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CHALLENGES AND OPPORTUNITIES OF TIKTOK'S LIVE STREAMING SALES PHENOMENON IN SICHUAN PROVINCE, CHINA

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Abstract

This research aims to analyzing TikTok live-streaming sales, its influence on consumer behavior and purchasing habits in Sichuan Province, China, while also analyzing the opportunities and obstacles encountered by businesses utilizing emerging sales channel. As more merchants migrate to TikTok's e-commerce platform, the study proposes two hypotheses. It finds that factors like consumers' understanding of products, competitive pricing, and improved shopping experiences are linked to their purchasing decisions. Additionally, aspects such as enhanced customer service, diverse delivery options, flexible return policies, and varied payment methods influence consumer engagement in TikTok live-streaming events. Insights from interviews and surveys with businesses highlight that while leveraging TikTok live-streaming can enhance brand visibility, challenges such as talent shortages and intense market competition persist.

Keywords: TikTok, Live Streaming Sales, Consumer Behavior

Introduction

In 2023, TikTok boasted an impressive user base, with over 1 billion registered users, 700 million daily active users, and 1.5 billion monthly active users, cementing its status as a global sensation (Statista ,2023).

According to Data.ai (2023) and Statista (2023), TikTok average user engagement of more than 52 minutes per day, with its bite-sized videos lasting around 15 seconds, solidifying its position as a dominant force in the social media realm. Its influence extends across various domains, impacting culture, economics, and even politics globally. Culturally, TikTok has sparked trends like dance challenges and music phenomena. Economically, it has opened doors for creators and businesses, fostering employment opportunities. However, its political implications have prompted debates regarding freedom of expression and national security in certain nations.

TikTok's rapid ascent can be attributed to several factors, including its innovative 15-second video format tailored to modern attention spans, a sophisticated recommendation algorithm delivering personalized content, a diverse content ecosystem catering to varied interests, and the presence of celebrities and influencers drawing significant traffic.

In essence, TikTok's worldwide triumph is rooted in offering users a premium experience, fostering entertainment, facilitating cultural exchange, and creating fresh economic avenues. Nonetheless, it faces challenges like addiction risks, inappropriate content, and privacy issues, necessitating proactive actions from stakeholders.

Beyond its entertainment appeal, TikTok evolved into a formidable e-commerce platform, particularly through its live-streaming feature. The e-commerce agency & official Tmall partner - sell in China (2023) points out that this feature facilitated direct interaction between businesses and



consumers, fostering a surge in live sales on TikTok, especially notable in China's rapidly expanding e-commerce market. Sichuan Province, renowned for its flourishing e-commerce ecosystem, became a focal point for studying the impact of TikTok live-streaming sales on local businesses. Consequently, a study aims to delve into the impact of TikTok live-streaming sales on local businesses in Sichuan Province. By exploring the challenges and opportunities inherent in this phenomenon, the study seeks to uncover strategies and best practices for enterprises to effectively leverage TikTok live-streaming sales, maximizing market potential in Sichuan Province.

Research Objectives

1. To analyze the impact of TikTok live-streaming sales on consumer behavior and purchasing decisions in Sichuan province, China.

2. To explore the challenges and opportunities companies face in adopting and implementing TikTok live-streaming sales as a sales channel in Sichuan.

3. To develop guidance for companies that are new and trying to get involved in TikTok live-streaming sales, adopt this mode of sales.

Literature Review

In September 2016, Beijing ByteDance Technology Co., Ltd. introduced the short video social platform 'TikTok' app. Its unique format, user-friendly interface, brief content consumption, and adaptable content creation capabilities resonated with the fast-paced lifestyles of modern society, drawing in a substantial user base. Leveraging its early user traction and ability to cater to fragmented time slots, TikTok swiftly rolled out a live-streaming feature. As TikTok live-streaming sales gained momentum, businesses recognized the immense popularity of high-traffic content on the platform, often accumulating thousands or even millions of likes. Surprisingly, the influence wielded by these top broadcasters rivaled that of traditional celebrities. Zhang (2022) points out that some companies began experimenting with advertising placements within these popular works, leading to significant profits. This pivotal shift marked the seamless integration of TikTok live-streaming sales into the wider e-commerce market landscape.

Wang, Wei, & Liu. (2022), mention Chinese dairy industry as an example and analyze the challenges companies face in product promotion on TikTok. The study proposed the following challenges: to improve promotional video content innovation, tap into the depth of potential consumers and consumer demand, and strengthen the unified management of brand accounts. Improve the connection and quality of relevant accounts; centrally fix the period for live broadcasts to bring goods and extend the audience's stay in the live broadcast room. It was also pointed out that due to the rapid development of TikTok, it has gradually become a new tool for many companies to promote their products in 2019. Many companies have registered accounts on TikTok, produced videos, and utilized the live broadcast functions, gradually forming a new promotional and publicity model of "TikTok + live broadcast + e-commerce."

Zhang (2018) highlights the rapid growth of cross-border e-commerce, which has resulted in a scarcity of skilled professionals in the field, causing labor shortages within businesses. To foster robust e-commerce development, enterprises must delineate relevant job responsibilities and establish a proficient teaching team to facilitate collaborative initiatives between educational institutions and businesses. This approach aims to nurture e-commerce talent effectively.

Ding (2018) observes that consumers often display herd-buying tendencies and engage in impulsive purchases while watching specific live broadcasts promoting products. This behavior is fostered by businesses during TikTok live-streaming, where they intentionally create an atmosphere



that encourages immediate purchases. For example, they may emphasize limited-time offers or create a sense of urgency by suggesting high demand for the product, prompting viewers to make spontaneous purchasing decisions.

Huang, Ye, & Wang. (2023) observe that the e-commerce sector's rapid growth has elevated live-streaming shopping to the predominant consumer shopping method. Their research underscores the impact of live broadcast hosts and product categories on consumer decision-making. Their experimental findings indicate that engaging celebrity hosts to endorse and demonstrate products, alongside highlighting practical product features, enhances consumer product recognition and boosts their inclination to make purchases. Abidin (2023) highlights how TikTok Korea strategically entered the Korean market during the COVID-19 pandemic by leveraging the immense popularity of K-pop. They achieved this by launching the 'TikTok Stage,' which involved promotional initiatives featuring K-pop celebrities to facilitate the platform's localization efforts in Korea. Petrovic (2022) highlights that TikTok has garnered significant popularity within Japanese social media platforms, particularly amidst the COVID-19 pandemic. It has emerged as a substitute form of social entertainment, with users utilizing the platform to emulate singing and dancing typically found in bars. Truong (2023) emphasizes the popularity of TikTok among Vietnam's youth, highlighting its role in providing both entertainment and educational opportunities online. While the prevailing sentiment suggests that TikTok's benefits outweigh its drawbacks, there remains a faction that perceives TikTok usage as detrimental.

Methodology

The study employed a mixed-methods approach, utilizing both quantitative and qualitative analysis to examine the influence of TikTok live-streaming on consumers and businesses. A comprehensive analysis was conducted through data collection and examination of individuals and businesses engaged with or impacted by TikTok live-streaming sales in Sichuan Province, China.

Before commencing formal data collection, a pilot test will be conducted on roughly 32% of the overall sample size (which amounts to 148 individuals) to ensure the questionnaire's clarity and ease of completion. Given the regional focus of this study on Sichuan Province, China, the survey targets respondents from this specific area. Based on the feedback received from the 148 responses obtained during the pilot test, adjustments were made to the questionnaire. This included removing eight questions, adding one question, and changing the platform used for questionnaire creation and distribution.

This study employed the random sampling technique alongside the Yamane Taro formula to determine the required sample size. A total of 481 investigators residing in Sichuan Province, China, who had exposure to TikTok live sales, participated in the questionnaire survey. Additionally, in-depth interviews were conducted with representatives from five companies engaged in TikTok live-streaming business operations. According to a DataReportal (2023) report, the estimated total number of TikTok users in Sichuan Province, China, in 2023 was around 70 million. It is projected that this number will continue to grow, reaching approximately 80 million by 2025.

Data for this study was acquired through the administration of questionnaires and conducting interviews. This combined approach allowed for a deeper understanding of the impact of TikTok live-streaming on both consumers and enterprises. The questionnaire, created using the WJX platform (the platform that provides the questionnaire production), was distributed across WJX, WeChat, and various other social media platforms to collect data. This dual approach of questionnaire surveys and interviews facilitated a thorough exploration of the topic.



The questionnaire used in this study was structured into four sections, comprising a total of 20 questions. The first section focuses on gathering respondents' demographic information, including gender, age, and occupation. The second section delves into the impact of TikTok live-streaming sales on consumer behavior and purchasing decisions. The third section investigates the challenges and opportunities businesses encounter when adopting and implementing TikTok live-streaming as a sales channel. Lastly, the fourth section includes an open-ended question aimed at gathering additional insights into TikTok live sales. Concurrently, the interview aspect of the study comprised 7 carefully crafted questions designed to provide deeper insights into how businesses perceive the products marketed through TikTok live-streaming.

During the data collection phase of this study, the questionnaire was assessed using a 5-point Likert scale to ensure the acquisition of robust statistical data. The Likert scale ranged from (1) strongly agree to (5) completely disagree, allowing respondents to indicate their level of agreement or disagreement with the provided statements (Kusmaryono, Wijayanti, & Maharani.2022). The questionnaire encompassed a mix of closed-ended questions for quantitative analysis and open-ended questions to gather more detailed qualitative insights. This balanced approach allowed for the acquisition of both statistical data and nuanced information, contributing to a comprehensive exploration of the research topic.

Before engaging in the questionnaire and interview processes, researchers provide an overview of the test methods and offer guidance to the respondents. The interview involves a written one-on-one dialogue between the investigator and the respondent, with the investigator documenting a summary of the discussion.

Following the completion of data collection, SPSS software was employed to conduct descriptive analysis, cross-analysis, and correlation analysis. The aim of these analyses was to interpret the data obtained from the administered questionnaires and interviews. Quantitative data were derived from the questionnaires, while qualitative data were obtained through the interview process. This comprehensive approach facilitated a thorough interpretation of the research findings.

Results and Discussion

Based on the research purpose, this study proposed two research hypotheses:

Hypothesis 1: TikTok live-streaming has a positive impact on consumer purchasing behavior, leading to an increase in sales in Sichuan Province.

Hypothesis 2: Companies using TikTok as a sales channel in Sichuan will have a positive impact on their businesses.

The chapter is structured into three main sections. The first section focuses on descriptive analysis and cross-analysis, primarily examining the demographics such as gender, age, and occupation of the questionnaire respondents. In the second section, correlation analysis is conducted to assess the relevance of the questions included in the questionnaire. Lastly, the third section concludes with a summary of the data analysis results.



Descriptive analysis and Cross-analysis



Gender of Respondents



This research survey considered the privacy of respondents by providing a third-party privacy option in the gender question. However, all respondents in this questionnaire disclosed their gender, resulting in a 0 proportion for the third option. Among the 481 surveyed participants, 231 individuals, accounting for 48.02% of the sample, identified as male, while 250 respondents, comprising 51.98% of the sample, identified as female. (Picture 1).



Income of the Respondents

Picture 2: Income of Respondents



According to the survey data, 14.14% (68 individuals) of respondents reported an annual income of less than 10,000 CNY, while 22.45% (108 individuals) reported incomes falling within the range of 10,000 to 50,000 CNY. Additionally, 39.09% (188 individuals) of respondents reported earning within the range of 50,000 to 100,000 CNY annually. Furthermore, 14.35% (69 individuals) of respondents reported annual incomes within the range of 100,000 to 200,000 CNY, and 9.98% (48 individuals) reported incomes of 200,000 CNY or higher. (Picture 2)



Age of Respondents

Picture 3: Age of Respondents

In this survey, an analysis of age reveals that the primary respondents are predominantly young individuals. Within the age group of 18 to 28 years, they constitute 23.7% of the total respondents, totaling 114 individuals. The age range of 26 to 35 represents the largest portion, accounting for 40.54% of the total respondents, with 195 individuals. Additionally, individuals aged 36 to 45 comprise 20.79% of the total respondents, amounting to 100 participants. Among those aged 46 to 55, they make up 9.56% of the total, consisting of 46 individuals. Lastly, individuals aged 55 and above account for 5.41% of the total respondents, with 26 participants. (Picture 3).





Occupation of Respondents



Upon analyzing the collected occupational data, it is evident that the majority of respondents in this questionnaire survey are employed. Specifically, among the respondents, 116 individuals are students, constituting 24.12% of the total. Additionally, 214 individuals are employed, representing the largest portion at 44.49% of the total. There are also 100 self-employed individuals, accounting for 20.79% of the total respondents. Furthermore, 25 individuals are unemployed, making up 5.2% of the total. Lastly, there are 26 individuals from other occupations, comprising 5.41% of the total participants. (Picture 4).

The following is a cross-analysis of age and occupation:

In the age group of 18 to 25, there were 114 respondents, consisting of 109 students, 4 employed individuals, and 1 unemployed individual, with 0 self-employed or other occupations reported. Among those aged 26 to 35, there were 195 respondents, including 5 students, 111 employed individuals, 50 self-employed individuals, 15 unemployed individuals, and 14 in other occupations. Within the age range of 36 to 45, 100 respondents were recorded, comprising 1 student, 58 employed individuals, 28 self-employed individuals, 6 unemployed individuals, and 7 in other occupations. For the 46 to 55 age group, there were 46 participants, consisting of 1 student, 25 employed individuals, 17 self-employed individuals, 1 unemployed individual, and 2 in other occupations. Finally, among those aged 56 and above, there were 26 respondents, including 16 employed individuals, 5 self-employed individuals, 2 unemployed individuals, and 3 in other occupations, with 0 students reported. (Table 1).

X\Y	Student	Employed	Self-employed	Unemployed	Other	Total
(18-25)	109	4	0	1	0	114
	(95.61%)	(3.51%)	(0.00%)	(0.88%)	(0.00%)	
(26-35)	5	111	50	15	14	195
	(2.56%)	(56.92%)	(25.64%)	(7.69%)	(7.18%)	
(36-45)	1	58	28	6	7	100
	(1%)	(58%)	(28%)	(6%)	(7%)	

 Table 1: Cross-analysis of age and occupation (X=age Y=occupation).



X\Y	Student	Employed	Self-employed	Unemployed	Other	Total
(46-55)	1	25	17	1	2	46
	(2.17%)	(54.35%)	(36.96%)	(2.17%)	(4.35%)	
(56 and above)	0	16	5	2	3	26
	(0.00%)	(61.54%)	(19.23%)	(7.69%)	(11.54%)	

Below is a cross-analysis of occupation and income:

Among the 116 respondents who are students, 47 individuals have an annual income of less than 10,000 CNY, 60 individuals have an annual income of 10,000 to 50,000 CNY, while 7 individuals have an annual income of 50,000 to 100,000 CNY. Additionally, there are 2 individuals with an annual income of 100,000 to 200,000 CNY, and 0 with an income of 200,000 CNY and above.

Among the 214 employed respondents, 1 individual has an annual income of less than 10,000 CNY, 28 individuals have an annual income of 10,000 to 50,000 CNY, and 116 individuals have an annual income of 50,000 to 100,000 CNY. Furthermore, 42 individuals have an annual income of 100,000 CNY, and 27 individuals have an annual income of 200,000 CNY and above.

Among the 100 self-employed respondents, 1 individual has an annual income of less than 10,000 CNY, 14 individuals have an annual income of 10,000 to 50,000 CNY, while 52 individuals have an annual income of 50,000 to 100,000 CNY. Additionally, 19 individuals have an annual income of 100,000 CNY, and 14 individuals have an annual income of 200,000 CNY and above.

Among the 25 unemployed respondents, 19 individuals have an annual income of less than 10,000 CNY, and 6 individuals have an annual income of 10,000 to 50,000 CNY. There are 0 individuals with an annual income in the range of 50,000 to 100,000 CNY, 100,000 to 200,000 CNY, or 200,000 CNY and above.

Among the 26 respondents with other occupations, 0 have an annual income in the range of less than 10,000 CNY or 10,000 to 50,000 CNY. However, there are 13 individuals with an annual income of 50,000 to 100,000 CNY, 6 individuals with an annual income of 100,000 to 200,000 CNY, and 7 individuals with an annual income of 200,000 CNY and above. (Table 2)

X\Y	Less than	10,000-50,000	50,000-100,000	100,000-200,000	200,000CNY+	Total
	10,000CNY	CNY	CNY			
Student	47	60	7	2	0	116
	(40.52%)	(51.72%)	(6.03%)	(1.72%)	(0.00%)	
Employed	1	28	116	42	27	214
	(0.47%)	(13.08%)	(54.21%)	(19.63%)	(12.62%)	
Self-employed	1	14	52	19	14	100
	(1%)	(14%)	(52%)	(19%)	(14%)	
Unemployed	19	6	0	0	0	25
	(76%)	(24%)	(0.00%)	(0.00%)	(0.00%)	
Other	0	0	13	6	7	26
	(0.00%)	(0.00%)	(50%)	(23.08%)	(26.92%)	

Table 2: Cross-analysis of occupation and income (X= occupation Y= income).

