	Title	Method and model
Mielitz et al., (2018)	Financial literacy education in a work release program for an incarcerated sample	Ordinary least square method
(Cucinelli et al., 2019)	Financial Literacy: The Role of the Local Context	Multiple regression model
Singh &Malik, (2022)	An empirical analysis on household financial vulnerability in India: exploring the role of financial knowledge, impulsivity, and money management skills	Fractional regression model
Khan et al., (2022)	Financial capability as a function of financial literacy, financial advice and financial	Regression
Adewumi, (2022)	Financial literacy and business risk-taking among business start-up students in Nigeria	Kaiser & Meyer – olkin test & Bartlett test and regression method

Vieira et al., (2021)	Financial well-being of the beneficiaries of the minha casa minha vida program: Perception and antecedents	Descriptive statistical analysis, confirmatory factorial analysis, and multiple linear regressions.
Iramani &Lutfi, (2021)	An integrated model of financial well-being: The role of financial behaviour	Structural equation modeling
(Robson & Peetz, 2020)	Gender differences in financial knowledge, attitudes, and behaviors: Accounting for socioeconomic disparities and psychological traits	Ordinary least square method
(Aydin & Akben Selcuk, 2019)	An investigation of financial literacy, money ethics, and time preferences among college students:	A structural equation modeling
(Dogra et al., 2023)	Antecedents of the Youngster's Awareness About Financial Literacy:	A structural equation modeling
(Diem et al., 2023)	The impact of personal financial literacy on the choice of lending channel by Vietnamese householders who just escaped poverty.	binary logistic regression

Source: Author contribution

Performance analysis

Table 3. Trend of publication in time

Year	No.of publication
2013	1
2014	2
2015	4
2016	8
2017	8
2018	8
2019	15
2020	24
2021	19
2022	22
2023	17

Source: Author contribution

Figure 1.1elaborates the upsurge of publications available on the Scopus data on financial literacy in the period 2013 – 2023. There has been an increased in publication: from just one article published in 2013 to 17 articles till July 2023. In 2009, national strategies for financial education programs were launched as a tool to describe the causes of financial crisis. In 2012, G 20 leaders recommended rules and regulation related to national strategies on financial education presented by OECD INFE.

Figure 1.1: publication year-wise. Source: Author's contribution.

Publication trends

The 131 publications analyzed are dispersed across 40 journals. Figure 1.1represents the list of the most protuberant journals publishing on financial literacy. Journal of Financial Counselling is the most prolific platform, publishing 11 articles, followed by the international journal of bank marketing. In addition, many of these journals have a social science citation index (SSCI), social citation index (SCI), and Australian Business Deans Councils (ABDC) ranking which clarifies that financial literacy domains occupy a position in the quality journals of business and management research.

Table 4: Top journals for financial literacy

Source (journal)	TP	TC	FI-NANCE	abdc ranking	Publisher
journal of family and economic issues	4	223	✓	x	Springer International Publishing AG
international journal of bank marketing	8	203	X	A	Emerald Group Publishing
journal of financial counseling and planning	11	129	✓	C	Springer Publishing Company
International journal of consumer studies	3	67	X	A	Wiley-Blackwell Publishing
institutions and economies	2	61	✓	x	University of Malaya
journal of behavioral and experimental finance	3	60	✓	A	ELSEVIER
journal of consumer affairs	4	53	X	A	Wiley-Blackwell Publishing
research in international business and finance	2	34	✓	B	Elsevier
review of behavioral finance	2	34	✓	B	Emerald Group Publishing Limited
international journal of social economics	2	25	✓	B	Emerald Group Publishing
citizenship, social and economics education	3	22	✓	X	SAGE Publications Inc.
managerial finance	5	10	✓	B	Emerald Group Publishing
international handbook of financial literacy	2	9	✓	X	Springer Publishing Company
public finance quarterly	3	3	✓	X	State Audit Office of Hungary
universal journal of accounting and finance	2	2	✓	X	Horizon Research Publishing
journal of risk and financial management	2	1	✓	B	MDPI
problems and perspectives in management	2	1	X	X	Business Perspectives
finance: theory and practice	2	0	✓	X	Financial University under The Government of Russian Federation
journal of eastern european and central asian research	2	0	X	X	Institute of Eastern Europe and Central Asia

Note: ABDC= Australian Business Deans Council 2022 journal ranking list. TP= total publications. TC =total citations in this table journals are presented according to total citations.

Top journals for financial literacy research

The top journals are published in financial literacy are presented in Table 3. Journal of family and economic issues and international journal of bank marketing are the two most prominent journals in terms of citations with 223 and 202 citations respectively. however, journal of family counselling and planning and international journal of bank marketing are the top two journals in terms of publication with 11 and 8 publications respectively.

County wise publication

The figure 1.2 shows that the United States have the most articles published on financial literacy, totaling 23 as mentioned in figure 1.2. India is the second list in the number of articles, and Malaysia is the third list in the number of articles. The United States is the first in the number of citations while India is the second in the number of citations. In the bibliographic coupling analysis, a total no of 6 clusters were identified country- wise in the analysis. In the first cluster, Australia, Austria, Belgium, Canada, Germany, Hungary, Indonesia, the Netherlands, South Africa, Sweden, and Vietnam worked together on the financial literacy area. Brazil, India, Spain, Thailand, and Turkey worked together in the second cluster. In the third cluster Czech Republic, Portugal, and the United Kingdom work together. In the fourth cluster, China and Hong Kong worked together and cooperated as mentioned in the figure. In the last and sixth cluster, Poland and the United States are working together and it can be seen that the authors were enthusiastic about their work.