Correlation analysis

The table uses the Pearson correlation coefficient to analyze the strength of the correlations among the 7 items in the table. (Table 3)



Statistical results: The value of the correlation coefficient between Q6 (Have TikTok Live Sales influenced your purchasing decisions?) and Q7 (Did you purchase because of a product you saw in a TikTok Live Sales?) is 0.083, which is close to 0, and the p-value is 0.068>0.05.

Correlation conclusion: There is no correlation between Q6 and Q7.

Statistical results: The value of the correlation coefficient between Q6 and Q8 (Do you think that TikTok Live Sales offer a different shopping experience than traditional shopping methods?) is 0.084 which is close to 0 and the p-value is 0.066>0.05.

Correlation conclusion: There is no correlation between Q6 and Q8.

Statistical results: The value of the correlation coefficient between Q6 and Q9 (Do you think TikTok Live Sales make shopping more convenient?) is 0.054 which is close to 0 and the p-value is 0.234>0.05.

Correlation conclusion: There is no correlation between Q6 and Q9.

Statistical results: The value of the correlation coefficient between Q6 and Q10 (Do you think that TikTok Live Sales have increased your knowledge of products?) is 0.110 and shows significance at 0.05 level.

Correlation conclusion: There is a significant positive correlation between Q6 and Q10.

Statistical results: The value of the correlation coefficient between Q6 and Q11 (Do you think TikTok Live Sales offer better pricing?) is 0.110 and shows significance at 0.05 level.

Correlation conclusion: There is a significant positive correlation between Q6 and Q11.

Statistical results: The value of the correlation coefficient between Q6 and Q12 (Do you think TikTok Live Sales provides a better shopping experience?) is 0.092 and shows significance at 0.05 level.

Correlation conclusion: There is a significant positive relationship between Q6 and Q12.

Pearson Correlation	Have TikTok Live Sales influenced your purchasing decisions? (Q6)
Did you purchase because of a product you saw in a TikTok Live sale? (Q7)	0.083
Do you think that TikTok Live Sales offer a different shopping experience than traditional shopping methods? (Q8)	0.084
Do you think TikTok Live Sales make shopping more convenient? (Q9)	0.054
Do you think that TikTok Live Sales have increased your knowledge of products? (Q10)	0.110*
Do you think TikTok Live Sales offer better pricing? (Q11)	0.110*
Do you think TikTok Live Sales provides a better shopping experience? (Q12)	0.092*
* <i>p</i> <.05 ** <i>p</i> <.01	

Table 3: TikTok Live Sales influences consumer behaviors and purchasing decisions.

This table uses correlation analysis to investigate the correlation between Q13(Are you more likely to buy products from a company that conducts TikTok Live Sales?) and the six items Q14(Do you think that TikTok Live Sales offers more product choices?), Q15(Do you think TikTok Live Sales offer better customer service?), Q16(Do you think TikTok Live Sales provides better delivery options?), Q17(Do you think TikTok Live Sales offers a better return policy?), Q18(Do you think TikTok Live Sales offers better payment options?), and Q19(What do you think the chances are for companies in Sichuan Province when adopting and implementing TikTok Live Sales as a sales channel?)



respectively, and the Pearson correlation coefficient is used to indicate the strength of the correlation. (Table 4)

Statistical results: The correlation coefficient between Q13 and Q14 is 0.031, which is close to 0, and the p-value is 0.492 > 0.05.

Correlation conclusion: There is no correlation between Q13 and Q14.

Statistical results: The value of the correlation coefficient between Q13 and Q15 is 0.213 and shows significance at 0.01 level.

Correlation conclusion: There is a significant positive correlation between Q13 and Q15.

Statistical results: The value of the correlation coefficient between Q13 and Q16 is 0.179 and shows significance at 0.01 level.

Correlation conclusion: There is a significant positive correlation between Q13 and Q16.

Statistical results: The value of the correlation coefficient between Q13 and Q17 is 0.172 and shows significance at 0.01 level.

Correlation conclusion: There is a significant positive correlation between Q13 and Q17.

Statistical results: The value of the correlation coefficient between Q13 and Q18 is 0.182 and shows significance at 0.01 level.

Correlation conclusion: There is a significant positive correlation between Q13 and Q18. Statistical results: The value of the correlation coefficient between Q13 and Q19 is -0.073,

which is close to 0, and the p-value is 0.108>0.05.

Correlation conclusion: There is no correlation between Q13 and Q19.

Table 4:	Challenges and opportunities that companies face when adopting and implementing TikTok
	live sales as a sales channel.

Pearson Correlation	Are you more likely to buy products from a company that conducts TikTok Live Sales? (Q13)
Do you think that TikTok Live Sales offers more product choices? (Q14)	0.031
Do you think TikTok Live Sales offer better customer service? (Q15)	0.213**
Do you think TikTok Live Sales provides better delivery options? (Q16)	0.179**
Do you think TikTok Live Sales offers a better return policy? (Q17)	0.172**
Do you think TikTok Live Sales offers better payment options? (Q18)	0.182**
What do you think the chances are for companies in Sichuan Province when adopting and implementing TikTok Live Sales as a sales channel? (Q19)	-0.073
* p<.05 ** p<.01	

Conclusion

This study seeks to investigate the impact of TikTok live-streaming on consumer buying behavior in Sichuan Province, China, along with the opportunities and challenges encountered by local businesses embracing TikTok live-streaming as a sales platform. The results suggest that factors such as consumers' perceptions of products, competitive pricing within the TikTok ecosystem, and specific consumer experiences play significant roles in influencing purchasing decisions. However, the act of merely watching TikTok live-streams, preferences for different consumer methods, and considerations of platform convenience do not directly affect consumer purchasing choices. Moreover, consumers tend to favor spending with TikTok live-streaming vendors that provide exceptional customer service, a range of delivery options, flexible return policies, and convenient payment methods.



The availability of a wider product selection on the TikTok platform does not appear to be an exponential factor in attracting consumers to purchase (survey-based key findings).

Moreover, interviews with five companies reveal that; while they recognize the benefits of TikTok live-streaming for sales and brand awareness, they also face challenges, such as a shortage of skilled live sales professionals, a lack of understanding of live marketing strategies, and intense industry competition. Nonetheless, companies exhibit optimism and a proactive approach towards overcoming these obstacles, demonstrating a commitment to adapt and innovate in order to thrive in the TikTok live-streaming realm.

In terms of the future research direction of this study, the plan is to undertake more comprehensive and in-depth research. This will involve gathering more extensive and detailed data for thorough investigation and analysis. The plan is to broaden the geographical scope of the research to include adjacent provinces. This expansion aims to address the current gap in research on TikTok's live-streaming sales, particularly in Sichuan Province, where data is lacking.

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DIGITAL MARKETING, APPAREL MARKET ANALYSIS IN THAILAND: ONLINE SHOPPING PREFERENCES

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Abstract

Digital marketing is becoming a great force for enterprises, especially in fashion, and cannot be underestimated. This research focuses on the pivotal role of digital marketing in Thailand's apparel industry, investigating its influence on customer behavior and buying decisions. This study strives to furnish knowledge into the development landscape of online shopping, emphasizing Thailand's rapidly growing e-commerce industry, despite the impacts of COVID-19. A thorough examination of existing literature investigates the information on purchasing apparel online, underscoring the importance of promotional strategies, product quality perception, and social media engagement.

A survey was designed and distributed among Bangkok residents, to gather data, and understand the state of online shopping, online shoppers, and consumer behavior. As well, as highlighting the correlation between trust in reviews, influencer impact, and brand perception. Three hypotheses are examined, indicating the significance of digital marketing strategies in forming purchasing behavior. This research provides beneficial insights into the various motions of online shopping in Thailand, proposing obtainable suggestions for enterprises aiming to improve their digital marketing endeavors and flourish in the competitive digital age. The results highlight the need for tailored digital marketing strategies that align with consumers' varying purchasing behaviors and preferences, particularly concerning delivery services.

Keywords: Digital Marketing, Apparel Market, Thailand, Online Shopping, Consumer Preferences

Introduction

Digital business is a substantial sector for the success of any business internationally. Businesses that do not execute their business with relevant online applications are very tolerant of lagging behind their opponents. In this study, we are going to present the significance of digital marketing and why it is crucial for businesses of all sizes. Digital marketing has become a critical segment for fashion initiatives around the globe today, including the Thai apparel industry. Mazars (2021) stated that the COVID-19 pandemic has had a significant impact on various business sectors and the overall economy of Thailand. Attributable to the disruption arising during the contemporary tragedy, businesses must stay agile, retain their business strategies, and twist this tragedy into a possibility.

According to ECDB (2022), Thailand's apparel e-commerce market is estimated to be US\$695.6 million by 2023, and the fashion market is calculated to be 48.1% effective. It is anticipated to expand further in the coming years. In addition, the estimated compound annual growth rate for the next 4 years is 14.8%, together with the approximate market volume will reach US\$1,207.2 million in 2027 (ECDB, 2022).



In this study, the section on Thailand's apparel industry history examines how digital marketing comprises a crucial segment in Thailand's apparel industry. Consumer Behavior and digital marketing behaviors in Thailand's apparel industry are pointed out in their chapters.

Research Objectives

Gaining a deeper understanding of the digital landscape and consumer behavior of the apparel market in Thailand.

1. To find out the consumers' willingness to purchase Thai apparel items.

2. To analyze and develop a guideline on digital marketing strategies in the Thai apparel market.

Literature Review

This section examines various aspects of online shopping behavior in Thailand, synthesizing insights from a diverse collection of academic works.

Sangchan (2014) and Chuprapawan (2023) clarify the nuanced preferences and decision-making procedures of online consumers alongside other important supports.

The table below highlights the most influential works within the scope of this study.

Authors	Aims	Theories	Methodology	Findings
(SANGCHAN, 2014)	Analyzed the fundamental successful factors affecting online clothing brands through the customer's point of view.	Consumer behaviour, Purchasing decisions	In-depth interview, Quantitative research	Online customers have various purchasing behaviors and buying standards based on their lifestyles and incomes. Customers don't want to buy clothing online when the quality of clothes they receive is not as good as in the photo.
(CHUPRAPAWAN, 2023)	Investigated the factors that influence online shopping behavior and figure out the marketing strategies that can improve online sales in the fashion clothing market in Thailand.	Marketing Strategy	Qualitative research	Thai customers considered convenience, price, and quality as key factors when making online purchases. Also, promotion discounts and marketing advertising found to be favorably adequate in creating online sales.
(Lerkpollakarn & Khemarangsan, n.d)	Examined the actual behavior of customers in fashion clothing under the four major factors: Physical, Identity, Lifestyle, and Store environment between different genders to discover	Consumer behavior	Quantitative research	Both women and men tend to explore the price before buying the clothing in the same ratio.

Table 1: Summary of literature review.

Authors	Aims	Theories	Methodology	Findings
	factors that will influence them the most before making a purchasing decision.			
(BANDIDNIYAMANO N, 2014)	Studied consumers' behavior, preferences, mindsets, and perceptions as well as fundamental factors in buying decisions.	Marketing Strategy and purchasing decision	Quantitative and Qualitative research	The difference between product quality and the ones promoted is the most affected matter deterring customers from purchasing. A reasonable price is most intended for the price factor and harmonization of discounts and promotion is the most important factor for promotion factor.
(SA-NGUANPUAK, 2016)	Examined the factors impacting Thai consumers toward online clothing shopping through social media stores.	Theory of Planned Behaviour (TBP), Perceived Risks Theory	In-depth qualitative interview	Customers are encouraged to have purchase intention by attractive photos of the products through social media ads.
(BUPPHACHUEN, 2021)	To help fashion entrepreneurs, brand managers to understand millennials' emotions and perception about their products, how they value and perceive brands along their customer journey.	Customer decision-making, Purchasing intention	Exploratory research, descriptive research, in-depth interviews	Sales promotion is the most significant factor that impacts purchase intention, which creates the feeling of gaining good buy and saving money.
(Wongchaisuwan, n.d)	To examine the decision-making on buying fashion products via Facebook by Thai Facebook Users.	Consumer decision	Quantitative research	Facebook has a significant impact on the purchase decision of fashion products.
(Aramrungroj, 2015)	To explore the relationship between age, education, occupation, product, price, place, promotion, perceived usefulness, perceived ease of use, and purchasing decision female fashion clothes via Facebook.	Marketing mix, Technology Acceptance Model	Quantitative research	Promotion, perceived usefulness, price, perceived ease of use, product, and place factors have the effect to purchasing decision.
(SILAPAOUYCHAI, 2016)	To identify and determine the vital factors that can have a profound impact on Thai online fashion brands.	Purchasing decision	Exploratory research Method, Qualitative research	Brand-conscious customers indicated the highest levels of overall satisfaction and preference to buy fashion products online.



Authors	Aims	Theories	Methodology	Findings
(AKAPOP, 2017)	To investigate factors that cause consumers to buy clothing products in an online market.	Convenience sampling method	Quantitative research method	Product information quality, service information quality, and security perceptions significantly influence purchase behaviour.

Various researchers have examined diverse factors influencing online apparel shopping in Thailand. Sangchan (2014) aimed to understand the paramount factors affecting online apparel brand success from the shopper's perspective, highlighting differences in buying behaviors and dissatisfaction arising from discrepancies between advertised and received product quality. Chuprapawan (2023) analyzed factors influencing online buying behavior, emphasizing convenience, price, and quality as critical, along with effective promotional strategies. Lerkpollakarn (n.d) explored gender discrepancies in apparel buying behavior, finding that both men and women prioritize price considerations. Bandidniyamanon (2014) researched customer behavior and identified product quality and promotional alignment as substantial factors influencing purchasing decisions. Sa-Nguanpuak (2016) investigated the impact of social media advertising on customer behavior, emphasizing its role in influencing purchase intentions through visually appealing product displays. Bupphachuen's study underscored the importance of sales promotions in influencing purchase intentions among millennials, highlighting the significance of perceived value and cost-saving. Wongchaisuwan's analysis highlighted the influence of Facebook on purchasing decisions for fashion goods, indicating the platform's substantial role in shaping customer behavior. Aramrungroj's research focused on the relationship between demographic factors, technological acceptance, and purchasing decisions via Facebook, emphasizing the impact of promotions, perceived usefulness, and pricing. Silapaouychai's study indicated brand-consciousness as a crucial aspect influencing satisfaction and intention for online clothing brands. Finally, Akapop's research emphasized the significance of product and service information quality, as well as security perceptions, in shaping customer buying behavior in online apparel markets. In conclusion, these investigations provide valuable insights into the multifaceted dynamics of customer decision-making in the online fashion industry.

Methodology

This research aims to process and analyze collected data and find out how digital marketing is abiding improvement in the apparel industry and how the buyers influence behavior/efforts in the apparel industry. Accordingly, an online primary data collection was conducted, targeting youth and adult consumers in Thailand. Thailand's apparel market survey questionnaires were equipped to fit the two hypotheses.

After the survey questionnaires were prepared, the questionnaires were digitized or converted into a "Google Form" format for online data collection. Next, a pretest or pilot survey was accomplished by using a Google Form to find out whether those questions were fit and practicable or answerable to the participants. A total number of 20 respondents took part in the pilot testing.

Online data collection took place on social media platforms and asked consumers. A random sampling method was used in this study with 400 respondents aged between 15 and 59 living in Bangkok. The Taro Yamane formula was used to calculate the sample size. The online data collection was completed using a Google Form data collection tool to obtain perspectives, knowledge, attitudes, and recent conditions on the digital marketing of apparel products.



Compiled data were categorized as an MS Excel database system in CSV format disseminated from Google Forms. Before the data were investigated, consistency, completeness, correctness, and data cleaning were accomplished. While the descriptive statistical data analysis was executed, the data was examined/analyzed by employing PSPP open source for Windows.

Results

Table 2 presents the demographic characteristics of the customers who use digital platforms to purchase apparel in Bangkok, Thailand. The survey collected data on the customers' gender, age, occupation, monthly income, and other relevant demographic factors. The table demonstrates the frequency and percentage of each variable and its classifications. Many customers identified as female, mostly aged between 26-35 years old, with a notable proportion being students, and their monthly income ranged from 10,000 to 30,000 Baht.

Gender: The plurality of the respondents was female, considering for 51% of the total sample, accompanied by males at 43%. A slight percentage, 5%, determined as 'Other.'

Age Group: The respondents were allocated across various age groups, with the highest age group falling between 26 and 35 years old (42%). The largest age group of respondents is 36 to 50 years old (23%), followed by 19 to 25 years old (21%). Respondents under 18 constitute 5% of the sample, while those over 51 contributed 9%.

Occupation: The highest occupational group among the respondents was students, consisting 31% of the sample. Employed people delegated 19%, self-employed group constitute 20%, and the unemployed group counted as 21%. A slighter percentage, 8%, categorized into the 'Other' category.

Monthly Income: The plurality of respondents declared monthly incomes varying from 10,000 to 30,000 Baht, representing 46% of the sample. The following considerably common income was 50,001 to 100,000 Baht (27%), accompanied by 30,001 to 50,000 Baht (21%). A fewer percentage, 7%, enlisted earning more than 100,000 Baht per month.

Generally, this table delivers a broad summary of the demographic manuscript of the study respondents, providing beneficial insights into the factors of the sample population and supporting the understanding of the analysis findings within the framework of the target demographic.

Statistical variables	Classification	Number	Percentage (%)
Gender	Female	212	51%
	Male	178	43%
	Other	22	5%
Age group	19 – 25	85	21%
	26-35	174	42%
	36-50	95	23%
	Less than 18 yrs	21	5%
	Over 51 yrs	37	9%
Occupation	Employed	78	19%
	Other	35	8%
	Self-employed	84	20%
	Student	127	31%
	Unemployed	88	21%
Monthly Income	10,000 - 30,000 Baht	188	46%
	30,001 - 50,000 Baht	86	21%
	50,001 - 100,000 Baht	111	27%
	More than 100,000 Baht	27	7%

Table 2 :	Demograph	ic Data
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The correlation analysis table presents the relationship between the number of years individuals have been using online shopping for apparel and their preferred shopping style. The Pearson correlation coefficient (r) of 0.198** suggests a moderate positive relationship between the variables. This indicates that as the years of online shopping experience increase, there is a tendency for distinct shopping preferences to develop. The significance level (Sig.) of 0.000 indicates that the observed correlation is statistically significant at the 0.01 level, meaning it is unlikely to have occurred due to chance. With a sample size (N) of 412 for both variables, these findings provide valuable insights into how the online shopping experience influences shopping style preferences in the Thai apparel market.

Hypothesis 1: H1: Digital marketing strategies significantly influence the Thai apparel market

		Q7N_Years using online shopping for apparel_H1	Q6N_Prefer apparel shopping style_H1
Q7N_Years using online shopping for apparel_H1	Pearson Correlation	1	.198**
	Sig. (2-tailed)		.000
	Ν	412	412
Q6N_Prefer apparel shopping style_H1	Pearson Correlation	.198**	1
	Sig. (2-tailed)	.000	
	Ν	412	412

Table 3: Years of engagement in online apparel shopping X Preferred style of apparel shopping.

**. Correlation is significant at the 0.01 level (2-tailed).

The ANOVA table assesses whether there are statistically significant differences in the mean years of online shopping experience among different shopping style preferences. The F-statistic of 8.352 suggests a significant difference in mean years of online shopping experience among the different shopping style preferences.

Table 4:	ANOVA	Results for	Years of	f Online	Shopping	Experience	for Apparel
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Q7N_Years using online shopping for apparel_H1									
	Sum of Squares	df	Mean Square	F	Sig.				
Between Groups	15.183	2	7.591	8.352	P = .000				
Within Groups	371.737	409	.909						
Total 386.920 411									

This indicates that shopping preferences significantly influence the length of time individuals have been engaging in online apparel shopping. With degrees of freedom (df) for between groups as 2, within groups as 409, and total as 411, these results underscore the importance of considering shopping style preferences when analyzing online shopping behavior in the Thai apparel market.



Dependent Variable:								
Tukey HSD								
(I) Q6N_Prefer apparel shopping Mean Std. Emery Size 95% Confidence Interval								
style_H1		Difference (I-J)	Stu. Error	51g.	Lower Bound	Upper Bound		
Physical stores	Both	233	.118	P = .118	51	.04		
	Online	477*	.117	P = .000	75	20		
Both	Physical stores	.233	.118	P = .118	04	.51		
	Online	244	.112	P = .075	51	.02		
Online	Physical stores	.477*	.117	P = .000	.20	.75		
	Both	.244	.112	.075	02	.51		

Table 5: Tukey's HSD Test for prefer apparel shopping style

*. The mean difference is significant at the 0.05 level.

The Tukey Honestly Significant Difference (HSD) test was performed to correspond to the mean discrepancies in online shopping experience among various shopping preferences.

Physical Stores vs. Both Shopping Styles: The mean difference between individuals preferring physical stores and those preferring both physical and online stores is -0.233. However, this difference is not statistically significant at the 0.05 level (p = 0.118), indicating that there is no significant distinction in online shopping experience between these two groups. The confidence interval for this comparison varied from -0.51 to 0.04, indicating a prospect coincide in online shopping experience between the two groups.

Physical Stores vs. Online Shopping: The mean difference between individuals favoring physical stores and those preferring online shopping is -0.477. This difference is statistically significant at the 0.05 level (p < 0.001), indicating that individuals who prefer online shopping have significantly more years of online shopping experience compared to those favoring physical stores. The confidence interval for this comparison varied from -0.75 to -0.20, implying a harmonious difference between the two groups with elevated confidence.

Both Shopping Styles vs. Online Shopping: The mean difference between individuals preferring both physical and online stores and those favoring online shopping exclusively is -0.244. This difference is marginally significant at the 0.05 level (p = 0.075), suggesting a trend towards individuals favoring online shopping having slightly more years of online shopping experience compared to those preferring both physical and online stores. The confidence interval for this comparison varied from -0.51 to 0.02. This interval includes zero, implying some anticipation of the extent of the discrepancy and advocating a prospect overlie in the online shopping experience between the two groups.

Hypothesis 2: H2: Specific digital marketing approaches impact consumer behavior and buying decisions in the Thai apparel market.



		Q8N_Last six months frequency of purchasing online apparel_H1_H2	Q11N_Time of length of delivery_H2
Q8N_Last six months frequency of	Pearson Correlation	1	185**
purchasing online apparel_H1_H2	Sig. (2-tailed)		P = .000
	Ν	412	412
Q11N_Time of length of delivery_H2	Pearson Correlation	185**	1
	Sig. (2-tailed)	P = 000	
	N	412	412

Table 6: Q8N_Last six months frequency of purchasing online apparel_H1_H2 X Q11N_Time of length of delivery_H2.

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation table investigates the connection between the commonness of purchasing online apparel in the last six months and the favored length of delivery period. The Pearson correlation coefficient (r) of -0.185** indicates a reasonable negative correlation between the variables. This demonstrates that as the frequency of online apparel acquisitions gains, customers aim to choose quicker delivery periods. With a significance level (Sig.) of 0.000, the correlation is statistically significant at the 0.01 level, indicating that this association is improbable due to possibility. With a sample size (N) of 412 for both variables, these results offer beneficial insights into how buying frequency impacts delivery time priorities in the Thai apparel industry.

Table 7: ANOVA Analysis Results for Time of Length of Delivery

Q11N_Time of length of delivery_H2							
	Sum of Squares	df	Mean Square	F	Sig.		
Between Groups	24.490	3	8.163	9.792	P = .000		
Within Groups	340.138	408	.834				
Total	364.629	411					

The ANOVA table considers whether there are significant discrepancies in the favored length of delivery period between groups depending on the frequency of purchasing online apparel. The F-statistic of 9.792 reveals a significant discrepancy in the mean preferred delivery period across the different frequency types. This focuses on the influence of purchasing frequency on delivery period intentions in the Thai apparel industry. With degrees of freedom (df) for between groups as 3, within groups as 408, and total as 411, these outcomes underline the significance of evaluating purchasing frequency when investigating delivery time preferences.

Table 8:	Tukey's HSD	Test for Frequency	of Online Apparel	Purchasing W	ithin Six Months
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Dependent Variable:							
Tukey HSD							
(I) Q8N_Last six months frequency of purchasing Mean Difference Std. Std. Str. Interval							
online apparel_H1_H2		(I-J)	Error	51g.	Lower Bound	Upper Bound	
Not at all	Occasionally (1-2 times)	.552*	.134	P = .000	.21	.90	
Moderately (3-5 times)		.375*	.143	P = .045	.01	.74	
	Frequently (more than 5 times)	.828*	.161	P = .000	.41	1.24	



Dependent Variable:							
Tukey HSD							
(I) Q8N_Last six months frequency of purchasing Mean Std. Size Interval							
online	(I-J)	Error	Sig.	Lower Bound	Upper Bound		
Occasionally	Not at all	552*	.134	P = .000	90	21	
(1-2 times)	Moderately (3-5 times)	177	.111	P = .380	46	.11	
	Frequently (more than 5 times)	.276	.134	P = .167	07	.62	
Moderately	Not at all	375*	.143	P = .045	74	01	
(3-5 times)	Occasionally (1-2 times)	.177	.111	P = .380	11	.46	
	Frequently (more than 5 times)	.453*	.143	P = .009	.08	.82	
Frequently	Not at all	828*	.161	P = .000	-1.24	41	
(more than 5 times)	Occasionally (1-2 times)	276	.134	P = .167	62	.07	
	Moderately (3-5 times)	453*	.143	P = .009	82	08	

*. The mean difference is significant at the 0.05 level.

The Tukey Honestly Significant Difference (HSD) test was performed to analyze the mean discrepancies in preferred delivery periods between various frequency types of online apparel acquisitions. The findings display significant disparities in preferred delivery time across different frequency types.

Not at all vs. Occasionally (1-2 times): People who do not buy online apparel at all have a mean delivery time priority of 0.552 days higher than those who buy occasionally (1-2 times). This discrepancy is statistically significant at the 0.05 level (p = 0.000), implying that non-buyers choose a faster delivery period. The confidence interval for this comparison varies from 0.21 to 0.90, indicating a substantial deviation in delivery time tendencies among the two groups.

Not at all vs. Moderately (3-5 times): Non-buyers have a mean delivery period preference of 0.375 days higher than those who buy moderately (3-5 times). Nonetheless, this discrepancy is slightly significant at the 0.05 level (p = 0.045). The confidence interval varies from 0.01 to 0.74, demonstrating some overlie in delivery period preferences between the two groups.

Not at all vs. Frequently (more than 5 times): Non-buyers have a mean delivery time preference of 0.828 days higher than those who buy frequently (more than 5 times). This disparity is statistically significant at the 0.05 level (p = 0.000), indicating a powerful priority for quicker delivery periods between frequent shoppers. The confidence interval for this comparison varies from 0.41 to 1.24, demonstrating a substantial discrepancy in delivery period preferences between the two groups.

Similar comparisons were created between Occasionally (1-2 times) and Moderately (3-5 times), and between Moderately (3-5 times) and Frequently (more than 5 times), with differing degrees of significance and confidence intervals.

Hypothesis 3: H3: Social media marketing has a positive impact on purchasing decisions in the Thai apparel market.



considering a purchase_H3 X	Return frequency to	the seller in a year_H3.	
		Q19N_Trust customer reviews or influencer recommendations on social media for considering a purchase_H3	Q14N_Return frequency to the seller in a year_H3
Q19N_Trust customer reviews or influencer	Pearson Correlation	1	126*
recommendations on social media for	Sig. (2-tailed)		P = .011
considering a purchase_H3	Ν	412	412
Q14N_Return frequency to the seller in a	Pearson Correlation	126*	1
year_H3	Sig. (2-tailed)	.011	
	Ν	412	412

Table 9: The Degree of Trust for Reviews or Influencer Recommendations on social media for considering a purchase_H3 X Return frequency to the seller in a year_H3.

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 9 Correlation test between trust of customer (Q19N_Trust customer reviews or influencer recommendations on social media for considering a purchase_H3) and stuffs return (Q14N_Return frequency to the seller in a year_H3) which are negatively correlated (-0.128) by Pearson Correlation method.

As in the Table 9 output, correlation is significant by a flagged (foot note) and p value (.000) which is less than 0.05.

Table 10:	Tukey's HS	SD T	fest for	trust	customer	reviews	or	influencer	recommendations	on	social
	media for c	consi	dering a	purc	hase.						

Dependent Variable:									
Tukey HSD									
(I) Q19N_Trust c	(I) Q19N_Trust customer reviews or Many Difference 95% Confidence Interval								
influencer recommendations on social media for considering a purchase_H3		(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound			
Do not trust at all	Neutral	673*	.203	P = .005	-1.20	15			
	Trust	-1.086*	.188	P = .000	-1.57	60			
	Strongly trust	145	.211	P = .902	69	.40			
Neutral	Do not trust at all	.673*	.203	P = .005	.15	1.20			
	Trust	413	.173	P = .079	86	.03			
	Strongly trust	.528*	.197	P = .038	.02	1.04			
Trust	Do not trust at all	1.086*	.188	P = .000	.60	1.57			
	Neutral	.413	.173	P = .079	03	.86			
	Strongly trust	.941*	.182	P = .000	.47	1.41			
Strongly trust	Do not trust at all	.145	.211	P = .902	40	.69			
	Neutral	528*	.197	P = .038	-1.04	02			
	Trust	941*	.182	P = .000	-1.41	47			

*. The mean difference is significant at the 0.05 level.

The Tukey Honestly Significant Difference (HSD) test compares the average differences in return frequency to the seller among various levels of trust in social media recommendations. The results show significant disparities in return frequency across different trust levels. For instance, those who don't trust social media recommendations at all have a higher return frequency compared to those



with moderate or high trust levels. Specifically, individuals who don't trust recommendations at all exhibit a significantly higher return frequency than those who trust them, indicating the impact of trust in social media on return behavior. These findings shed light on how consumer trust in social media influences their return habits in the Thai apparel industry.

Based on the comprehensive analysis of 412 participants in the Thailand apparel market, our study delves into various facets of consumer behavior and preferences. Through statistical methods such as correlation analysis and ANOVA, we unveiled significant insights: customers, predominantly female (51%), aged between 26-35 years old (42%), and with monthly incomes ranging from 10,000 to 30,000 Baht, exhibit diverse shopping patterns. Moreover, our findings underscore the impact of digital marketing strategies on consumer behavior, the correlation between online shopping frequency and delivery time preferences, and the influence of social media on purchasing decisions. Moving forward, tailored marketing strategies and efficient delivery mechanisms aligned with consumer preferences are recommended to bolster the Thailand apparel market's competitiveness and sustainability.

The study delves into the difficulties of online apparel buying behavior in Bangkok, delivering a broad investigation of consumer behavior and marketing techniques within the apparel industry. Picking up on the insights furnished by Sangchan (2014), which accentuated the critical position of perceived quality in online apparel shopping, and Chuprapawan (2023), which emphasized the importance of convenience, price, and quality, this investigation provides subtle viewpoints. Findings from Aramrungroj (2015) and Silapaouychai (2016), considering the impact of marketing promotions and brand awareness on consumer purchasing decisions to make improve our understanding of customer behavior in the digital age.) The results of this study align with these previous insights and indicate substantial correlations and variations in buying behavior. Through three hypotheses, the analysis corroborates the great impact of digital marketing techniques and delivery duration on customer behavior, resonating with existing analysis results. Additionally, the empirical correlation between trust in social media suggestions and downward return frequency reflects the contentions made by Sa-nguanpuak (2016), highlighting the undergoing impact of social media in forming customer perceptions. Conjointly, these outcomes offer valuable insights for fashion businesses aiming to improve their digital marketing strategies and adapt to evolving consumer preferences in the digital era.

Conclusion

In conclusion, this research illustrates substantial insights into the connections of online apparel shopping decisions in Bangkok. Across extensive statistical investigations and hypothesis testing, the study has revealed critical correlations between different facets such as online shopping background, delivery period preferences, and faith in social media recommendations. These results emphasize the complicated interaction between customer preferences, digital marketing techniques, and buying decisions in the booming digital business industry of the apparel market in Thailand.

The results highlight the need for tailored digital marketing strategies that align with the varying purchasing behaviors and preferences of consumers, particularly concerning delivery services.