Figure1.2. country wise publication

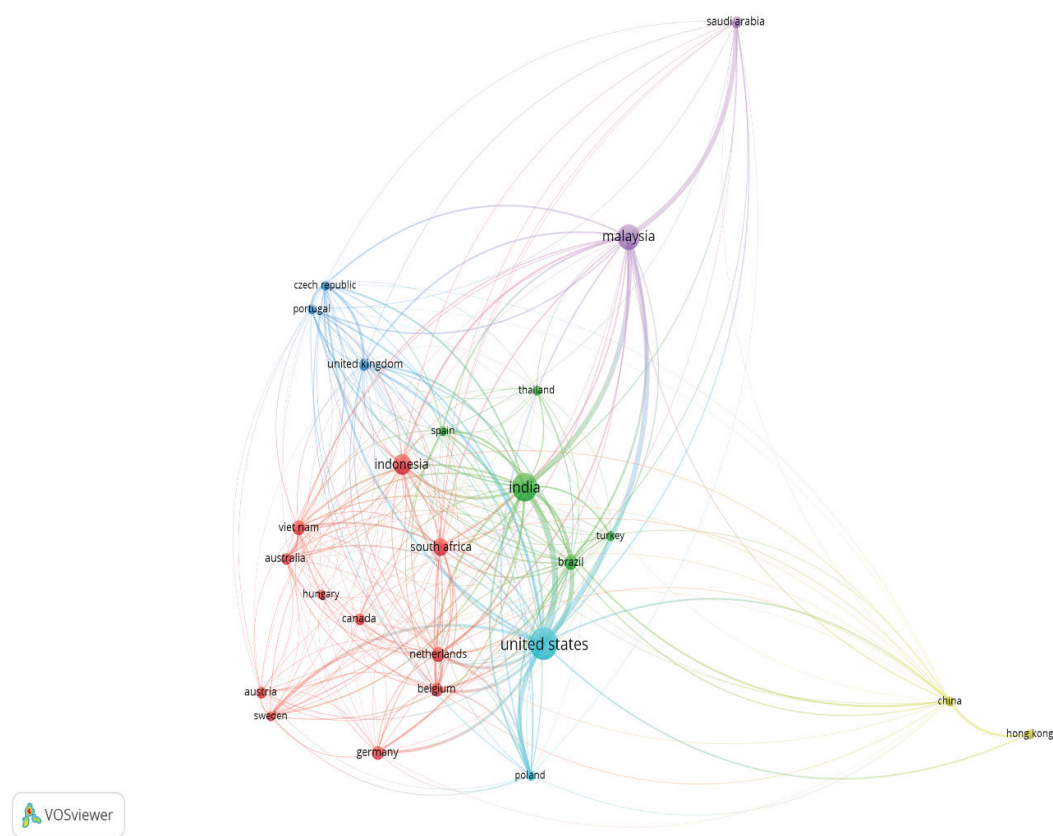


Figure 1.3. country-wise publication through bibliographic coupling

Author wise publication

The author-wise publications are presented in Figure 1.4. Dewi, v.i.&Vieira, K.M. are the top two author in research articles in the financial literacy field. Future researchers get good idea while studying these prominent author's work.

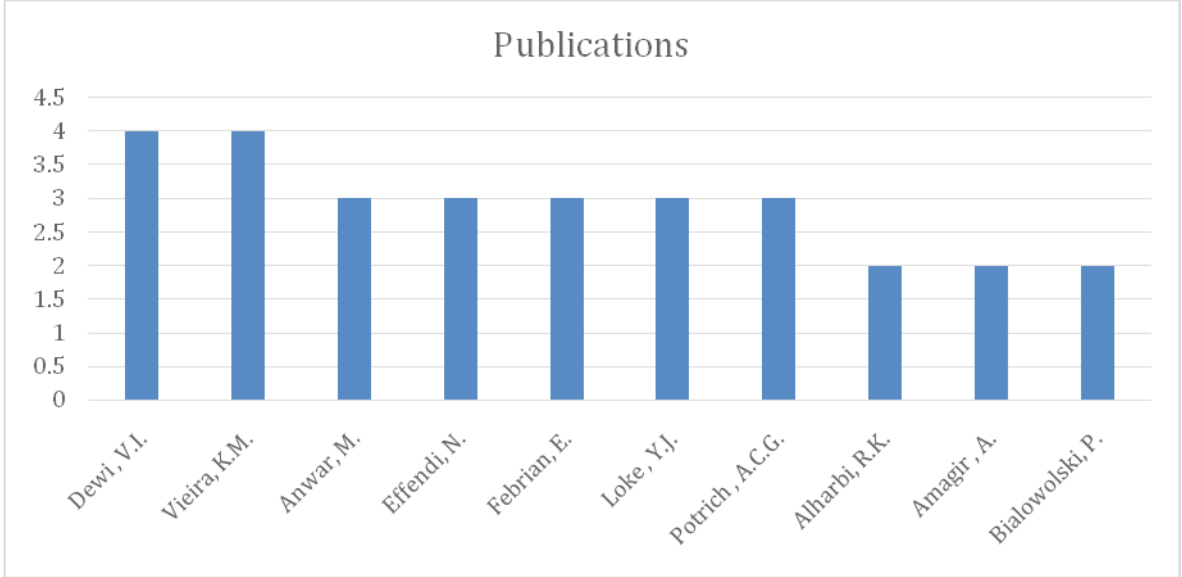


Figure 1.4. Author wise publication

Table 5. Top sponsored institutions

Top funding sponsor	Publications
Deutsche forschungsgemeinschaft	3
Ministry of Finance	3
Australian Research council	2
Conselho Nacional de desenvolvimento	2
Fonds wetenschappelijk onderzoek	2
Lembaga pangeola dana pendidikan	2
Social science and humanities research	2
Universiti malaya	2
Administration for children and families	2

Source. Author contribution

Document by top sponsored institutions

Figure 1.6 represents document by top sponsored institutions. The German funded research institute Deutsche forschungsgemeinschaft and ministry of finance are the top two sponsored institutions in terms of publication. The prospective researcher may help these institutions to submit article publishing price.

Fig Figure 1.6. a document by funding sponsor institutions**Table 6. Documents by subject area**

Subject area	Documents
<i>Economics, econometrics and finance</i>	99
<i>Business, management and accounting</i>	75
<i>Social science</i>	31
<i>psychology</i>	8
<i>Decision science</i>	5
<i>Arts and humanities</i>	4
<i>Medicine</i>	3
<i>Environmental science</i>	2
<i>Computer science</i>	1
<i>Engineering</i>	1

Source: Author contribution

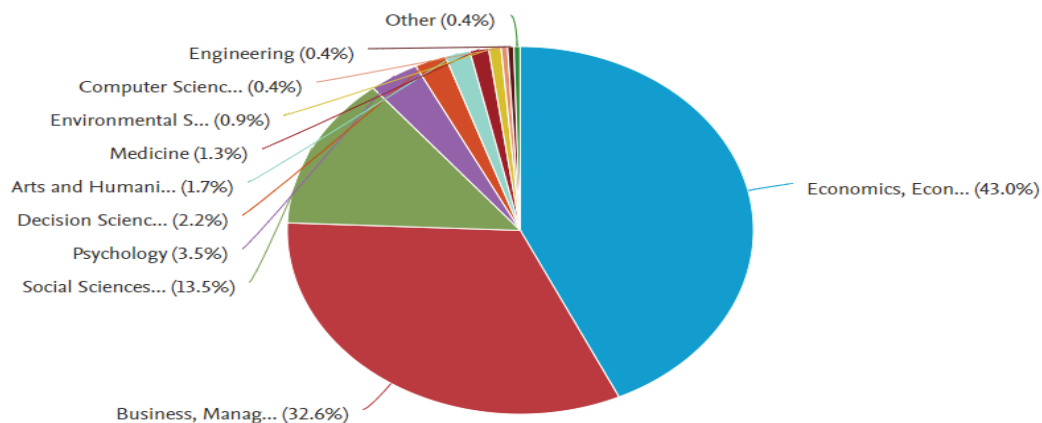
Documents by subject area**Figure1.7: document by subject area.**

Table 7. Top authors, Top organization and Top country of research in financial literacy