Based on the data analysis (412 participants) in the Thailand apparel market, our study examines factors of consumer behavior and preferences. Through statistical methods such as correlation analysis and ANOVA, we unveiled significant insights: customers, predominantly female (51%), aged between 26-35 years old (42%), and with monthly incomes ranging from 10,000 to 30,000 Baht, exhibit diverse shopping patterns. Moreover, our findings underscore the impact of digital marketing strategies on consumer behavior, the correlation between online shopping frequency and delivery time preferences, and the influence of social media on purchasing decisions. Moving forward,



tailored marketing strategies and efficient delivery mechanisms aligned with consumer preferences are recommended to bolster the Thailand apparel market's competitiveness and sustainability.

The study offers insights into the association between trust in social media suggestions and return manners in the Thai apparel industry.

The findings underscore the importance of trust in social media recommendations in shaping purchasing decisions and return behaviors in the Thai apparel industry.

By comprehending these connections, enterprises can improve and adapt to their marketing techniques, build up customer experiences, and aim for durable development in the ambitious e-commerce industry. In the future, additional analysis into arising movements and developing customer behaviors will be vital to keeping forward in this quickly growing digital market.

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DIGITAL TRANSFORMATION IN THE TRANSPORTATION FIELD FOCUSES ON ELECTRIC VEHICLES AS THE FUTURE: MARKET DYNAMICS AND SUCCESS FACTORS

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Abstract

The world of transportation is about to change forever, as the electric vehicle has become the key contribution in the market and upside market share. This research involved a questionnaire survey among 462 respondents who showed an interest in electric vehicles. This study investigates consumer preferences and expectations regarding electric vehicles (EVs). Key findings are that customers emphasize factors such as cost, vehicle performance, after-sales service, charging infrastructure availability, brand reputation, and aesthetics when weighing the decision to purchase an electric vehicle. To a lesser extent financial incentives and environmental friendliness are also influenced purchasing decisions. Key factors in making a purchase intention include increased charging infrastructure, longer battery capability per charge, and faster charging speeds. Consumers express difficulties about the transition from traditional petrol vehicles to EVs and the perceived reliability of EVs for long-distance driving. These results can help manufacturers in fashioning strategies to meet customer expectations and encourage EV sales.

Keywords: Electric Vehicle. Customer Interest in Electric Vehicle, Customer Expectation in Electric Vehicle, Customer Perception in Electric Vehicle

Introduction

As a consequence of the worldwide phenomenon of climate change caused by the carbon dioxide and greenhouse gas emissions that increasing in significant levels. This rise in greenhouse gas concentration has resulted in the greenhouse effect, ultimately contributing to the phenomenon of global warming. The accumulation of carbon dioxide in the Earth's atmosphere has resulted in the retention of heat, leading to an increase in global temperatures. (Sadatshojaie & Rahimpour, 2020). Therefore, to lower the level of greenhouse gas emissions. The method that can be used against greenhouse gas emissions could be the renewable power source. Such as electric vehicles (EVs). Because electric vehicles (EVs) are a good option compared to traditional vehicles with internal combustion engines (ICEs) because they let owners lower their general running costs and lessen the negative effects of changing oil prices. (Khan et al., 2018) Furthermore, a lot of human actions, like factories, homes, transportation, and more, release a lot of CO2 into the air. This has big effects on our environment, like global warming, rising sea levels, and acid rain. About 80% to 90% of the world's CO2 pollution comes from burning fossil fuels. Carbon dioxide is known to be responsible for almost 75% of all greenhouse gas (GHG) pollution in the world. (Dehane et al., 2022). On the other hand, the solution that most governments is seeking "net zero emissions" means that the amount of greenhouse gases released into the atmosphere is equal to the amount taken out. In other words, the goal should be to get as close to zero as possible and only use carbon offsets when they are really needed. This means



that we need to quickly get rid of all fossil fuels, like coal, oil, and gas, and switch all parts of our business to green energy. (Council, 2023). Moreover, the method to help reduce the buildup of carbon dioxide is through wide spread use of electric vehicle as by relying on electricity to generate power for the engine for driving purposes the automobile's carbon foot print is reduced. As electric vehicles are becoming a main contributor to the transportation industry, EVs have many advantages that can become the key to the future in terms of an eco-friendly environment. (Sorlei et al., 2021). There are 4 types of electric car in the market. First is the battery-electric vehicle (BEV), this type of electric vehicle operates exclusively on electrical energy derived from their batteries, providing a driving range that typically spans from 100 kilometers to 500 kilometers. (Hua et al., 2021) The second are hybrid electric vehicles (HEVs). This engine falls within the spectrum of propulsion systems, positioned between the conventional internal combustion engine found in gasoline-powered vehicles and the electric powertrain utilized in electric vehicles. The convergence of both engines results in the formulation of an unusual approach to engines (Hannan et al., 2014). The third is plug-in hybrid electric vehicles (PHEV), These types of EVs are a noteworthy topic of discussion. This engine exhibits a striking resemblance to a hybrid electric vehicle (HEV). Nevertheless, the distinction is within the engine. Plug-in hybrid electric vehicles (PHEVs) typically rely on electric propulsion as their primary driving mechanism, resulting in a larger battery capacity and the ability to recharge either at dedicated charging stations or by connection to the electrical grid. (Krupa et al., 2014). Lastly are fuel cell electric vehicles (FCEV). This engine variant uses fuel cells as its power source, harnessing hydrogen and oxygen chemical reaction to provide electrical energy that drives the motor. This category of vehicle appears to hold promise as a leading contender in the realm of electric cars (EVs) in the future. (Muthukumar et al., 2021) These different electric vehicle types present a solution for the transportation industry that can save our world from global warming.

Research Objectives

1. To explore the consumer demand for electric vehicles (EVs).

2. To identify the key differences in attitudes for customer in EVs, either favorable or unfavorable.

3. To explore the obstacles and determinants associated with electric cars (EVs).

4. To explore the decisive factors and functionalities that lead to an EVs purchase.

Literature Review

A literature review was conducted through academic and professional journals to identify key issues among potential purchaser of electric vehicles. The review covered the last decade up to the present. Table 1 presents the summary of the literature review.

Authors	Research Foci	Theories	Methodologies	Findings
(Adenuga et al., 2019)	The authors investigated the different of industry 3.0 to 4.0 and how it shifts.	Industry 3.0 to 4.0	Descriptive analysis and Quantitative research	The findings indicated the important of technology changes that impact the transportation industry via robot and internet.

Table 1:	Summarv	of literature	review
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Authors	Research Foci	Theories	Methodologies	Findings	
(Badue et al., 2021)	The authors explored a self-driving method and how it applies.	Self-Driving concept	Qualitative research	The findings indicated the reason why self-driving is important.	
(Chen & Mao, 2022)	The author describes the influence of tesla technology and how it impacts EVs industry.	Self-Driving Tesla	Qualitative research	The findings revealed the technology that tesla has in their EVs and why it impacts the industry.	
(Cherry, 2022)	The authors describe a Maslow's Hierarchy need in physiological, safety and love & belonging.	The Maslow's Hierarchy need	Analytical and Empirical research	The findings demonstrated the factor of motivation that can be affect the customer purchasing.	
(Embamrung, 2022)	The authors explored a term of place in Marketing Mix.	Marketing Mix "place"	Questionnaire survey	The findings revealed the important of the place when customer making the decision.	
(Goedecke et al., 2007)	The authors describe a motivation factor of cost in EVs.	The EVs cost	Questionnaire survey	The finding demonstrates the EVs cost and how to apply to the EVs market.	
(Gray & Rumpe, 2015)	The author describes the future digitalization and the reason that digital transformation was important.	Future of EVs in digitalization and digital transformation	Qualitative research	The finding demonstrates the future in term of digitalization that effect the world ad how it performs in the world of digital transformation that has shift in the several years after the significant increase in EVs tread.	
(Ho et al., 2022)	The authors explored a term of price in Marketing Mix.	Marketing Mix "price"	Questionnaire survey	The findings revealed the important of the price when customer making the decision.	
(Jain & Jain, 2022)	The authors explored a term of product in Marketing Mix.	Marketing Mix "product"	Questionnaire survey	The findings revealed the important of the product when customer making the decision.	
(KONGMEE, 2019)	The authors explored a term of Promotion in Marketing Mix.	Marketing Mix "promotion"	Questionnaire survey	The findings revealed the important of the promotion when customer making the decision.	
(Lee, 2020)	The authors analysis a term of AI and how AI been applied to the EVs.	The concept of AI	qualitative research	The findings demonstrated the importance of AI and why it should be significant to the transportation industry.	



Authors	Research Foci	Theories	Methodologies	Findings
(Llopis-Albert & Rubio, 2021)	The authors explore the possibility of outcome when EVs dominate the market.	The outcome of EVs in transportation industry	Analytical and Empirical research	He finding indicate the outcome of the EVs in the global market and what is the reason that EVs will gaining a ton of market share.
(Mcleod, 2023)	The authors describe a Maslow's Hierarchy need in self-esteem and self-actualized	Maslow's Hierarchy of self-esteem & self-actualized	Analytical and Empirical research	The findings demonstrated the factor of self-motivation that can be affect the customer purchasing.
(Mester & Pisarov, 2021)	The authors investigated a significant amount of technology that has been involve in nowadays.	The digitalization in the future of EVs	ligitalization in Qualitative research ture of EVs	
(Mishra et al., 2021)	The authors describe a motivation factor of environmental in EVs.	The EVs effect to environmental	Questionnaire survey	The finding indicates the motivation factor that is causing global warming with the fossil fuel has been using a ton and causing the carbon dioxide. Therefore, it also describes how the EVs will affect in positive direction to the world and environment
(Morris et al., 2022)	Iorris et al., 2022) The authors describe a motivation factor of human behavior in EVs. The EVs to human behavior Analytical and Empirical research		Analytical and Empirical research	The finding indicates the motivation factor that affect the human behavior in variance way. Such as intrinsic motivation that is the wat people will use to do something because of they want to do it. another one is extrinsic motivation that is the wat people will do when they feel that is worth it or has the reward for do it.
(Pitchumani, 2023)	The authors describe a motivation factor in EVs.	The motivation	Qualitative research	The finding indicates the motivation factor that will people using to persuade themselves.
(Tariq Khan, 2014)	The authors analysis a term of marketing mix.	Marketing Mix	Questionnaire survey	The finding demonstrates the method of how marketing mix will be applied to the customer it 4 different term such as price, product, place & promotion



Authors	Research Foci	Theories	Methodologies	Findings
(Teoh & Kidd, 2017)	The author investigated the influence of Waymo and how it works.	Self-Driving Waymo	Qualitative research	The findings revealed the technology that Waymo has in their EVs and the significant technology in self-driving such as radar, gps or control by AI.
(Trait, 2019)	The authors analysis a term of Maslow's Hierarchy.	ysis a Maslow's Hierarchy Analytical and Empirical research		The finding indicate the effect of Maslow's Hierarchy that has been applied to the motivation theory in 5 order of term. 1.Self-esteem 2.Self-actualized 3.Love and belonging 4.Safety 5.Physiological
(VENGADESHWARI & Kannaiah, 2015)	The authors describe a purchasing process between a traditional and online shopping.	The purchasing process	Qualitative research	The finding demonstrates the traditional shopping that has been for so long however, the effect of digitalization and covid 19 has affect the human behavior in process of making purchase. Therefore, the online payment has become the key contribution to any transition nowadays.
(Williams & Learning, 2023)	The authors describe a Alderfer's ERG Theory need in 3 different way: Existence, Relatedness and growth needs.	Alderfer's ERG Theory need	Analytical and Empirical research	The findings demonstrated the factor of Alderfer's ERG Theory need. Existence is a fundamental part of how we need to live. Relatedness stands for fundamentals of interpersonal relationships is involve the social interaction. Lastly, Growth is stand for fundamentals of development.
(World of Work, 2021)	The authors analysis a term of Alderfer's ERG Theory	Alderfer's ERG Theory	Analytical and Empirical research	The finding indicates the effect of Alderfer's ERG Theory that has been applied to the motivation theory in 1.Existence 2.Relatedness 3.Growth

Authors	Research Foci	Theories	Methodologies	Findings
(Xu et al., 2021)	The authors investigated the different of industry 4.0 to 5.0 and the reason that 5.0 is so important to the transportation industry.	Industry 4.0 to 5.0	Descriptive analysis and Quantitative research	The findings indicated the important of technology changes that impact the transportation industry via the cloud and AI.

The literature on the transformation of electric vehicle transportation in the future focused on market dynamics and success factors that could be classified into three groups: Digitalization that impact electric vehicles, the marketing mix in electric vehicles and the motivation factors of customer who are willing to purchase electric vehicle.

First, the authors focused on the factor of digitalization that impacts electric vehicles in (Mester & Pisarov, 2021) studied the purpose of digitalization in electric vehicles. For (Lee, 2020), (Vengadeshwari & Kannaiah ,2015), (Badue et al., 2021), (Chen & Mao, 2022) and (Teoh & Kidd, 2017) all of them studied about the advance technology that can be applied in electric vehicles such as AI or self-driving technology that Tesla and Waymo are trying to push forward. (Gray & Rumpe, 2015), (Adenuga et al., 2019), (Xu et al., 2021) and (Llopis-Albert & Rubio, 2021) studied about the revolution in the industry in term of the technology change such as the scale of work and living standards and the application of AI. Furthermore, the study included the future possibility outcomes of the digital transformation that will happen in the near future.

Second, the authors focused on the factors of the marketing mix in electric vehicles. Tariq Khan, (2014) studied the marketing mix and how to apply it to electric vehicles. (Jain & Jain, 2022), (Embamrung, 2022), (Ho et al., 2022), and (Kongmee, 2019) focused on each type of the marketing mix and an analysis of the process of each term.

Lastly, the authors focused on the factor of motivation in customers who are willing to purchase electric vehicles. (Pitchumani, 2023) studied the definition of motivation in electric vehicles, including the method that people are willing to use such vehicles. (Goedecke et al., 2007) studied the overall cost of electric vehicles such as maintenance, taxation and the energy cost. (Mishra et al., 2021) studied what was happening to today's world in terms of transportation with electric vehicles and petrol cars. (Morris et al., 2022) studied human behavior to find the reason that motivates customers to purchasing products. For (Trait, 2019), (Mcleod, 2023) and (Cherry, 2022) they studied in Maslow's Hierarchy Theory and found evidence of the reasons or factors that motivate customers. (World of Work, 2021) & (Williams & Learning, 2023) studied motivation and Alderfer's ERG Theory and found the differences or facts that motivate customers.

Methodology

This study aims to reveal that the digital transformation field is significantly improved and has the possibility of becoming the key factor for electric vehicles. Therefore, the success factor of the electric vehicle can be determined by the dominant market dynamics of the electric vehicle. Therefore, the results and responses are based on customers who are interested in electric vehicles in the Bangkok Metropolitan Region. Moreover, the study was based on a quantitative approach, using surveys and statistical analysis to determine the effect of electric vehicles on a wide scale.

This study sample group was determined by the population sample of people who purchased electric vehicles in the year 2022. This year's total sales of electric vehicles equaled 50,347 vehicles. The sample size of this survey was 382 respondents. However, after collecting the information the total



number of respondents equaled 462 respondents. These respondents came from people expressing interest in electric vehicles.

The instrument of the survey consists of 30 questions separated into 4 different types of questions, namely demographic questions, scaling questions, general questions and specific questions. All the questions were collected by Google Forms.

The 4 types of questions can be classified as follows. First, demographic questions contained 6 questions such as age, gender, education, location, income and financial support. Second, the scaling questions contained 11 questions of customer perception or expectation in electric vehicles from not important to very important in the scale of 1 to 5. Third, the general questions contained 7 questions on customer perspectives toward electric vehicles from a scale of 1 to 5, strongly disagree to strongly agree. Lastly, the specific questions contained 6 questions of customer knowledge and perception in the electric vehicle market and the future of the transportation field.

The data is analyzed by using descriptive statistics as primary data to analyze the sample of people along with frequency statistics evaluating the mean numbers and standard deviation to help analyze the survey responses. The secondary data was analyzed using inferential statistical techniques to analyze independent variables, such as one-way ANOVA (F-test) and correlation and regression analysis to assess the research hypothesis.

Result

Table 2 exhibited the result of the survey on the demographic factor of respondents who interest in electric vehicles in Bangkok metropolitan region. The survey collected data in ages, genders, education, location, income, and financial supporter. The table shows the frequency and percentage of each variable and its classifications. Most respondents were age between 18 to 24, Male, bachelor's degree graduated, domicile in Bangkok, with the income range of 30K to 60K baht, and supported by Father and/or Mother.

variables	Classification	Frequency	Percentage
Ages	18 to 24	331	71.6
	25 to 32	104	22.5
	33 to 40	14	3
	41 to 49	9	1.9
	50 or more	4	0.9
Genders	Male	253	54.9
	Female	179	38.7
	Transgender	9	1.9
	Non-Binary	14	3
	Other	7	1.5
Educations	Elementary School	0	0
	High School	0	0
	Bachelor's degree	432	93.5
	Master's degree	23	5
	Doctor's degree	7	1.5
Location	Bangkok	345	74.8
	Samut Prakan	87	18.8
	Pathum Thani	14	3
	Nonthaburi	9	1.9
	Other	7	1.5

Table 2: The demographic variable



variables	Classification	Frequency	Percentage
Income	Least than 10,000 Baht/Month	7	1.5
	10,001 to 30,000 Baht/Month	101	21.9
	30,001 to 60,000 Baht/Month	244	52.8
	60,001 to 100,000 Baht/Month	87	18.8
	More than 100,001 Baht/Month	23	5
Financial Supporter	Father or Mother	331	71.6
	Brother or Sister	9	1.9
	Other Family Member	14	3
	Employer	7	1.5
	Don't have it	101	21.9

Table 3: Mean, standard deviation and interpretation about the factors of customer who is interested to purchasing the electric vehicle.

Customer who is interested to purchasing the electric vehicle.	Mean	S.D.	Interpretation
1. The electric vehicle is very interest preferable choice	3.79	1.16	High
2. The electric vehicle is the planning for the near future purchasing	3.21	1.59	Moderate
3. The vehicle brand is significant factor to determine the purchasing	2.95	1.31	Moderate
Total	3.32	1.21	Moderate

Table 4: Show the mean, standard deviation and interpretation about the factors of customer expectation in electric vehicle.

Customer expectation in electric vehicle	Mean	S.D.	Interpretation
1. The important of cost in electric vehicle	4.33	0.77	Very high
2. The important of brand reputation in electric vehicle	3.66	0.77	High
3. The important of promotion in electric vehicle	3.27	0.84	Moderate
4. The important of appearance in electric vehicle	3.62	1.20	High
5. The important of performance in electric vehicle	4.34	0.79	Very high
6. The important of after sales service in electric vehicle	4.36	0.81	Very high
7. The important of taxation in electric vehicle	3.76	1.11	High
8. The important of environmentally friendly in electric vehicle	2.81	0.95	Moderate
9. The important of number of charging station in electric vehicle	4.78	0.41	Very high
10. The important of Charging speed in electric vehicle	4.78	0.41	Very high
11. The important of maximum battery capacity per charge in electric	4.78	0.41	Very high
vehicle			
Total	4.04	0.24	High

The data presents the mean, standard deviation, and interpretation of customer expectations regarding various factors related to electric vehicles. Notably, the importance of cost in electric vehicles is perceived as very high, with a mean of 4.33 and a standard deviation of 0.77, indicating a strong consensus among customers. Similarly, factors such as performance, after-sales service, the number of charging stations, charging speed, and maximum battery capacity per charge are all rated as very high in importance, with mean scores of 4.34 to 4.78 and relatively low standard deviations, highlighting unanimous agreement among respondents. Brand reputation, appearance, and taxation are also regarded as high in importance, with mean scores ranging from 3.62 to 3.76. However, factors such as promotion and environmental friendliness are perceived as moderately important, with mean scores of 3.27 and 2.81, respectively. Overall, the total mean expectation score is 4.04, indicating a high level of expectation among customers regarding electric vehicles.



Customer perception in transportation industry	Mean	S.D.	Interpretation
1. The petrol fuel cost is too expensive	4.21	1.01	High
2. The electric vehicle is the new option for transportation industry	3.40	0.90	Moderate
3. The electric vehicle is better than petrol vehicle	2.75	1.02	Moderate
4. The electric vehicle will have stable sales even fuel price is drop	2.84	1.02	Moderate
5. It will convince you or not if electric vehicle can have 1,000 km driving distance per charge.	3.77	1.18	High
6. It will convince you or not if every 80 km outside of Bangkok have the charging station.	2.57	1.24	Low
7. It will convince you or not if electric vehicle has the same price as petrol car.	2.53	1.25	Low
8. The electric vehicle is hard to change from petrol vehicle	2.95	1.27	Moderate
9. It will convince you or not to purchase the electric vehicle if you friend using electric vehicle	3.68	0.92	High
10. The perception of electric vehicles will change the world transportation industry. Are you feel that its right statement.	3.69	0.84	High
Total	3.24	0.47	Moderate

Table 5: Mean, standard deviation and interpretation about the factors of customer perception in transportation industry based on electric vehicle.

Regarding the issue of petrol costs. Responses found customers strongly perceive petrol fuel costs as expensive. Concerning electric vehicles as an option, respondents have a moderate perception that electric vehicles are a new option for the transportation industry. Respondents perceive electric vehicles as better than petrol vehicles to a moderate extent. On the question of whether electric vehicles will have stable sales even if fuel prices drop, respondents perceive that electric vehicles will have stable sales even if fuel prices drop to a moderate extent. On the question of whether a driving range of 1,000 km per charge would influence buyers' perceptions, respondents are strongly convinced such is the case. The issue of charging stations would convince prospective purchasers if stations were every 80 km outside of Bangkok, respondents have a low level of conviction regarding the presence of charging stations every 80 km outside of Bangkok. Regarding price the results showed a low level of conviction regarding electric vehicles having the same price as petrol cars. Respondents perceive it to be moderately difficult to transition from petrol vehicles to electric vehicles. Responses showed consumers are strongly convinced to purchase electric vehicles if their friends are using them. Respondents felt strongly that electric vehicles will change the world transportation industry.

Table 6:	Mean,	standard	deviation,	and	interpretation	of the	hypothes	is of	the rese	earch.
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Customer expectation in electric vehicle.	Mean	S.D.	Interpretation
1. Customer who is interested to purchasing the electric vehicle.	3.32	1.21	Moderate
2. Customer who is interested to purchasing the electric vehicle.	4.04	0.24	High
3. Customer expectation in electric vehicle.	3.24	0.47	Moderate

Summarizing the data on customer expectations in electric vehicles, there is a mix of moderate and high expectations among customers interested in purchasing electric vehicles, while the overall expectation level among all customers is moderate.



Results of correlation analysis

The correlation statistics examine a correlation matrix showing the Pearson Correlation coefficients, significance levels (2-tailed), and sample sizes (462) for three of customer interest, customer expectation and customer perception. The asterisk (**) indicates that the correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlations

		Customer Interest	Customer Expectation	Customer Perception
Customer Interest	Pearson Correlation	1	.786**	.863**
	Sig. (2-tailed)		< 0.001	< 0.001
	Ν	462	462	462
Customer Expectation	Pearson Correlation	.786**	1	.720**
	Sig. (2-tailed)	< 0.001		< 0.001
	Ν	462	462	462
Customer Perception	Pearson Correlation	.863**	.720**	1
	Sig. (2-tailed)	< 0.001	< 0.001	
	Ν	462	462	462

**Correlation is significant at the 0.01 level (2-tailed).

Table 8: The model of explanation (R2) of Regression.

Model Summary					
Model	R	Std. Error of the Estimate			
1	0.49	0.24	0.24	0.71	

Table 9: The model of explanation ANOVA.

ANOVA						
Model	Sum of Squares	df	Mean Square	F	Sig.	
Regression	75.77	3	25.25	49.96	< 0.001	
Residual	231.52	458	0.50			
Total	307.29	461				

Table 10: Multiple regression analysis of dependent variables of digital transformation of transportation field, electric vehicles as future, market dynamics, success factors for customer future purchasing.

Coefficients ^a					
Model	В	Std. Error	β	Т	Sig.
Constant	1.78	0.80		2.21	0.027
Customer Interest	0.45	0.06	0.67	7.39	< 0.001
Customer Expectation	0.46	0.22	0.13	2.09	0.037
Customer Perception	- 0.65	0.14	-0.37	-4.64	< 0.001

Table 11: Summary of hypothesis

	Hypothesis	Statistics	Sig.	Result
H1	Customer Interest	F-test	< 0.001	Supported
H2	Customer Expectation	F-test	0.037	Not supported
H3	Customer Perception	F-test	< 0.001	Supported



Discussions

Consumers placed a high importance on the cost of electric vehicles, which would suggest that price is an important factor influencing their decision-making process. Significantly, vehicle performance and after-sales service are emphasized suggesting that customers prioritize quality and services in coming to a buying decision for electric vehicles. Also, the availability and convenience of charging infrastructure were important factors such as the number of charging stations, charging speed, and maximum battery capacity per charge.

Customers consider brand reputation and electric vehicles style as substantial factors, indicating that perceived quality and attractiveness influence the purchasing decision. Financial incentives such as the taxation of electric vehicles suggests that customers are cognizant of the charges in owning and operating such vehicles and factor these burdens onto the purchasing decision.

Promotion and environmental friendliness are moderately important. While the promotion and environmental friendliness of electric vehicles are not rated as high as other factors, they still represent moderate concern, indicating that customers value sustainability but may prioritize other factors in their decision-making process.

Overall, the data underscores a high level of expectation among customers regarding electric vehicles, with a strong emphasis on affordability, performance, infrastructure, brand reputation, and aesthetics. These insights can help manufacturers fashion strategies to meet customer expectations of those consumers interesting in electric vehicles.

The findings of this study indicate that people are interested in buying electric vehicles. Many people want to try the electric vehicle as the alternative transportation. However, to buy the electric vehicle there still have the preference of brand selecting. Therefore, it proves that even electric vehicles are recently popular in the transportation industry. People are still planning to purchase it as their next main vehicle in the future.

For the expectation of customer toward the electric vehicle, the main contribution that customers want are more charging stations and more battery capacity per charge along with the high charging speed. This expectation may be because nowadays, the charger is very limited and mostly available in Bangkok. But outside of Bangkok metropolitan region there are a few of them. Another one is battery capacity per charge is too short as it allows only for 300 to 500 km per charge which people believe that it will not be enough to driving in a distance such as Bangkok to Chiang Mai. For the charging speed, it takes around 2 to 10 hours per charge depending on the charger type and the electricity of the charger. Even though some chargers can have speed charge to 80 percent of battery capacity in 30 minutes, customers still feel that it is too long compared to the traditional method, which is filling the tank by the petrol fuel.

For the perception of customer toward the electric vehicle, the perception of switch to engine method still be the problem. As the customer feels that it is too hard to switch from petrol vehicle to electric vehicle. Another reason is that the electric vehicle service station is not enough for their satisfaction. However, the results that the people have mixed feelings about the electric vehicle can be the main contribution in the transportation industry. Moreover, for driving in distance, customers do not believe in electric vehicles at all. The customers prefer petrol vehicles because they are still more reliable than electric vehicles.

Conclusions

The study reveals that the digital transformation field is becoming more relevant and can be the key factor for the electric vehicle to achieve and dominate market dynamics, as well as the success factor for customers who have an interest in the electric vehicle. furthermore, the Interest in electric


vehicles is exceptionally large, and people still believe that electric vehicles can become a key contributor in the transportation industry. The study has assessed the implications, limitations, and potential future recommendations. The study's main implications are customer demand, expectations, and perceptions of electric vehicles. The study's main limitation is that the area of research is only available in the Bangkok metropolitan region, and most people are between the ages of 18 and 24. The study's main recommendation is to extend the research work to the entire country of Thailand, which can translate to a larger sample size because it adds more variety to the respondents.

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FACTORS THAT AFFECT THE USE OF DIGITAL TECHNOLOGY IN HUMAN RESOURCES MANAGEMENT: A CASE STUDY OF NEW ELECTRICAL TECHNOLOGY LTD

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Abstract

The rapid and significant expansion of social media in the present era has surpassed all expectations, having a profound impact on consumer behavior and compelling business owners to utilize it means to generate revenue and exert strategic influence. The pervasiveness of its incorporation into daily routines has established it as an essential channel for businesses to maintain competitiveness and minimize labor hours. Conversely, conventional brick-and-mortar businesses encounter a variety of obstacles, including economic and environmental, which compel them to adjust by embracing digital technology. Understanding the factors that influence New Electrical Technology Co., Ltd. employees' utilization of digital technology for human resource management is the purpose of this study. The objective is to implement a transformative system for digital technology infrastructure, facilitating personnel access to efficient processes and offering guidance for the advancement of digital technology. By employing the Technology Acceptance Model (TAM), the research compiled data from a sample of 250 participants via an online questionnaire and social media platforms. The primary focuses of the data collection were perceived utility and ease of use.

According to the findings of this study, the determinants of perceived usability and perceived simplicity were it influences the manner in which digital technology is implemented within the context of HRM. The primary determinant influencing the adoption of digital technology in human resource management is the Perceived ease of use. Perceived usefulness also have a similar impact on behavior. Digital technology plays a crucial role in human resource management by streamlining processes, enhancing communication, and improving access to data and analytics.

Keywords: Perceived ease of use, Perceived usefulness, Usage behavior, Human resource management, Digital technology

Introduction

Today's organizations face rapid and complex changes driven by technological factors. This has a significant impact on work methods, business models, and even personnel behavior. Technology is seen as both a challenge and an opportunity, with many businesses adapting to it for survival, Rattanarojmongkol (2020). Human Resource (HR) departments, as the "heart" of organizations, play a crucial role in managing talent and adapting to these changes.

To remain competitive, HR needs to embrace digital technologies. This includes using systems for tasks like recruitment, training, performance evaluation, and employee data management. These technologies can streamline processes, reduce errors, and ultimately contribute to organizational success. New Electrical Technology Co., Ltd. or NET, a company using a digital HR management system, exemplifies this transformation studied by Google https://newelectricaltechnology.com (2023) .The study



aims to understand factors affecting employee usage of such systems to further improve and develop them.

Research Objectives

- 1. To study demographic factors that affect the use of digital technology in human resources.
- 2. To analysis the behavior of using digital technology in human resources.
- 3. To develop the guidelines for developing the digital technology system.

Literature Review

A review of relevant literature or other relevant contexts has been conducted. The behavior of using digital technology in human resources concerns on both perceived usefulness and ease of use applying Technology Acceptance Model (TAM). Tanurak et al. (2017) found that both perceived ease and usefulness of technology positively influence Thai wholesale and retail employees' attitude and intention to use it. This suggests user-friendliness and perceived value are key drivers of technology adoption in this sector.

A study by Panjatawee & Jairak ((2014using a case study found that perceived benefits, efficiency expectations, and supervisor support positively influence information system acceptance among employees at an institute in Chiang Mai. This suggests user engagement and positive reinforcement are key for successful technology adoption.

Kaspo (2017) found that performance expectations and perceived ease of use positively influence customer acceptance of electronic financial transactions, while perceived risk negatively impacts it. Other factors like perceived usefulness, effort expectancy, price value, and hedonic motivation also play a role. This suggests a balance between perceived benefits, ease of use, and security concerns is crucial for technology adoption in financial services.

Nurittmont (2019) investigated how perceived benefits and ease of use of mobile phone apps for financial transactions influence user behavior. The study found that users who perceived the apps as both beneficial and easy to use were more likely to use them for financial transactions. These findings suggest that service providers should focus on developing mobile apps that are both user-friendly and offer clear benefits to users. This can help to increase adoption and usage of mobile financial transaction services.

A study by Chuchuen et al. (2016) found that small and medium organic farms in Chiang Mai highly value perceived benefits, ease of use, positive attitudes, and peer pressure when deciding to adopt information systems. This suggests user-centric design, clear value propositions, and community support are crucial for technology adoption in this sector.

Saengsongfah et al. (2021) found that strong leadership, efficient operations, and robust support are key to successfully transitioning government employees to digital platforms. This highlights the importance of a holistic approach with dedicated resources across various levels to ensure smooth technology adoption in public organizations.

Thanadechawat (2021) A study of manufacturing workers in Thailand found that perceived ease, benefits, and positive attitudes significantly influence their use of electronic conferencing platforms. This supports the Technology Acceptance Model (TAM), suggesting user-friendliness and value perception are key for technology adoption.

Lin et al. (2010) Applying TAM to mobile banking in China, the study found that both perceived usefulness and ease of use strongly influence customer adoption intentions. This highlights the importance of balancing user-friendliness with clear benefits for successful technology adoption.



Munoz-leiva (2017) User perception of usability, system reliability, and risk perception all influence user adoption of mobile banking apps in Spain. This suggests building trust and user-friendly interfaces is crucial for successful financial technology adoption.

Fathema et al. (2015) User-centric design matters! In US universities, perceived ease of use, system quality, and perceived benefits significantly influence faculty adoption of learning management systems. Building confidence and offering clear advantages can drive technology adoption in educational settings.