Author	TP	TC	Institutions	TP	TC	country	TP	TC
stolper o.a.; walter a.	1	178	justus-liebig-universität gießen, licher straße 74, gießen, 35394, Germany	1	178	united states	23	437
henager r.; cude b.j.	2	96	philipps-universität marburg, am plan 1, marburg, 35032, Germany	1	178	Germany	4	331
gerrans p.; speel- man c.; campitelli g.	1	92	school of psychology and social science, edith cowan university, joondalup, wa, Australia	1	92	India	17	212
agarwalla s.k.; barua s.k.; jacob j.; varma j.r.	1	82	uwa business school, universi- ty of western australia, craw- ley, wa, 6009, m250 35 stirling highway, Australia	1	92	Malaysia	14	189
potrich a.c.g.; vieira k.m.; mendes-da- silva w.	1	74	Indian institute of management Ahmedabad, india	1	82	Brazil	5	154
kaiser t.; menkhoff l.	1	72	economics and finance, school of business, whitworth university, 300 w. hawthorne rd, weyerhaeuser hall 310c, spokane, 99251, wa, united states	1	78	Australia	3	100
rai k.; dua s.; yadav m.	1	72	financial planning, housing and consumer economics, university of georgia, 305 san- ford dr., dawson hall, athens, 30602, ga, united states	1	78	Nether- lands	5	96
kaiser t.; lusardi a.; menkhoff l.; urban c.	1	64	federal university of santa maria, santa maria, brazil	1	74	Sweden	2	76
eniola a.a.; ente- bang h.	1	63	university of são paulo, são paulo, Brazil	1	74	United Kingdom	3	69
sayinzoga a.; bulte e.h.; lensink r.	1	62	humboldt-university of berlin and german institute for eco- nomic research (diw berlin), berlin, 10108, Germany	1	72	Rwanda	1	62
lind t.; ahmed a.; skagerlund k.; strömbäck c.; väst- fjäll d.; tinghög g.	1	60	rukmini devi institute of ad- vanced studies, Delhi, 110085, India	1	72	Viet Nam	5	58
riitsalu l.; murak- as r.	1	57	university of koblenz-landau and german institute for eco- nomic research (diw berlin), landau, 76829, Germany	1	72	Estonia	1	57
morgan p.j.; long t.q.	1	55	German institute for economic research (diw berlin), kiel in- stitute for the world economy (ifw kiel), humboldt univer- sität zu berlin, berlin, 10108, Germany	1	64	Indonesia	9	57

kim k.t.; anderson s.g.; seay m.c.	1	53	montana state university and institute for labor studies (iza), bozeman, 59717, mt, united states	1	64	Japan	1	55
aydin a.e.; akben selcuk e.	1	46	the george washington university school of business and nber, washington, 20052, dc, united states	1	64	China	2	54
muñoz-murillo m.; alvarez-franco p.b.; restrepo-tobón d.a.	1	46	university of koblenz-landau, landau, 76829, Germany	1	64	Canada	3	46
yong c.-c.; yew s.-y.; wee c.-k.	1	45	department of business management, universiti malaysia sarawak (unimas), kota samarahan, sarawak, Malaysia	1	63	Colombia	1	46
loke y.j.	3	41	development economics group, wageningen university, Netherlands	1	62	turkey	2	46
mouna a.; anis j.	1	34	university of groningen, Netherlands	1	62	Belgium	4	42
santini f.d.o.; ladeira w.j.; mette f.m.b.; ponchio m.c.	1	34	university of Rwanda, Rwanda	1	62	Hong Kong	2	38

Note: TC= total citations, TP= total publication. Here author, institutions and country are presented according to citation with the help of citation analysis.

Source: Author's contribution

Keyword

The author conducted the co-occurrence analysis using the author keywords and identified 14 main clusters of financial literacy literature as shown in Figure 1.8. It shows that financial literacy appears 96 times the overall authors' keywords, which is the most total link strength. Financial knowledge, financial behavior, financial attitude, financial behavior, and financial education appeared 51, 42, 24, and 22 times respectively. Keyword network figure helps the researcher in recognizing unfruitful research areas. Keyword analysis was performed using VOS Viewer to identify the most prominent themes in financial literacy. Financial advice, financial capability, financial well-being and financial inclusion are other emergent themes in this area.

Table8: Top keywords on the basis of occurrence

Keyword	occurrences	Total link strength
financial literacy	96	223
financial knowledge	51	148
financial behavior	42	118
financial attitude	24	76
financial behaviour	22	70
financial education	20	61
financial well-being	7	26
financial inclusion	9	23
financial skills	5	20
financial attitudes	6	19
financial capability	6	19

meta-analysis	4	12
subjective financial knowledge	3	11
personal finance	4	10
university students	3	10
household finance	3	9
objective financial knowledge	2	9
Sem	3	8
financial self-efficacy	2	8
financial management	3	7
debt literacy	2	7
financial advice	2	7
financial decisions	2	7
financial satisfaction	2	7
financial wellbeing	2	7
undergraduates	2	7
adolescents	2	6
age groups	2	6
experiment	2	6
financial stress	2	6

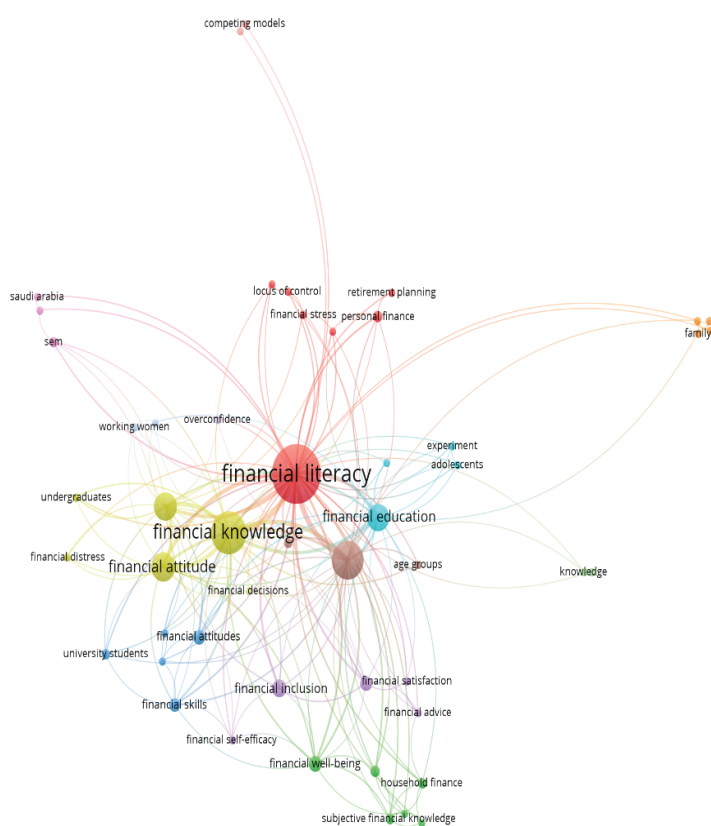


Figure 1.8. keyword analysis: source: Author's contribution

Co-citation analysis:**Table9: top cited author on the basis of citations**

Author	Citations	total link strength
lusardi a.	607	25703
mittchell o.s.	299	14377
xiao j.j.	169	9377
shim s.	84	4900
serido j.	73	4296
huston s.j.	70	3418
robb c.a.	54	3062
alessie r.	65	2989
van rooij m.	62	2919
chen h.	58	2800
hogarth j.m.	47	2643
jappelli t.	47	2588
tufano p.	48	2577
volpe r.p.	49	2575
zia b.	55	2550
atkinson a.	56	2535
curto v.	54	2511
vieira k.m.	43	2452
lynch j.g.	41	2350
mandell l.	48	2251
hair j.f.	47	2225
danes s.m.	51	2215
yoong j.	37	2203
potrich a.c.g.	38	2187
fernandes d.	40	2157
hira t.k.	37	2157
netemeyer r.g.	40	2154
grable j.e.	43	2116
gathergood j.	35	2082
parker a.m.	36	2073

Source: Author's contribution.**Co-citation analysis**

This analysis is used for the intellectual structure of a research field and to analyse the relationship among cited publications. To figure out the most influential authors on financial literacy, the most cited author was Lusardi A. with 607 citations, followed by Mitchell o.s. with 299 citations. A total of 4 clusters are identified in co-citation analysis. This figure represents highly cited authors with the help of Vos Viewer based on citations with a threshold of a minimum of 15 citations. The other three most cited authors are Xiao j.j. (169) citation), Shim s. (84 citation) and Serido j. (73 citations).

figure 1.9. Co-citation analysis. Source: Author's Contribution.

co-citation means the most cited reference in research articles. Each node denotes a reference that has been cited. Each node color denotes a semantic grouping reference based on theme similarity. The degree of local citations is represented by the size of the nodes, with bigger nodes reflecting more concentration of local citations.

Table 10.A thematic cluster of financial literacy

Author	TC	Theme	Title
Cluster 1		Financial literacy and financial behaviour	
henager r.; cude b.j. (2016)	78		Financial literacy and long – and short-term financial behavior in different age groups
gerrans p.; speelman c.; XXXampitelli g. (2014)	92		The Relationship Between Personal Financial Wellness and Financial Wellbeing: A Structural Equation Modelling Approach
muñoz-murillo m.; XXXampite-franco p.b.; reštrepo-tobón d.a. (2020)	46		The role of cognitive abilities on financial literacy: New experimental evidence
kim k.t.; XXXampitel s.g.; seay m.c. (2019)	53		Financial Knowledge and Short-Term and Long-Term Financial Behaviors of Millennials in the United States
morgan p.j.; long t.q. (2020)	55		Financial literacy, financial inclusion, and savings behavior in Laos
riitsalu l.; murakas r. (2019)	57		Subjective financial knowledge, prudent behaviour and income: The predictors of financial well-being in Estonia
lind t.; ahmed a.; skagerlund k.; strömbäck c.; västfjäll d.; tinghög g. (2020)	60		Competence, Confidence, and Gender: The Role of Objective and Subjective Financial Knowledge in Household Finance
Cluster 2		Financial behaviour and financial knowledge	
agarwalla s.k.; barua s.k.; XXXampi j.; varma j.r. (2015)	82		Financial Literacy among Working Young in Urban India
sayinzoga a.; bulte e.h.; lensink r. (2016)	62		Financial Literacy and Financial Behaviour: Experimental Evidence from Rural Rwanda
santini f.d.o.; ladeira w.j.; mette f.m.b.; ponchio m.c. (2019)	34		The antecedents and consequences of financial literacy: a meta-analysis
rai k.; dua s.; XXXampi m. (2019)	72		Association of Financial Attitude, Financial Behaviour and Financial Knowledge Towards Financial Literacy: A Structural Equation Modeling Approach
kaiser t.; menkhoff l. (2020)	72		Financial education in schools: A meta-analysis of experimental studies
kaiser t.; XXXampite a.; menkhoff l.; urban c. (2022)	64		Financial education affects financial knowledge and downstream behaviors
Cluster 3		Model for university student and financial literacy model	
Aydin A.E.; Akben Selcuk E. (2019)	46		An investigation of financial literacy, money ethics and time preferences among college students: A structural equation model

Yong C.-C.; Yew S.-Y.; Wee C.-K. (2018)	45	Financial knowledge, attitude and behaviour of young working adults in Malaysia
eniola a.a.; entebang h. (2017)	63	SME Managers and Financial Literacy
potrich a.c.g.; XXX-ampit k.m.; mendes-da-silva w. (2016)	74	Development of a financial literacy model for university students

Notes: TC= total citations

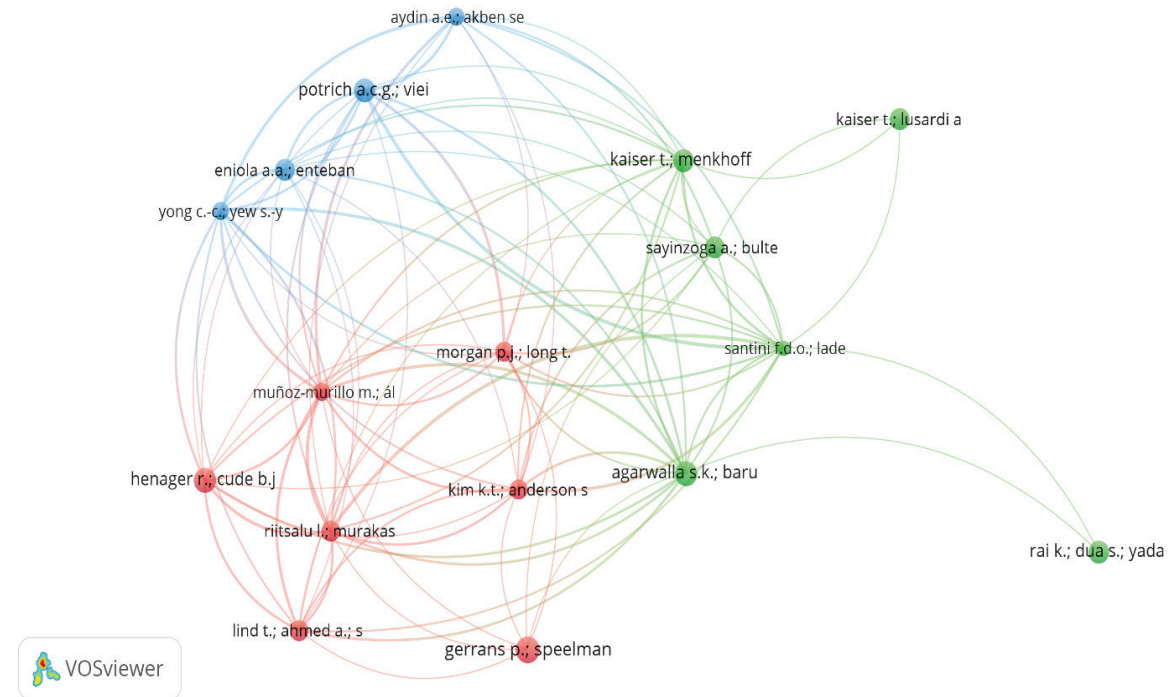


figure2.0: bibliographic coupling analysis

Thematic cluster of financial literacy through bibliographic coupling

Bibliographic coupling analysis shows the citing publication. It tells the existing knowledge in the field. This analysis shows the three thematic cluster that is presented in table no 11.

Cluster 1 consists of 7 articles on financial literacy and financial behaviour. It's have been 441 times cited according to Scopus. Gerrans p.; speelman c.; XXXampitelli g. (2014) and henager r.; cude b.j. (2016) are top two cited articles in this cluster with 92 and 78 citations respectively. (Gerrans et al., 2014) used SEM analysis and identified linkage between quality of life and financial literacy. (Henager & Cude, 2016) measured financial literacy in three ways: objective, subjective and capability and used a logit regression model.

Cluster 2 consists of 6 articles on financial behaviour and financial knowledge. It's have been 386 times cited according to Scopus. agrawalla et.,al (2015) and rai. a etal., (2016) are top two cited articles in cluster 2 with 82 and 72 citations respectively. (agrawalla et.,al 2015) discussed that education, marital status, family income and education are significant factor that influence financial literacy. In this study OECD INFE questionnaire was used to collect data. (Rai et al., 2019) mentioned financial literacy among working women and financial literacy in their study and found that FL and FB have significant association with financial literacy.

Cluster 3 consists of 4 articles on model for university students and financial literacy model. Potrich (2016) and Eniola (2017) are the top two cited articles in cluster 3 with 74 and 63 citations respectively. (Potrich et al., 2016) found that financial attitude and knowledge have a positive impact on financial behavior and the author used Structural equation modeling. (Eniola & Entebang, 2017) examined SME managers and financial literacy in the southwest Nigeria and their findings show that financial knowledge, financial attitude and financial awareness increase the firm performance of MSE managers.