Al-Emran & Shaalan (2015) In Oman, student acceptance of a new online learning platform was influenced by perceived ease of use, perceived benefits, and intention to use. However, factors like gender and age also played a role. This highlights the need for a nuanced approach to technology adoption that considers both user characteristics and platform design.

Methodology

This study employed a quantitative approach, using surveys and statistical analysis to understand factors influencing digital technology adoption in HRM. Specifically, it used a one-group pretest-questionnaire design with three parts: collecting personal data, identifying influencing variables, and gathering suggestions. This research focused on NET, acronym for "neuroendocrine tumor", but the method discussed is applicable to a broader range of HRM technology adoption investigations, Mertler (2021).

Included in the population used to store the data were 500 NET employees. This study's sample group determined the size of the sample population by applying the Taro Yamane formula to 500 individuals. Therefore, the sample size is equal to 222 samples, and an additional 250 samples from NET employees are required to ensure adequate sample sizes.

The researcher created the instrument used to collect data for the study of factors that influence the use of digital technology in the management of human resources of employees of NET in order to collect information on three variable factors believed to be associated with the acceptance of digital technologies. The researcher defined it as a three-part questionnaire on the factors that influence NET employees' adoption of the company's digital technology system.

The first section of the fundamental information questionnaire consisted of five inquiries regarding the respondent's gender, age, length of employment, job title, and monthly income. The second section of the questionnaire concerned the factors that influence NET employees' adoption of digital technology. There were fourteen queries measuring the respondents' level of opinion. This survey provided an overview of the factors that influence the adoption of digital technology. The researcher employed the Likert Scale as their measuring instrument. Therefore, five levels of criteria are defined for measuring the opinions of sample groups, Mcleod (2023). The third section contained recommendations regarding the factors that influence NET employees' adoption of digital technology.

The researcher has delineated the subsequent assessment protocols for research instruments: the research adviser was given the questionnaire to verify its correctness and get suggestions. The questionnaire was revised after the suggestion of three experts: Asst. Prof. Dr. Suttisak Jantavongso, Amporn Puapradit, and Dr. Phunpiti Bhovichitra. The concordance IOC formula is used to assess the content, comprehension, and language proficiency across three levels.

In order to obtain the most accurate and reliable information for the research, the researcher have chosen to conduct quantitative research in the form of survey research using a questionnaire. This study will investigate the factors that influence the use of digital technology in the process of data collection. After conducting an arbitrary test using a google form, it will be distributed to the employees of NET as the primary data collection instrument for the compilation of primary information.



Descriptive statistics and inferential statistics were employed in the analysis of primary and secondary data, respectively. Initially, the descriptive statistical methods were used to characterize the sample by analyzing frequencies mean and standard deviations. Therefore, the inferential statistical techniques used in this study were the independent sample (t-test), One-way ANOVA (F-test) and multiple regression analysis to assess the research hypothesis.

Results and Discussion

Based on the objective of the study, three hypotheses were formulated: demographic affects usage behavior; perceived usefulness affects usage behavior; and perceived ease of use affect usage behavior.

The section is organized into three distinct sections: general respondent information, questions, factors affecting the adoption of digital technology in HRM, and digital technology behavior in HRM.

Table 1 displays a comprehensive presentation of numerical values and corresponding percentages, so facilitating the subsequent analysis.

Gender: Among the 250 workers at NET, the majority consisted of 205 men, representing 82% of the total, while the remaining 45 employees were females, accounting for 18% of the workforce. Table 4.1 displays a comprehensive presentation of numerical values and corresponding percentages, so facilitating the subsequent analysis.

Age: The majority of NET workers fall within the age range of 26-30 years, comprising 56.8% of the total workforce, with 142 individuals. This is followed by the age range of 31-40 years, which accounts for 31.2% of the employees, with 78 individuals. Individuals who are 25 years old or younger, with 25 comprising 10% of the total population. In the age group of 41-50 years, there were a total of 5 workers at NET, accounting for 2% of the workforce. Conversely, in the age group of 51 years and above, there were no employees, representing 0% of the workforce.

Period of work: The duration of employment periods may be categorized into several ranges. The majority of individuals, comprising 58.4% (146 individuals), have a work time ranging from 1 to 3 years. This is followed by a smaller proportion of individuals, accounting for 24.4% (61 individuals), who have a work period ranging from 4 to 6 years. In the sample population, a minority of individuals, namely less than 1 year of experience, accounted for 12% (30 individuals) of the total. Additionally, a small proportion of individuals, specifically 7 to 9 years of experience, accounted for 4% (10 individuals) of the total. Furthermore, a subset of 3 workers with more than 10 years of experience accounted for 1.2% of the total.

Job position: Almost all of position (198 representing 79.2%) are the operational level, followed by command level positions (27 or 10.8%), middle management positions (20 or 8%), and top executive positions (5 or 2%), respectively.

Monthly income: The largest proportion of monthly income (132 representing 52.8%) is between the range of 10,001-20,000 THB, followed by 20,001-30,000 THB (76 representing or 30.4%), 30,000 - 40,000 THB (25 representing or 10%), 40,001 THB and above (13 representing or 5.2%), and less than or equal to 10,000 THB (4 representing or 1.6%), respectively.



Information about personal factors	Number (person)	Percentage (%)
Gender		
Male	205	82
Female	45	18
Age	•	
Less than or equal to 25 years	25	10
26 – 30 Years	142	56.8
31 – 40 Years	78	31.2
41 – 50 Years	5	2
51 Years and over	0	0
Period of work		
Less than 1 year	30	12
1 – 3 Years	146	58.4
4 – 6 Years	61	24.4
7 – 9 Years	10	4
More than 10 years	3	1.2
Job position	•	
Operational level	198	79.2
Command level	27	10.8
Middle management	20	8
Top executive of the line	5	2
Monthly income		
Less than or equal to 10,000 THB	4	1.6
10,001 – 20,000 THB	132	52.8
20,001 – 30,000 THB	76	30.4
30,001 – 40,000 THB	25	10
40,001 THB and over	13	5.2

 Table 1: The number (person) and percentage (%) of the personal factors.

Table 2 reported on the finding of the knowledge the present study aimed to conduct a comprehensive data analysis on the many aspects that having an impact on the utilization of digital technology within the realm of human resource management. These utilization included perceived usefulness. The mean and standard deviations were used to characterize the data, indicating the degree of consensus within the sample group. The data provided may be succinctly summarized in the following manner.

Table 2: The mean (\overline{X}) standard deviation (S.D.) and interpretation about the perceived usefulness.

	Perceived usefulness	Mean	S.D.	Interpretation
1.	The system of digital technology increases operational efficiency.	4.28	0.62	Very high
2.	2. The digital technology framework enables rapid news delivery.		0.62	Very high
3.	Using digital technology, you can obtain accurate and trustworthy information.	4.34	0.61	Very high
4.	Systems based on digital technology are beneficial for operational decision-making.	4.34	0.63	Very high
5.	Digital technology frees up time for other pursuits.	4.42	0.66	Very high
6.	The application of digital technology reduces operational procedures.	4.44	0.63	Very high



Perceived usefulness	Mean	S.D.	Interpretation
7. The technological system facilitates coordination between the stakeholders.	4.50	0.62	Very high
Total	4.39	0.41	Very high

Table 3 presented the findings of the current research, which seeks to perform a thorough data analysis on several factors that influence the adoption of digital technology in the field of human resource management. The elements included in this study encompassed the perceived simplicity of use. To analyze the data and assess the level of agreement within the sample group, the mean and standard deviations were used. The information supplied may be concisely summarized as follows.

Table 3: The mean (\overline{X}) standard deviation (S.D.) and interpretation about the perceived ease of use.

	Perceived ease of use	Mean	S.D.	Interpretation
1.	The user-friendly digital technology will motivate you to learn more.	4.23	0.59	Very high
2.	Utilizing digital technology does not require a significant amount of effort.	4.34	0.71	Very high
3.	3. Digital technology can be applied to conventional methods of operation.		0.61	Very high
4.	Digital technology expedites the accessibility of information.	4.47	0.66	Very high
	Total	4.38	0.43	Very high

Table 4 presented the results of the current research, which proposes to do a thorough data analysis on various factors influencing the use of digital technology in the field of human resource management. The elements included in this study are the participants' use behavior affecting the use of digital technology, mean and standard deviations as measures to describe the data, hence reflecting the level of agreement within the sample group. The information supplied may be concisely summarized as follows.

Table 4: The mean (\overline{X}) standard deviation (S.D.) and interpretation about the attitude to the use of digital technology in HRM: NET employees.

	Use Attitude	Mean	S.D.	Interpretation
1.	You are interested and willing to learn about new digital technologies.	4.31	0.56	Very high
2.	You believe that the implementation of digital technology in your workplace could be advantageous for your operations.	4.49	0.62	Very high
3.	You believe the workplace will be well connected to the digital technology system.	4.54	0.59	Very high
	Total	4.45	0.43	Very high

Table 5 presented the results of the assumption of NET employees are influenced by various demographic factors that impact the utilization of digital technology in HRM. The information supplied may be concisely summarized the means of the two groups are very close, 4.44 for males and 4.47 for females. The negative t-value indicates that the mean for males is slightly lower than for females, but given the high p-value (0.764), this difference is not statistically significant. In statistical terms, a p-value higher than 0.05 typically indicates that the difference between groups is not significant,



meaning there is no strong evidence to suggest that the observed difference in means is not due to random chance. Therefore, we would conclude that there is no statistically significant difference between males and females on the measured variable based on the data provided in this table.

Table 5 : Results of the demographic assumption test that affect gender-partitioned NET employees' digital technology behavior.

Gender	n	Mean	S.D.	t	Sig.
Male	205	4.44	0.42	-0.30	0.764
Female	45	4.47	0.50		

Table 6 presented the analysis does not find a statistically significant difference in the mean scores across the four age groups, as the significance value of 0.385 is well above the conventional threshold of 0.05. This suggests that any differences in the mean scores between the age groups could likely be due to chance. Additionally, the small sample size in the oldest age group (41 to 50 years) might not provide enough power to detect a difference even if one exists.

Table 6 : Results of the demographic assumption test that affect age-partitioned NET employees' digital technology behavior.

Age	n	Mean	S.D.	F	Sig.
Less than or equal to 25 years	25	4.59	0.55	1.02	0.385
26 – 30 Years	142	4.42	0.43		
31 – 40 Years	78	4.44	0.41		
41 – 50 Years	5	4.47	0.30		

Table 7 presented the F-value for the ANOVA, which tests whether there are any statistically significant differences between the means, is 0.82. The significance (Sig.) value associated with this F-value is 0.515. The analysis shows no significant differences in mean scores for various work experience periods, with a significance level of 0.515, suggesting any differences are likely due to chance. Varied group sizes, especially the smallest with only 3 participants, may affect the test's reliability.

Table 7 : Results of the demographic assumption test that affect period of work-partitioned NET employees' digital technology behavior.

Period of work	n	Mean	S.D.	F	Sig.
Less than 1 year	30	4.53	0.55	0.82	0.515
1-3 Years	146	4.45	0.40		
4-6 Years	61	4.42	0.45		
7 – 9 Years	10	4.27	0.44		
More than 10 years	3	4.44	0.38		

Table 8 presented the F-value from the ANOVA is 1.98, and the significance level (Sig.) is 0.123. This suggests that while there are differences in the mean scores among different job positions, they are not statistically significant, as the Sig. value exceeds the usual cutoff of 0.05. The reliability of these results may be affected by the varying sample sizes across job positions, particularly the small size of the top executive group.



Job position	n	Mean	S.D.	F	Sig.
Operational level	198	4.48	0.41	1.98	0.123
Command level	27	4.32	0.50		
Middle management	20	4.30	0.52		
Top executive of the line	5	4.40	0.28		

Table 8 : Results of the demographic assumption test that affect job position-partitioned NET employees' digital technology behavior.

Table 9 presented the F-value is 4.86, which is associated with a significance level (Sig.) of 0.001. Significant differences in mean scores exist across income brackets (Sig. value 0.001), with the lowest income group scoring highest and a general decrease as income rises, despite a slight uptick in the highest bracket. Varying participant numbers per bracket could affect results.

Table 9: Results of the demographic assumption test that affect monthly income-partitioned NET employees' digital technology behavior.

Monthly income	n	Mean	S.D.	F	Sig.
Less than or equal to 10,000 THB	4	4.83	0.19	4.86	0.001
10,001 – 20,000 THB	132	4.54	0.34		
20,001 – 30,000 THB	76	4.36	0.52		
30,001 – 40,000 THB	25	4.24	0.46		
40,001 THB and over	13	4.33	0.43		

Table 10 presented PUF and PEU have a correlation of 0.716, which is considered strong (indicated by the asterisk, which typically denotes significance). PEU is perfectly correlated with itself as well. In summary, there's a strong and likely significant positive relationship between how useful and how easy to use people perceive a system to be.

 Table 10:
 The correlation analysis.

Variable	PUF	PEU
Perceived usefulness (PUF)	1	.716*
Perceived ease of use (PEU)	.716*	1

Table 11 presented the model includes a constant (intercept) with a value of 1.60 and a standard error of 0.26. Its t-value is 6.21, indicating it's significantly different from zero (Sig. = 0.000). The coefficient for "Perceived" (presumably usefulness) is 0.32 with a standard error of 0.08, a standardized coefficient (beta) of 0.30, and a t-value of 3.99, which is significant (Sig. = 0.000). The coefficient for "Perceived ease of" (use) is 0.33 with a standard error of 0.08, a beta of 0.33, and a t-value of 4.41, also significant (Sig. = 0.000). The overall model has an R (correlation coefficient) of 0.58, explaining 34% of the variance ($R^2 = 0.34$), with an F-value of 62.24, indicating the model is statistically significant (Sig. = 0.000). The regression shows that perceived usefulness and ease of use significantly predict the outcome, with the model explaining 34% of the variance.



Model	В	Coeffi	cients ^a	f	Sig
Widder	D	Std. Error	β	t	org.
Constant	1.60	0.26	0.00	6.21	0.000
Perceived usefulness	0.32	0.08	0.30	3.99	0.000
Perceived ease of use	0.33	0.08	0.33	4.41	0.000
	R = 0.58	$R^{2} = 0.34$	F = 62.24	Sig.0.000	

Table 11: Multiple regression analysis of dependent variables toward intention to use behavior affecting the use of digital technology in HRM: NET employees.

Table 12 presented Gender: A T-test shows a significance (Sig.) of 0.764, so the hypothesis is not supported. Age: An F-test gives a Sig. of 0.385, leading to the hypothesis not being supported. Period of work: An F-test results in a Sig. of 0.515, and the hypothesis is not supported. Job position: An F-test indicates a Sig. of 0.123, so the hypothesis is not supported. Monthly income: An F-test reveals a Sig. of 0.001, which means the hypothesis is supported.

H1	Statistics	Sig.	Result
Gender	T-test	0.764	Not supported
Age	F-test	0.385	Not supported
Period of work	F-test	0.515	Not supported
Job position	F-test	0.123	Not supported
Monthly income	F-test	0.001	Supported

Table 12: Summary of hypothesis 1

Table 13 presented the resulted of a hypothesis test for perceived usefulness. The statistical test used was multiple regression analysis (MRA). The significance (Sig.) level is 0.000. The result column indicates that the hypothesis concerning perceived usefulness is supported, as the significance level is below the conventional alpha threshold of 0.05, suggesting a statistically significant relationship in the regression model.

Table 13: Summary of hypothesis 2

H2 Statistics		Sig.	Result	
Perceived usefulness MRA		0.000	Supported	

Table 14 presented the resulted indicates that the hypothesis for perceived ease of use is supported, as shown by the highly significant result (Sig. = 0.000), suggesting that perceived ease of use has a significant impact on the model's dependent variable.

 Table 14:
 Summary of hypothesis 3

H3 Statistics		Sig.	Result	
Perceived ease of use MRA		0.000	Supported	

The study, focusing on NET's employee usage of digital HR systems, tested three hypotheses: 1) demographics would have no impact, 2) perceived ease of use would positively influence behavior, and 3) perceived benefits would also positively influence behavior. All hypotheses were confirmed.



Notably, perceived ease of use emerged as the strongest factor driving digital HR adoption, suggesting user-friendliness is crucial for successful technology implementation within organizations.

Each employee anticipates that the system will be upgraded to a more contemporary version. According to research conducted by Tanurak et al. (2017), Kaspo (2017), Nurittmont (2019), Chuchuen et al.(2016), Thanadechawat (2021), Lin et al. (2010), Munoz-Leiva (2017), Fathema et al. (2015), and Al-Emran and Shaalan (2015), it has been found that the perception of ease of use is positively correlated use digital technology in HRM. The use of this technology is not without complications, but it is straightforward and consistent.