Table 11. The most recognised theory in the financial literacy domain

Sr.no	Theory	Meaning	Studies
1	Theory of Planned Behaviour	TPB was given by Lcek Ajzen. It is based on attitude, subjective norms, and perceived behavioral control. This theory suggests that individual decisions may be predicted by their intention to engage in that behavior.	(Adil et al., 2023; Akhtar & Das, 2019; Sivaramakrishnan et al., 2017)
2	Theory of consumer socialization	This theory tells us that consumers can learn from a social agent and there are three processes involved in this theory, modeling, reinforcement, and social interaction.	(Goyal & Kumar, 2021)
3	Social learning theory	Albert Bandura's social learning theory states that learning happens through observation, imitation, and modeling and is impacted by aspects including attention, motivation, attitudes, and emotions.	(Chawla et al., 2022; Goyal et al., 2022)
4	Social network theory	This theory believes in the concept of interpersonal communication. This theory focuses on transforming information, building relationships and behavioral change.	(Bönte & Filipiak, 2012; Hermansson et al., 2022)
5	Goal setting theory	Goal-setting theory is founded on the premise that creating defined and quantifiable objectives is more successful than setting vague goals. In his essay "Towards a Theory of Task Motivation and Incentive," Edwin A. Locke established this hypothesis in 1968.	(Amagir et al., 2018, 2019; Carpena et al., 2017; Carpena & Zia, 2020b; Vijay Kumar & Senthil Kumar, 2023)
6	Self-determination theory	Self-determination theory attempts to explain how being self-determined affects motivation, arguing that individuals are more driven to act when they believe their actions will have an impact on the result. Discover how this idea works and what you can do to increase your self-determination.	(Deci & Ryan, 1990)

7	Human capital theory	This theory believes in the principle of hard work and perseverance. According to this theory, human value depends on their hard work, skills, and experience.	(Mielitz et al., 2018)
8	Trans theoretical model	The Transtheoretical Model (TTM), also known as the Stages of Change Model, was developed by Prochaska and DiClemente in the late 1970s. It evolved through studies examining the experiences of smokers who quit on their own compared to those requiring further treatment. The TTM focuses on the decision-making process of the individual and is a model of intentional change.	(Goyal et al., 2022; Heinberg et al., 2014; Peeters et al., 2018; Vijay Kumar & Senthil Kumar, 2023; Xiao et al., 2022)

Source: Author' contribution

Different types of indexes.

Table 12 displays different types of indexes. Lusardi. A and Mitchell o.s. have the highest I index and H index, with a value of 83 and 86 respectively. The H index counts how many papers have been published and how many times they have been mentioned. it represents a journal's repute. The I index was introduced by Google Scholar in year 2011. The I index is a basic and uncomplicated indexing metric discovered by counting the total number of published articles having at least 10 citations in a journal.

Table 12. Different type of indexes

Sr.no.	Author	H Index	I index
1	Lusardi. A	83	182
2	Mitchell o.s.	86	314
3	Jing jian xiao	54	115
4	Joycee serido	34	52
5	Cliff A. robb	23	31
6	Robb Alessia	38	88
7	Maarten Van roji	26	44
8	Haiyang chane	15	18
9	Tullio Jappelli	68	127
10	Peter tufano	51	91
11	Bilal Zia	25	33
12	Rilsa curto	7	6
13	Kelmara mendes Vieira	29	76
14	John G.lynch	51	66
15	Satish Kumar	56	153

In This paper, the author did a detailed bibliometric analysis and review of the financial literacy field, representing This table shows the h and I index of the top author based on the citation. These data are taken from Google Scholar.

Section 5.

Discussion and Results.

In This paper, the author did a detailed bibliometric analysis and review of the financial literacy field, representing 212 articles between 2013 and 2023. In this paper performance analysis and science mapping analysis are used. In this paper we used 4 types of bibliometric analysis such as citation analysis, co-citation analysis, bibliographic, and keyword

analysis. Based on this detailed review paper, authors can say that financial literacy has full-grown significantly in current years. Figure 1.1 fulfils my first objective in this review paper. The publication trend shows that financial literacy is a growing stage. Table 5, Table 6, and Table 8 also fulfil the first objective in terms of journals, authors, affiliated countries, and institutions. The Journal of Financial Counselling and Planning is the most prolific in the financial literacy area. Dewi, V.I. is the top author in this domain. Deutsche Forschungsgemeinschaft and the Ministry of Finance are the top sponsored institutions. United States of America, India, and Malaysia are the top country-wise publications in this subject area. Table 8 and Figure 1.8 fulfils the second objective. Table 8 shows that financial literacy, financial knowledge, and financial behaviour are the most used keywords in financial literacy literature. Table 2 represents the third objective. Regression analysis and program least square, structural equation modeling are the most used research tools in literature. Section 5 and Section 6 fulfill the fourth objective.

Conclusion and limitations:

Financial literacy is being discussed everywhere. Now financial literacy plays a significant role in accelerating economic growth of economies. This study comprises a review of 212 articles on financial literacy. The study's first and most significant drawback is that the year range taken for the study is between 2013 and 2023 and second all included articles in the paper are in English and are screened based on subject area economics, econometrics, finance, business management, and accounting only. The database was collected only from "SCOPUS," not from prominent databases like Web of Science, Elsevier, Google Scholar, etc. If data are taken from different sources, it may give better results. Future researchers may also use thematic analysis, meta-analysis corresponding analysis, and scientific mapping to find emerging sources in this field. This review paper has shown that the United States, Malaysia, and India have received the most noteworthy consideration in this research. Bibliometric analysis helps the researcher to identify the most prominent authors, keywords, countries, organizations, and research journals in that field or area. In this current study, all these things are used. Bibliometric analysis can help in emergent propensities and outlines in the studied subjects. Based on the evidence from the various studies, the big three major questions (compound interest, inflation, and risk diversification) are almost used in empirical base review papers. This bibliometric analysis derives valuable intuitions on financial literacy. In this review paper, the author suggests to policymakers to improve financial literacy programs and a course that is taught in schools and colleges.

Section 6

Future scope:

This review paper can be helpful to academicians, researchers, and policymakers. The field of financial literacy research embraces massive promise for the future. The keyword analysis suggests that future researcher focus on innumeracy in financial literacy, digital financial literacy, financial literacy and retirement planning, fintech, and financial literacy, sustainable finance, financial decision-making, and behavioral economics, financial literacy of rural people and the gender gap in financial literacy

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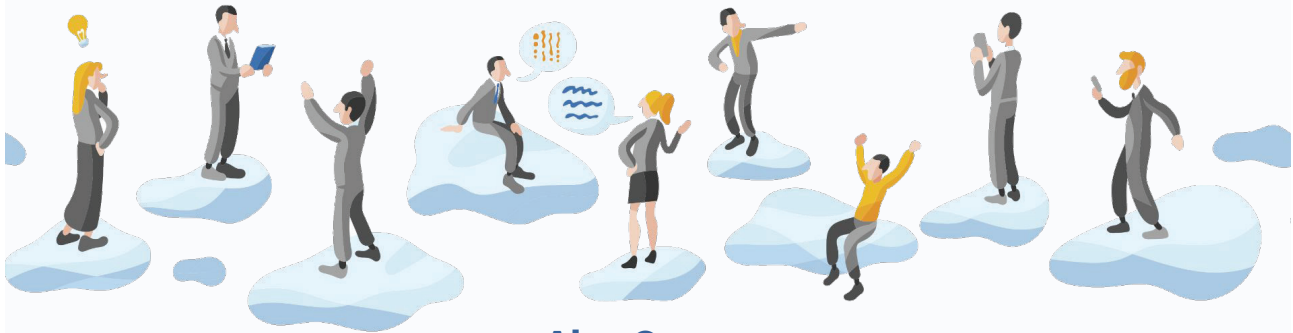
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Empowering Innovation in Asia

The Transformative Role of Low/No-Code Tools Across Industries



Alex Queen
Founder & CEO, Queen & Co.

Agenda

The Transformative Role of No- & Low-Code Tools Across Industries

-  What Do We Mean by Low/No-Code Tools?
-  The Benefits & Risks
-  Case Study: Honyaku Cloud
-  Future Trends in Low/No-Code Development
-  Jumping into Low/No-Code Solutions
-  Q&A





"The future of coding is no coding at all"
– Chris Wanstrath, Former CEO of Github

What Do We Mean by Low/No-Code Tools?

No-code platforms are designed to enable development without writing any code at all, wholly based on visual interface and drag-and-drop while **low-code platforms** require some amount of coding skills to build solutions.

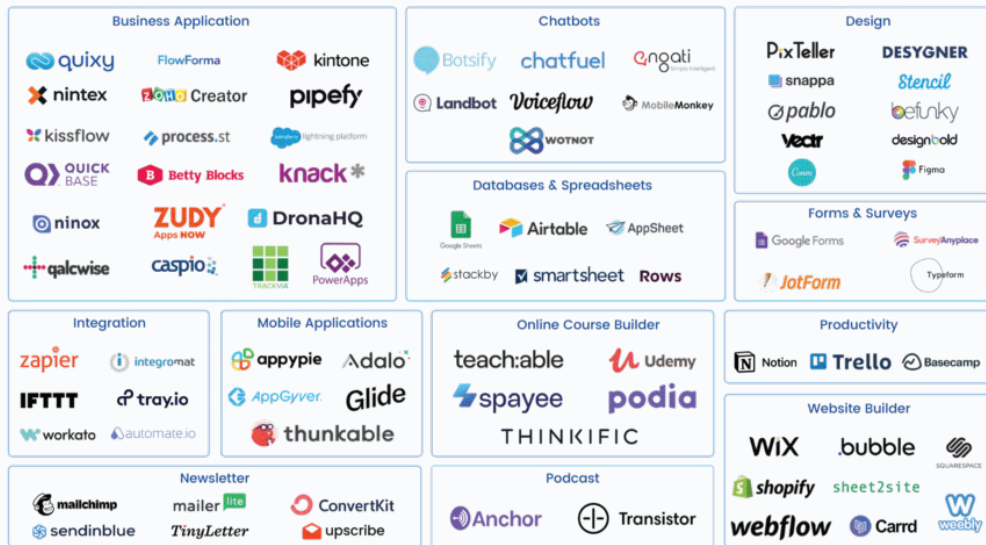
Low/No-Code: By the Numbers

- 1 Acceleration of Digitization & Automation Investments**
[85%](#) of companies accelerating digitization, 67% accelerated automation and AI since COVID-19, according to McKinsey
- 2 Inability to Attract Top Talent Fueling No-Code Adoption**
[82 percent of organizations](#) in NA/Japan/Europe can't attract and retain the quality and quantity of software engineers
- 3 More Than Half of Development Outside IT Department**
Almost [60%](#) of custom apps now built outside IT department in NA. 30% by "citizen developers" with limited/no technical skills
- 4 75% of Businesses Projected to Adopt Low/No-Code**
Mixture of low-code/no-code and conventional innovation is projected to be adopted by [75%](#) of businesses globally
- 5 Microsoft Anticipates 90% of Apps Created on Low/No-Code**
Microsoft anticipates that of 500 million apps created over the next five years [450 million](#) will be designed on low/no-code platforms



The Low/No-Code Landscape

Source: [Nasscom community](#)



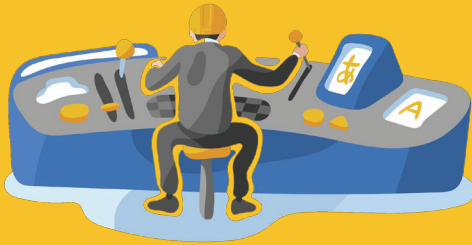
Benefits When Using These Tools

- Speed of development
- Reduced development costs
- Empowerment of non-technical staff
- Flexibility/agility
- Scalability



Risks When Using These Tools

- Limited customization and functionality
- Vendor lock-in
- Performance and integration challenges
- Security concerns and data compliance
- Long-term maintenance



Case Study: Honyaku Cloud

- Data capture and storage
- Data management and visualization
- Integrations / APIs
- Internal productivity system
- Client / supplier portals
- Web design
- And more...

Honyaku Cloud All-in-One Localization Suite

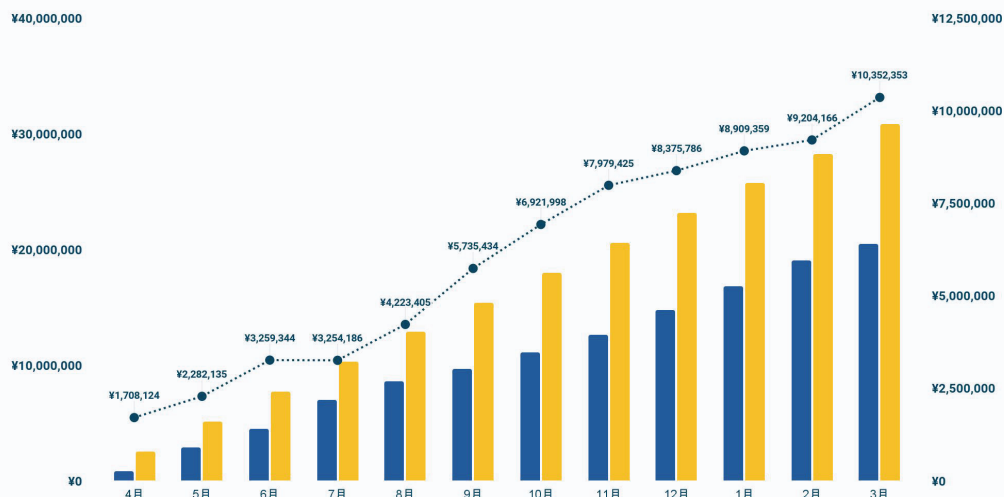
Crafted to include a localization dashboard and access to glossaries and translation memories, all inside a single portal accessible from any browser.