When the regression rate from this questionnaire was considered, the study discovered that the perception of the use benefits influenced the use behavior. Its value was determined to be 0.30 and it possessed a Sig value. In accordance with the findings of Tanurak et al. (2017), Kaspo (2017), Panjatawee and Jairak (2014), Nurittmont (2019), Chuchuen et al. (2016), Thanadechawat (2021), Lin et al. (2010), Fathema et al. (2015), and Al-Emran & Shaalan (2015), which indicate that corporate employees have embraced the adoption of digital technology for the global management of human resources rather than the existing system, The result of table 16 in cased indicates that employees had come to terms of perceived usefulness and perceived ease of use.

Conclusion

This research examines technology's impact on organizations and HRM, By focusing on NET, a company utilizing digital HRM systems, the study investigates what influences employee usage of such technology. Findings show that perceived ease of use, followed by demographic factors and perceived benefits, significantly impact behavior. This emphasizes the importance of user-friendly and relevant HRM systems for successful technology adoption within organizations.

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NANO-DRIVE-NET: AN ULTRA-LIGHTWEIGHT NEURAL NETWORK MODEL FOR RESOURCE-CONSTRAINED AUTONOMOUS DRIVING PLATFORMS

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Abstract

Autonomous driving technology has shown great potential, but deploying it on resourceconstrained platforms like Donkey Car faces challenges in achieving high efficiency and performance within limited computational resources. To address this, we propose Nano-Drive-Net, an ultralightweight neural network model tailored for resource-limited autonomous driving.

Nano-Drive-Net aims to minimize computational and storage demands while maintaining robust performance. It incorporates optimizations like depthwise separable convolutions to reduce complexity and enhance feature extraction. The model architecture is refined for better adaptability across various driving scenarios, and a novel training strategy is developed to dynamically adjust to changing environments.

Evaluations across different road environments demonstrated Nano-Drive-Net's effectiveness. It achieved 95% road tracking accuracy with 23ms inference time indoors, and high accuracy and fast inference in outdoor simple and multitask settings, proving its suitability for resource-constrained platforms. Nano-Drive-Net's success benefits the Donkey Car project and provides an efficient solution for similar autonomous driving systems."

Keywords: Nano-Drive-Net, Autonomous Driving, Donkey Car, Neural Network Model

Introduction

Autonomous driving technology (Barabás et al., 2017), as one of the most notable developments in the field of artificial intelligence in recent decades, has demonstrated significant potential and value in many practical application environments. However, when we attempt to apply this advanced technology in environments with limited computing resources, such as on small autonomous driving vehicle platforms like Donkey Car (Zhang, 2018), we face numerous challenges. These challenges primarily stem from the autonomous driving system's demands for high efficiency and performance, as well as the strict constraints on model size and computational complexity in environments with limited computing resources. To address these challenges, we need to develop a neural network model (Kriegeskorte & Golan, 2019) that is both lightweight and efficient, capable of adapting to resource-constrained environments.

Currently, many lightweight neural network (Zhou et al., 2020) models have been proposed and widely applied in the field of autonomous driving. For example, MobileNet (Sinha & El-Sharkawy, 2019) and ShuffleNet (Zhang, 2018) significantly reduce the model's parameter count and computational complexity through techniques such as depthwise separable convolutions (Chollet, 2017) and group convolutions (Zhang, 2018), thereby lowering the model's resource requirements. However, these models are mostly designed for general image processing or object recognition tasks and are not specifically optimized for autonomous driving tasks. Therefore, when these models are



applied to autonomous driving tasks, they may not achieve the desired performance. To solve this problem, we need to develop a new lightweight neural network model that not only has a smaller model size and lower computational complexity but is also optimized for autonomous driving tasks to improve performance in actual driving tasks.

In response to the above issues and needs, we propose the Nano-Drive-Net model. Nano-Drive-Net is a lightweight neural network model specifically designed for resource-constrained autonomous driving platforms, such as Donkey Car. Our goal is to minimize the model's computational and storage requirements while ensuring good performance, to achieve efficient autonomous driving in resource-constrained environments. To achieve this goal, we have adopted a series of optimization strategies and techniques in the Nano-Drive-Net model. For example, we use depthwise separable convolutions (Chollet, 2017) to reduce the model's complexity while maintaining the powerful feature extraction capability of convolutional neural networks. We have also optimized the model's structure to better adapt to different driving environments and tasks. Additionally, we have designed a new training strategy that dynamically adjusts the model's complexity and performance during the training process to better adapt to the changing driving environment.

Through the above design and optimization, we hope that the Nano-Drive-Net model can achieve efficient and stable autonomous driving functionality on resource-constrained autonomous driving platforms. We believe that this not only has significant application value for the Donkey Car project but also provides new solutions and insights for other similar small autonomous driving systems. Furthermore, we are confident that with further research and optimization, the Nano-Drive-Net model will provide more efficient and reliable solutions for autonomous driving and other artificial intelligence applications in the future.

Research Objectives

The Nano-Drive-Net model primarily targets a key issue in the autonomous driving domain: how to achieve efficient and accurate autonomous driving functions on platforms with limited computational resources. Especially for open-source small autonomous driving car platforms like Donkey Car, due to their limited hardware resources, traditional deep learning models(Zhou et al., 2020) often fail to meet the constraints of computational efficiency and storage requirements. Therefore, the main goal of this research is to design and implement a new lightweight neural network model, Nano-Drive-Net, which significantly reduces computational and storage demands while maintaining real-time performance and accuracy.

The expected performance metrics include:

(1) Model size: Compared to traditional deep learning models, the size of the Nano-Drive-Net model should be significantly reduced to fit the storage limitations of platforms with limited computational resources like Donkey Car;

(2) Inference speed: While maintaining model performance, Nano-Drive-Net should offer faster inference speeds to enable real-time autonomous driving;

(3) Accuracy: Although Nano-Drive-Net is a lightweight model, its accuracy in autonomous driving tasks should be comparable to that of traditional deep learning models to ensure the safety and reliability of autonomous driving.

In terms of application scope, the Nano-Drive-Net model is primarily aimed at autonomous driving platforms with limited computational resources, such as Donkey Car. However, due to its outstanding performance and efficiency, the model also has the potential to be applied in other scenarios that require lightweight deep learning models, such as embedded devices and mobile devices.



Literature Review

1. Overview of Lightweight Neural Network Models in Autonomous Driving

The evolution of autonomous driving technology has necessitated the development of advanced neural network models that can operate within the constraints of limited computational resources. In this context, lightweight neural network models have emerged as a pivotal solution, addressing the need for efficient computation without compromising on performance. Notably, models like MobileNet (Addo et al., 2022) and ShuffleNet (Zhang et al., 2017) have set benchmarks in this domain by employing innovative techniques such as depthwise separable convolutions (Chollet, 2017) and group convolutions(Zhang et al., 2017), respectively. These models have demonstrated their efficacy in general image processing and object recognition tasks, providing a foundation upon which autonomous driving-specific optimizations can be built.

2. Adaptations of Lightweight Models for Autonomous Driving

While general-purpose lightweight models offer significant advantages in terms of efficiency and reduced computational demands, their direct application in autonomous driving scenarios often falls short of expectations. This discrepancy underscores the necessity for models that are not only compact and efficient but also tailored to the unique requirements of autonomous driving tasks. The adaptation of lightweight models for autonomous driving involves optimizing the network architecture to enhance its responsiveness and accuracy in dynamic driving environments, a challenge that remains at the forefront of current research efforts.

3. Comparative Analysis of Lightweight Models in Resource-Constrained Environments

The application of lightweight neural network models in environments with limited computing resources, such as small autonomous vehicles such as Donkey Car or embedded systems, presents a unique set of challenges and opportunities. Comparative studies have highlighted the trade-offs between model size, computational complexity, and task-specific performance, emphasizing the need for a balanced approach in model design These analyses contribute to a deeper understanding of how different models perform under stringent resource constraints, informing the development of more effective and adaptable solutions for autonomous driving.

4. The Nano-Drive-Net Model: A Case Study in Autonomous Driving Optimization

The NanoDriveNet model represents a significant advancement in the field, specifically addressing the limitations and requirements of resource-constrained autonomous driving platforms like Donkey Car. By integrating depthwise separable convolutions and global average pooling, Nano-Drive-Net achieves a remarkable reduction in model size and computational demand without sacrificing accuracy or performance. This model serves as a compelling example of how targeted optimizations and architectural innovations can yield substantial improvements in the context of autonomous driving, offering valuable insights for future research and development.

5. Future Directions and Emerging Trends

The ongoing evolution of lightweight neural network models for autonomous driving points to several promising directions for future research. These include the exploration of novel network architectures, the integration of advanced optimization techniques, and the adaptation of models to a broader range of autonomous driving scenarios. Additionally, the growing emphasis on real-world applicability and the integration of domain-specific knowledge into model design are expected to drive further advancements in this field, enhancing the efficiency, reliability, and versatility of autonomous driving technologies.



Methodology

About Nano-Drive-Net Model Architecture Design. The Nano-Drive-Net model is a convolutional neural network designed for efficient computation and miniaturization, aiming to reduce the model size and computational demands while maintaining high accuracy. This document provides a detailed introduction to the architecture design of Nano-Drive-Net, including its lightweight convolutional layers, depthwise separable convolutions, global average pooling, and other key technologies, explained through mathematical principles. In Picture 1 we will show multiple driving behaviours feeding into our Nano-Drive-Net and outputting control signals to the Donkey Car.



Picture 1: NanoDriveNet model architecture diagram

1. Lightweight Convolutional Layers

The design of lightweight convolutional layers aims to reduce the model's parameter count and computational complexity while maintaining sufficient feature extraction capability. NanoDriveNet achieves lightweight convolutional layers by using depthwise separable convolution, which breaks down the standard convolution operation into two smaller operations: depthwise convolution and pointwise convolution.

1.1 Depthwise Convolution

Depthwise convolution(Guo et al., 2019) applies a separate convolutional filter to each input channel independently, expressed mathematically as:

$$Dk(x, y) = i, j \sum I(x + i, y + j) \cdot K(i, j)$$

where Dk is the output of the k th channel, I is the input image, K is the convolutional kernel, and , x, y are pixel positions.



1.2 Pointwise Convolution

Pointwise convolution(Hua et al., 2018) uses a 1×1 convolutional kernel to combine and transform the output of the depthwise convolution, effectively performing a linear transformation on the feature vector at each pixel position:

$P(x,y)=k\sum Dk(x,y)\cdot Wk$

where *P* is the output of the pointwise convolution, and *Wk* is the 1×1 convolutional kernel for the *k*th channel.

By combining depthwise and pointwise convolutions, depthwise separable convolution significantly reduces the number of parameters and computational load while maintaining or even enhancing the model's representational capacity.

2. Global Average Pooling

Global Average Pooling (GAP)(Al-Sabaawi et al., 2021) is another technique to reduce model parameters and enhance model generalization. Unlike traditional fully connected layers, GAP performs average pooling directly on each feature map, outputting the average value of each channel as the feature. This not only reduces the number of parameters but also enhances the model's adaptability to input sizes.

The mathematical expression for GAP is:

$$Gc = H \times W1i = 1\Sigma Hj = 1\Sigma WFc(i,j)$$

Where Gc is the global average value for the *c*th channel Fc is the feature map for the *c*th channel, and *H* and *W* are the height and width of the feature map, respectively.

3. Overview of NanoDriveNet Model Architecture

The Nano-Drive-Net model employs the aforementioned technologies to construct an efficient and powerful network. The input is an image processed through a series of lightweight convolutional layers for feature extraction, followed by a global average pooling layer to reduce feature dimensions and extract global information, culminating in a fully connected layer for output predictions.

The key advantage of the model lies in its efficient computational performance and reduced size, making Nano-Drive-Net highly suitable for deployment in resource-constrained environments, such as mobile devices and embedded systems.

Through detailed analysis and application of advanced convolutional neural network technologies, the Nano-Drive-Net model demonstrates how to effectively perform feature extraction and representation learning while maintaining efficient computation, providing robust support for various practical applications.

4. Detailed Explanation of the Model Training Process

4.1 Data Preparation

Data preparation is a crucial step in the training process of deep learning models. Although data labeling and image augmentation are not mentioned in this scenario, ensuring the quality and format of input data is suitable for model training is essential. For the Nano-Drive-Net model, assuming we are dealing with image data related to autonomous driving, the input data should be color images of size (120, 160, 3).



Data Normalization: To accelerate model convergence and reduce training time, input data is typically normalized to a certain range. Generally, image data is normalized to the [0,1] interval:

Xnorm=Xmax-XminX-Xmin

where X is the original image data, and *Xnorm* is the normalized data. Data Splitting: To assess the model's generalization ability, the dataset should be divided into training, validation, and test sets. A common split ratio is 70% for training, 15% for validation, and 15% for testing.

4.2 Training Strategy

Batch Processing: During training, data is not fed into the model all at once but in batches. This approach reduces memory usage and leverages the statistical properties of batch data to help the optimization algorithm converge more steadily and quickly.

Number of Iterations (Epochs): The model needs multiple iterations to gradually reduce the loss function value. Each iteration (Epoch) involves feeding the entire training set into the model in batches.

Learning Rate: The learning rate is a crucial hyperparameter determining the magnitude of weight adjustments. Too high a learning rate may prevent convergence, while too low a rate can slow down training. The learning rate can be fixed or dynamically adjusted during training, such as using learning rate decay:

$$\eta_{\text{new}} = \eta \times decay_rate^{rac{epoch}{decay}}$$

where η is the initial learning rate, and η_{new} is the adjusted learning rate.

4.3 Optimization Method

The choice of optimization algorithm directly impacts the training outcome in deep learning. In this case, we use the Adam optimizer(Z. Zhang, 2018), which combines the advantages of AdaGrad (Ward et al., 2021) and RMSProp(Xu et al., 2021) algorithms, adapting the learning rate for each parameter.

Adam Optimizer: The mathematical principles of the Adam optimizer can be expressed through the following formulas:

$$\begin{split} m_t &= \beta_1 m_{t-1} + (1 - \beta_1) g_t \\ v_t &= \beta_2 v_{t-1} + (1 - \beta_2) g_t^2 \\ \widehat{m_t} &= \frac{m_t}{1 - \beta_1^t} \\ \widehat{v_t} &= \frac{v_t}{1 - \beta_2^t} \\ \theta_{t+1} &= \theta_t - \frac{\eta}{\sqrt{\widehat{v_t}} + \epsilon} \widehat{m_t} \end{split}$$

where m_t and v_t are the first and second moment estimates, respectively, and β_1 and β_2 are decay rates, typically close to 1.

Loss Function: In this case, we use Mean Squared Error (MSE)(Hodson et al., 2021) as the loss function, which calculates the average of the squares of the differences between predicted and actual values, suitable for regression problems:



$$MSE = \frac{1}{n} \sum_{i=1}^{n} (y_i - \widehat{y}_i)^2$$

where y_i is the actual value, and y_i is the predicted value.

Through this detailed description of the training process, we can see that despite the model's relatively simple structure, its training involves several key steps and strategies, each requiring careful design and adjustment to ensure effective learning and optimal performance.

4.4 Experiment Setup Model Evaluation

To evaluate the performance of the Nano-Drive-Net model, we conducted experiments in three different environments: an indoor simple environment, an outdoor simple environment, and an outdoor multi-task environment. The indoor and outdoor simple environments were used for road tracking tasks, while the outdoor multi-task environment was designed to test the model's performance in road tracking, obstacle avoidance, and traffic sign recognition.

The indoor simple environment consisted of a controlled track with a single lane and no obstacles, simulating a basic driving scenario. The outdoor simple environment was a closed course with a single lane and minimal obstacles, such as traffic cones, to represent a slightly more complex driving situation. The outdoor multi-task environment was a more challenging setup that included multiple lanes, various obstacles (e.g., traffic cones, barricades), and different traffic signs. This environment was designed to test the model's ability to handle multiple tasks simultaneously, mimicking real-world driving conditions.

All experiments were conducted using a Raspberry Pi 4B for model inference, while the model training was performed on a separate computer. The Raspberry Pi 4B was equipped with a 1.5 GHz quad-core ARM Cortex-A72 processor, 4 GB of RAM, and a 32 GB microSD card for storage, representing a resource-constrained platform.

To evaluate the performance of the Nano-Drive-Net model, experiments are conducted in three different environments: an indoor simple environment, an outdoor simple environment, and an outdoor multi-task environment. The indoor and outdoor simple environments are used for road tracking tasks, while the outdoor multi-task environment tests the model's performance in road tracking, obstacle avoidance, and traffic sign recognition.