The Evolution of the Honyaku Cloud Stack

Application	Honyaku 1.0–2.0	Honyaku 3.0–4.0	Honyaku 5.0–
Data Input		Typeform	
Storage			
Website Building			
Integration			
Productivity			
CRM			
Client Portal	-		[Wized]

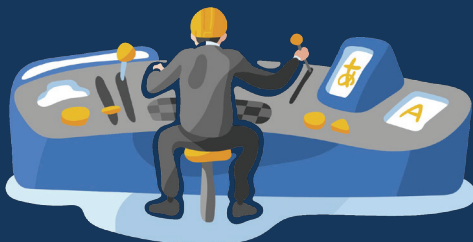
Low/No-Code Time/Cost Savings



*Figures from FY2022–2023

11

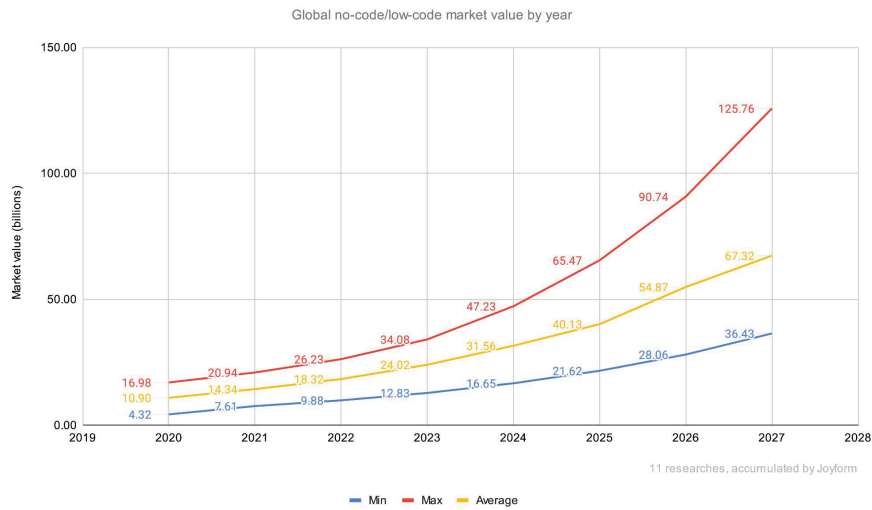
Future Trends in Low / No-Code Development



- Increased adoption across industries
- Advancement in AI and machine learning
- Growth of citizen developers
- Platform ecosystem expansion & integration
- Hybrid development approaches

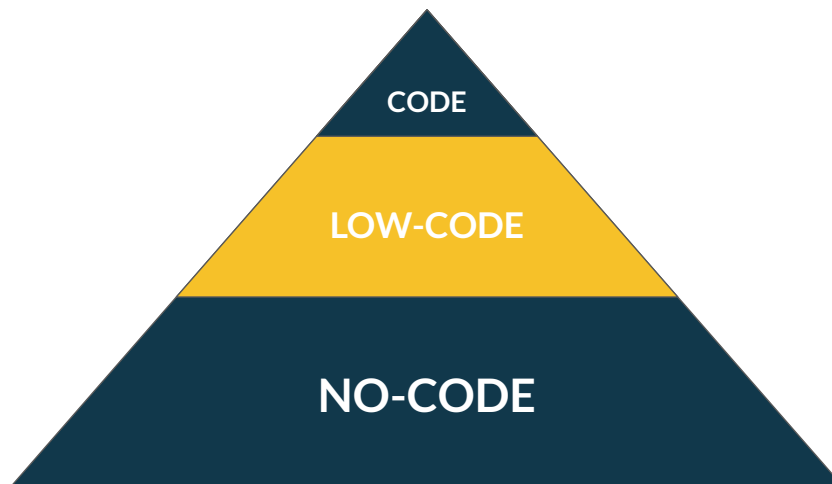
The Low/No-Code Market Value

Source: [joyform](#)



Citizen Developers: The Rise of Low/No-Code

Honyekku



Source: [Aurora-ecs Ltd](#)



Jumping into Low / No-Code Solutions

- Online Platforms & Communities
- Educational Resources
- Books & Podcasts
- Online Marketplaces
- Industry-Specific Forums

Q&A



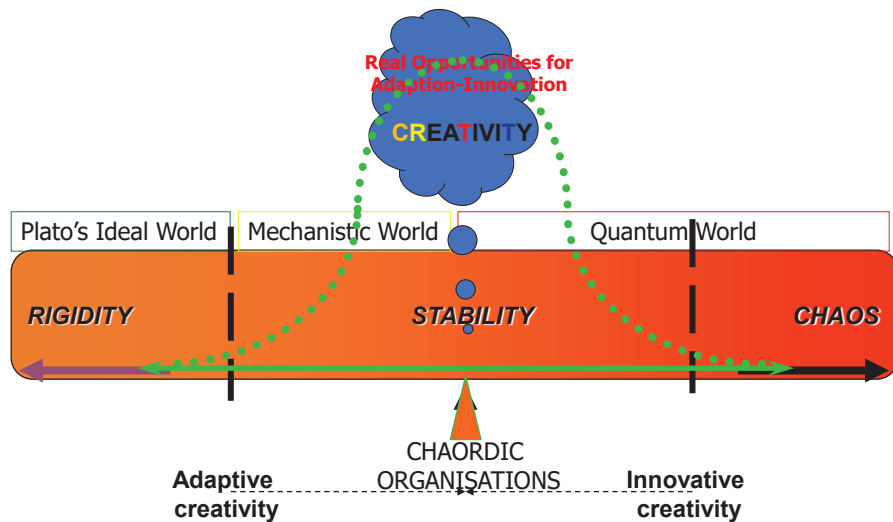
The human mind and AI in the knowledge hierarchy

Professor Kanes K Rajah

Executive Director

Centre for Executive and Professional Development London

Simplicity to complexity Rigidity, stability and chaos



Dr. Kanes Rajah © COPYRIGHT 2014

Four paradigms in terms of socio-economic change post WW2:



1. Experience economy post WW2

[Alvin and Heidi Toffler, *Future Shock*](#), first published in 1970, and [Pine, J. and Gilmore, J. \(1999\) *The Experience Economy*, Harvard Business School Press](#), Boston, 1999.

1. Attention economy because of industrialisation

Davenport, Thomas; Beck, John (2001). [The Attention Economy: Understanding the New Currency of Business](#). Cambridge: MA: Harvard Business School Press. [ISBN 9781578518715](#). Retrieved 29 October 2020, and the

1. **Sharing economy – common platforms for job sharing, to internet technologies, Wikipedia, social media all form part of the final**
2. **...Caring economy. ...prioritise care of one another and of the planet we live. It's an innovative and dynamic economy in which humans and our Covid 19 ...Pandemic thrive. Important to address the global challenges.**

The new Abnormal from lessons learnt.



The New Abnormal©2021 or The New Abnormal™

(Rajah, KK (2021) Proceedings of the International KAI Symposium 'Celebrating 45 Years of KAI adaption-innovation theory, Virginia Tech, USA)

Pandemic = CRISIS! Financial crash= CRISIS! Dotcom Bubble Bursting= CRISIS!

1. **Crisis and trauma creating change:** And we have to **embrace change as permanent. After Covid life can never go back to a new normal.** That calls for wanting too much of the past back.
2. **Change affects everyone:** The digital civilization is interconnected and interdependent.
3. **Each one of us needs to demonstrate leadership. It's about using survival skills to thrive in new lands:** New skills from the pandemic to survive and thrive, or become more marginalised, even perish.
4. **Coping behaviour unlocks extreme diversity –** chaordic organisations, people at the interface between chaos and rigidity generate their best ideas at the point of maximum tension
5. **Problem solving is a leadership trait:** All of us are leaders. We add value to ourselves as individuals, to our communities, and individually and collectively to society. Helps us make and take decisions to manage change risk.



Mechanistic to Quantum Age.....

Systems that introduced efficiencies...

- Taylorism
- Fordism
- Toyotism.....

and now

- Teslism



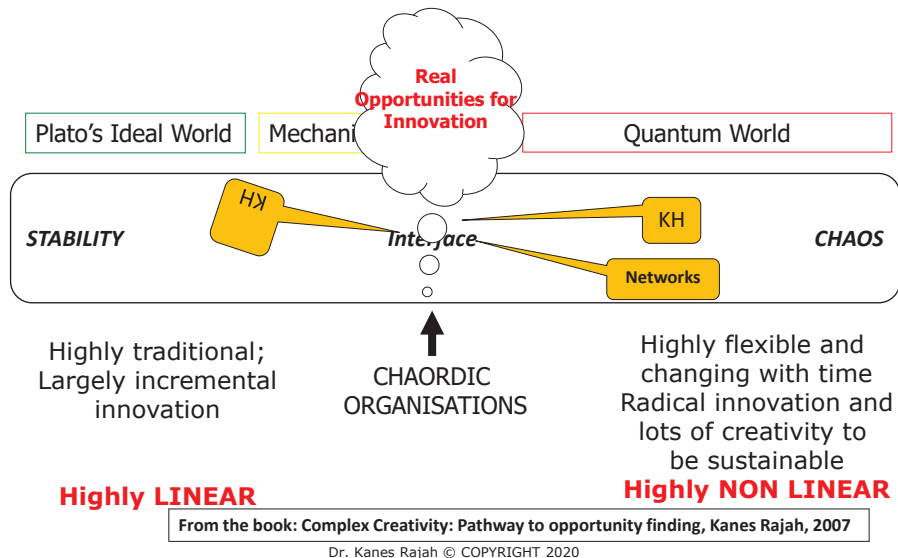
Hierarchies, Knowledge, and Power Inside Organizations

•

[\(\[Giovanni Dosi\]\(#\), \[Luigi Marengo\]\(#\), and \[Maria Enrica Virgillito\]\(#\) \(2021\)
<https://pubsonline.informs.org/doi/full/10.1287/stsc.2021.0136>,
Published Online:16 Aug\)](https://pubsonline.informs.org/doi/full/10.1287/stsc.2021.0136)

- This paper contributes to an old and still unresolved question in the theory of organizations, namely, *what do bosses do?* Whether and to what extent managerial functions are productive or not for the well functioning of an organization has to be understood with respect to the tension between *knowledge* and *power*.

High performing teams, instability and highly established organisational cultures



Hierarchy of Knowledge pre AI



Hierarchy of Digital Knowledge

Knowledge economy	Digital technologies	Digital economy
Wisdom	AI and Blockchain, IOT, mobile and remote technologies (some pre-programmed). Networks and networking	 Where does ChatGPT fit in?
Intelligence	Artificial intelligence, quantum computation, data analytics, Simulations	
Knowledge	Cloud storage, Digital marketing	
Information	Social networks and use of metrics and analytics	
Data	Social media Using G2, G3, G4, Next G5?	

Technology standard for cellular network

Technology	Application
1G - Japan 1981 Europe 1983 USA,	Used only for voice calls
2G 1991 in Finland	Users to send and receive text messages and multimedia messages (MMS).
2.5G	Enabled users to browse the web on their mobile phones.
2.75G	Further evolution to 2.75G, also called (EDGE) Enhanced Data rates for GSM Evolution. Faster than GPRS.
3G 2001 "Data packages"	GPS, Mobile TV, Video on Demand, Video Conference.
4G 2008 Speed standards set by ITU	HD TV, HD VOD, 3D TV and Games.
5G	Augmented Reality, Virtual Reality, Self-driving cars.

5G wireless devices

Connected to the [Internet](#) and the [telephone network](#) by [radio waves](#) through a [basestation](#) and antennae in the cell.

- higher [download speeds](#),
- Higher [bandwidth](#) to deliver faster speeds
- can connect more devices,

Due to the increased bandwidth, it is expected the 5G networks will increasingly be used as General internet service providers (ISPs), and also

- will make possible new applications in [internet-of-things](#) (IoT) and
- [machine-to-machine](#) areas.

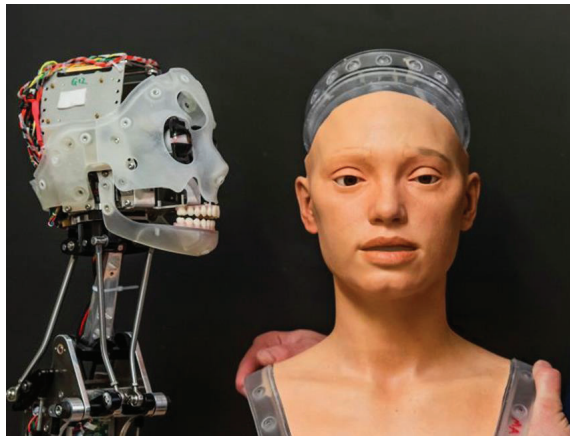
Machine to humans?

World's first humanoid robot In future will Chat GPT have a face?



Ai-Da 'sees'

- through a camera in her eye and
- responds without human intervention,
- isolating her subject from the background, interpreting it and drawing it by hand.



Ai-Da.

Hierarchy of Digital Knowledge and Scenarios for Applications

Knowledge economy	Digital technologies	Digital economy
Wisdom	AI and Blockchain, IOT, mobile and remote technologies (some pre-programmed). Networks and networking	
Intelligence	Artificial intelligence, quantum computation, data analytics, Simulations	
Knowledge	Cloud storage, Digital marketing	
Information	Social networks and use of metrics and analytics	Big brother knows all about you, and your secrets AI-DA gives it form and meaning?
Data	Social media Using G2, G3, G4, Next G5?	Collected without permission? Privacy laws? ALEXA gathers data and FAKE NEWS?

Hierarchy of Digital Knowledge and “the brain-computer interface”

Neuralink has implanted its first brain chip in human

([Alex Hern](#) (2024) *UK technology editor, The Guardian*, 30 Jan)

- Patient recovering well with signs of ‘promising neuron spike detection’, says startup’s founder [Alun Musk](#)
- The startup’s study, Prime, is a trial for its wireless brain-computer interface to evaluate the safety of the implant and surgical robot.

The brain-computer interface

-
- Researchers will assess the functionality of the interface, which enables people with quadriplegia to control devices with their thoughts, according to the company's website.
- Next step?

The dynamics of the 'Triangle'

Internal: Organisational Triangle i.e. within your team or group or division. Between division e.g. operations, logistics, finance, HR etc. Between regional operations.



The dynamics of the 'Triangle'

External: With stakeholders i.e. everyone that has a stake in your organisation e.g. customers, suppliers, competitors, shareholders, utility suppliers, government etc

Some examples of changes in the triangle

Suppliers: Important supplier(s) close(s) down. New suppliers appear.

Customers: Increase in customers or loss of customers, customer complaints

Government: New policies, change in regulations, new leadership and change in objectives etc

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The dynamics of the 'Triangle'

Triangle or Pentagon or Hexagon? Or even many more? We all have extensive networks but we don't make enough use of them.

We need to make more use of our networks!

We have many in our network. And the network is dynamic i.e. changes constantly.

- I. Social Networks: Family, relatives and friends.
- II. Business Networks: Related to your work
- III. Professional Networks: Those in your expert area i.e. the discipline you are qualified in, members in your professional association etc.

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The dynamics of the 'Triangle'

What if we have a human-computer link?

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Summary

- Everything is connected and interconnected
- Networks and networking is essential in a digital ecosystem
- Human Intelligence and Artificial Intelligence will become connected and interconnected
- The Knowledge Hierarchy can be used as a checklist for humans to stay on top.

**(IITAMS)
International
ITAM Society**

ITAM 28

**21-22 February 2024
Dayeh University, Taiwan**



The human mind and AI in the knowledge hierarchy

THANK YOU

Professor Kanesh K Rajah

Executive Director

Centre for Executive and Professional Development London