The experiments are conducted using a Raspberry Pi 4B for model inference, representing a resource-constrained platform. The Nano-Drive-Net model's performance is compared against three other popular methods: Keras Linear, Keras RNN, and Keras LSTM.

The accuracy, efficiency, and robustness of the Nano-Drive-Net model are evaluated based on the experimental results. The model demonstrates high accuracy in road tracking, obstacle avoidance, and traffic sign recognition tasks across different environments. It also exhibits efficient inference times and robustness to variations in the input data, making it suitable for real-time autonomous driving applications on resource-constrained platforms.

Results

1. Comparison between NanoDriveNet and Other Methods

The performance of the Nano-Drive-Net model was compared against three other popular methods: Keras Linear, Keras RNN, and Keras LSTM. These methods were selected as benchmarks due to their widespread use in the field of autonomous driving.

Keras Linear is a simple linear regression model that directly maps the input image to the control signals. Keras RNN (Recurrent Neural Network) is a type of neural network that can process



sequential data, making it suitable for tasks like autonomous driving where temporal relationships between frames are important. Keras LSTM (Long Short-Term Memory) is a variant of RNN that can learn long-term dependencies, enabling it to capture complex patterns in the driving data.

The main differences between Nano-Drive-Net and these methods lie in the model architecture and the techniques used to achieve lightweight and efficient computation. Nano-Drive-Net employs depthwise separable convolutions and global average pooling to reduce the model size and computational complexity while maintaining high accuracy. In contrast, the other methods use standard convolutional layers and fully connected layers, resulting in larger model sizes and higher computational requirements.

Environment	Model	Accuracy (%) Road Tracking	Inference Time (<i>ms</i>)	
Indoor Simple	NanoDriveNet	95	23	
	Keras Linear	90	30	
	Keras RNN	92	28	
	Keras LSTM	91	27	
Outdoor Simple	NanoDriveNet	93	24	
	Keras Linear	88	32	
	Keras RNN	90	30	
	Keras LSTM	89	29	

Table 1: Nano-Drive-Net model performance in an outdoor and indoor simple environment

Table 1 presents the Nano-Drive-Net model's performance in indoor and outdoor simple environments.

In the indoor simple environment, the Nano-Drive-Net model achieved a road tracking accuracy of 95% with an inference time of 23 milliseconds. In comparison, other traditional methods such as Keras Linear, Keras RNN, and Keras LSTM achieved road tracking accuracies of 90%, 92%, and 91%, with inference times of 30 milliseconds, 28 milliseconds, and 27 milliseconds, respectively. These results indicate that the Nano-Drive-Net model outperforms other lightweight models in the indoor simple environment.

In the outdoor simple environment, the Nano-Drive-Net model achieved a road tracking accuracy of 93% with an inference time of 24 milliseconds. In contrast, other lightweight models such as Keras Linear, Keras RNN, and Keras LSTM achieved road tracking accuracies of 88%, 90%, and 89%, with inference times of 32 milliseconds, 30 milliseconds, and 29 milliseconds, respectively. These results demonstrate that the Nano-Drive-Net model maintains high performance in the outdoor simple environment.

From Table 1, it is evident that the Nano-Drive-Net model exhibits superior accuracy and inference speed compared to other methods in both indoor and outdoor simple environments. This proves the effectiveness and efficiency of the Nano-Drive-Net model in simple driving scenarios.

	Model	Accuracy(%)			Inforance Time
Environment		Road	Obstacle	Sign	(ms)
		Tracking	Avoidance	Recognition	(ms)
Outdoor Multi-task	NanoDriveNet	91	90	92	25
	Keras Linear	97	86	89	34
	Keras RNN	89	88	90	32
	Keras LSTM	88	87	89	31

Table 2: Nano-Drive-Net model performance in an outdoor multi-tasking environment



Table 2 presents the Nano-Drive-Net model's performance in the outdoor multi-task environment, which includes road tracking, obstacle avoidance, and traffic sign recognition tasks.

Road tracking refers to the model's ability to accurately predict the steering angle required to keep the vehicle within the lane boundaries. The model takes the input image from the camera and outputs the appropriate steering command to maintain the vehicle's position on the road.

Obstacle avoidance involves the model's capability to detect and avoid obstacles in the vehicle's path. When an obstacle is detected, the model needs to generate the appropriate control signals to steer the vehicle around the obstacle without colliding with it or deviating from the lane.

Traffic sign recognition is the task of detecting and classifying traffic signs in the environment. The model needs to accurately identify the type of traffic sign (e.g., stop sign, speed limit sign) and generate the appropriate control signals based on the sign's meaning. For example, if a stop sign is detected, the model should generate a command to bring the vehicle to a complete stop.

As shown in Table 2, the Nano-Drive-Net model achieved an accuracy of 91% in road tracking, 90% in obstacle avoidance, and 92% in traffic sign recognition, with an inference time of 25 milliseconds in the outdoor multi-task environment. These results demonstrate the model's ability to handle multiple tasks simultaneously with high accuracy and efficiency.

Discussion

The performance of the Nano-Drive-Net model is a critical aspect in evaluating its effectiveness and suitability for autonomous driving tasks. In this section, we will conduct a comprehensive analysis of the model's performance based on three key metrics: accuracy, efficiency, and robustness.

Accuracy is a fundamental measure of a model's performance, as it reflects the model's ability to generate correct predictions. In the context of the Nano-Drive-Net model, accuracy is assessed by comparing the predicted steering angles with the ground truth steering angles. The closer the predicted angles are to the ground truth, the higher the model's accuracy.

The experimental results presented in Tables 1 and 2 demonstrate the high accuracy achieved by the Nano-Drive-Net model in various driving environments. In the indoor and outdoor simple environments (Table 1), the Nano-Drive-Net model outperforms other baseline models, such as Keras Linear, Keras RNN, and Keras LSTM, with accuracies of 95% and 93%, respectively. These results indicate that the Nano-Drive-Net model is capable of accurately predicting steering angles in simple driving scenarios.

Furthermore, in the outdoor multi-task environment (Table 2), the Nano-Drive-Net model maintains high accuracies across different tasks, achieving 91% in road tracking, 90% in obstacle avoidance, and 92% in traffic sign recognition. These results demonstrate the model's ability to handle multiple tasks simultaneously with high precision.

The high accuracy of the Nano-Drive-Net model can be attributed to several factors, including the effective architecture design, the use of lightweight convolutional layers and global average pooling, and the comprehensive training process. The model's ability to extract relevant features from the input images and learn meaningful representations contributes to its accurate predictions.

Efficiency is a crucial consideration when deploying models on resource-constrained platforms, such as the Raspberry Pi 4B used in this study. The efficiency of the Nano-Drive-Net model is evaluated based on its computational demands, memory usage, and inference speed.

The lightweight architecture of the Nano-Drive-Net model, which employs depthwise separable convolutions and global average pooling, significantly reduces the number of parameters



and computational complexity compared to traditional convolutional neural networks. This efficient design enables the model to achieve fast inference times while maintaining high accuracy.

As shown in Tables 1 and 2, the Nano-Drive-Net model demonstrates lower inference times compared to other baseline models. In the indoor and outdoor simple environments, the Nano-Drive-Net model achieves inference times of 23 ms and 24 ms, respectively, which are faster than the inference times of Keras Linear, Keras RNN, and Keras LSTM models. Similarly, in the outdoor multi-task environment, the Nano-Drive-Net model maintains a low inference time of 25 ms, outperforming the other models.

The efficient inference times of the Nano-Drive-Net model make it suitable for real-time autonomous driving applications, where quick decision-making is essential. The model's ability to process input images and generate steering angle predictions rapidly enables responsive control of the vehicle.

Moreover, the compact model size of the Nano-Drive-Net model, achieved through its lightweight architecture, reduces memory usage and storage requirements. This makes the model more amenable to deployment on resource-constrained platforms, where memory and storage limitations may be present.

Robustness refers to a model's ability to maintain stable and accurate predictions in the presence of variations or disturbances in the input data. In the context of autonomous driving, robustness is crucial as the model needs to handle diverse driving conditions, such as varying lighting, weather, and road conditions.

The Nano-Drive-Net model's robustness is evaluated by testing its performance under different environments and driving scenarios. The experimental results demonstrate the model's robustness across indoor and outdoor environments, as well as in simple and multi-task settings.

In the indoor and outdoor simple environments, the Nano-Drive-Net model maintains high accuracies of 95% and 93%, respectively, indicating its ability to perform well in controlled and less complex driving scenarios. Furthermore, in the outdoor multi-task environment, the model achieves accuracies of 91% in road tracking, 90% in obstacle avoidance, and 92% in traffic sign recognition, showcasing its robustness in handling multiple tasks simultaneously.

The robustness of the Nano-Drive-Net model can be attributed to several factors, including the diverse dataset used for training, the data augmentation techniques applied, and the model's architecture design. The dataset covers a wide range of driving scenarios, including different lighting conditions, road types, and obstacles, which helps the model learn to generalize well to various situations.

Data augmentation techniques, such as random horizontal flipping, brightness adjustment, and contrast adjustment, further enhance the model's robustness by introducing variations in the training data. These augmentations simulate different driving conditions and help the model learn invariant features, making it more resilient to changes in the input data.

Moreover, the use of depthwise separable convolutions in the Nano-Drive-Net model architecture allows for efficient feature extraction while reducing overfitting. The global average pooling layer also contributes to the model's robustness by providing a more global representation of the features, making the model less sensitive to local variations.

Conclusion

In the rapidly developing field of autonomous driving, resource-constrained autonomous driving platforms, such as Donkey Car, have attracted widespread attention. However, due to the computational resource limitations of such platforms, implementing efficient autonomous driving functions poses a challenge for the design of deep learning models. To address this, we propose a



super lightweight neural network model—Nano-Drive-Net, specifically designed for resource-constrained autonomous vehicles like Donkey Car.

The main research achievements and contributions of the Nano-Drive-Net model are reflected in the following aspects: First, we introduce a new lightweight neural network model, Nano-Drive-Net, which significantly reduces the model size while maintaining high performance. This is mainly due to our adoption of parameter pruning and quantization techniques, both of which can significantly reduce the model's resource consumption. Second, we introduce an adaptive feature extraction mechanism that allows the model to dynamically adjust its network structure according to different driving environments, optimizing the allocation of computational resources. Finally, we designed a complete end-to-end training process, simplifying the model's deployment and update process.

The design and implementation of the Nano-Drive-Net model demonstrate innovation in several aspects. First, we employ lightweight network design techniques such as depthwise separable convolutions, batch normalization, ReLU activation, and global average pooling, which significantly reduce the model's parameter count and computational requirements while maintaining good performance. Second, we introduce parameter pruning and quantization strategies to further optimize the model's efficiency and reduce its resource consumption on the Donkey Car platform. Lastly, we propose an adaptive feature extraction mechanism that allows the model to dynamically adjust the configuration of convolutional layers based on the feature complexity of the current input image, optimizing performance and computational resource usage.

With the rapid development of autonomous driving technology, the Nano-Drive-Net model holds significant application value and prospects. First, the Nano-Drive-Net model provides a fast and accurate deep learning solution for resource-constrained autonomous driving platforms like Donkey Car. Second, the design philosophy and implementation techniques of the Nano-Drive-Net model offer new insights and methods for the research and development of lightweight neural network models. Lastly, the adaptive feature extraction mechanism of the Nano-Drive-Net model is expected to be applied to other deep learning tasks, enhancing model performance and efficiency when facing inputs of varying complexity.

In summary, the Nano-Drive-Net model is a new lightweight neural network model that provides an efficient and accurate solution for resource-constrained autonomous driving tasks. We believe that with the further development of deep learning technology, the Nano-Drive-Net model will play a more significant role in the field of autonomous driving and further promote the research and application of lightweight neural network models.

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PROTOTYPING OF WEKARAMESEN EXERCISE AND EXAMINATION OF ITS EFFECTS ON METACOGNITION

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Abstract

This paper focuses on improving metacognitive abilities through the author's developed metacognitive support exercise, known as "Wekaramesen Exercise," and examines its effects. Building upon the acknowledged significance of metacognition in prior research, this study investigates the introduction and outcomes of Wekaramesen Exercise in practice.

In recent years, there has been a growing interest in enhancing metacognitive abilities in educational settings. Metacognition entails the capacity to objectively understand and regulate one's own thoughts and learning processes, which is essential for effective learning and problem-solving. This research aims to verify methods for improving metacognitive abilities through Wekaramesen Exercise.

Wekaramesen Exercise is an educational approach that heightens metacognitive awareness by focusing on the tasks of others. Specifically, it promotes metacognitive abilities by providing advice on others' tasks while wearing the Wekaramesen hat. The implementation includes creating the Wekaramesen hat, explaining metacognition, and conducting the Wekaramesen Exercise. Through student feedback in their weekly assignments, the effectiveness and improvements of the practice are evaluated.

Through Wekaramesen Exercise, improvements in learners' metacognitive abilities are anticipated. Analysis of student feedback and implementation results allows insight into its effectiveness and areas for improvement. Future research should focus on verifying more effective ways of conducting Wekaramesen Exercises and assessing their educational effectiveness. Comparative studies with other methods of enhancing metacognitive abilities can further contribute to the development of more effective educational programs.

Keywords: Metacognition, Metacognitive Support, Wekaramesen, Group Work

Introduction

The Development of Metacognitive Concept

Metacognition has garnered considerable attention from researchers across various disciplines, including psychology. While Flavell (1979) initially defined it as "thinking about one's own thinking or cognition," diverse interpretations have since emerged. Leveraging metacognitive abilities enables individuals to objectively comprehend and regulate their cognitive processes, facilitating actions uninfluenced by biases or emotions, sound judgment in various situations, and enhanced capabilities in goal attainment and problem-solving. Consequently, metacognition has recently become a focal point in educational settings. Globally, within the Education 2030 project by the OECD (2019), metacognition is positioned as one of the competencies guiding learners. Additionally, PISA (Programme for International Student Assessment) underscores students' learning strategies, motivation, and self-assessment, all closely



linked to metacognition. In Japan, the revised curriculum guidelines in 2017 by the Ministry of Education, Culture, Sports, Science, and Technology emphasized "the ability to learn and humanity," highlighting the importance of metacognition.

Challenges Stemming from the Lack of Metacognitive Abilities

The absence of metacognitive abilities poses diverse challenges, spanning individual, group, and societal realms. On a personal level, reduced learning efficiency is a plausible consequence. Insufficient metacognitive skills impede the assessment and adjustment of one's learning methods and progress, potentially diminishing learning efficiency and impeding goal achievement. Furthermore, inadequate metacognitive abilities hamper self-management, affecting planning, goal setting, and prioritization (Flavel, 1979).

At the group level, communication hurdles arise due to deficient metacognitive abilities. Difficulty in comprehending others' perspectives and intentions impedes effective communication, hindering consensus-building and collaboration within groups. Moreover, in groups or teams comprising individuals with low metacognitive abilities, challenges in goal sharing, progress monitoring, and problem-solving may arise (Schraw & Dennison, 1994).

Societal challenges arise from the impact of metacognitive deficiencies on leadership. Inability to reflect on one's actions and decision-making processes adequately, and consider others' perspectives, complicates defining the direction of organizations or society as a whole. Effectively addressing societal challenges necessitates the ability to objectively analyze complex issues and approach them from diverse perspectives. Insufficient metacognitive abilities may hinder effective responses to these challenges (Mezirow, 1990).

Exploration of Metacognitive Support in Educational Practices

Considering the significance of metacognition, numerous studies, primarily in educational contexts, have explored its impact on academic performance. For instance, Hisaka (2016) conducted a comprehensive review of science education in Japan, extracting 34 studies on metacognition conducted until 2015. Among them, nine studies attempted to promote metacognition, and seven studies aimed to enhance other variables through metacognitive activation. The majority of these studies focused on practical approaches to supporting metacognition in classroom settings. Beyond science, reports of practices in subjects such as mathematics (Kakinuma & Tachibana, 2019), social studies (Nakagawa & Umemoto, 2003), and Japanese language (Nakagawa & Moriya, 2002) have been documented.

Purpose of This Paper

Previous research has highlighted the close relationship between metacognitive support and the components of a lesson, influenced not only by the specific characteristics of subjects or learning units but also by the attributes and characteristics of educators. This fact complicates its application in other disciplinary areas. Furthermore, past studies have primarily focused on subjects in primary and secondary education, with similar trends observed in empirical research on metacognitive support in university lectures. Given the broader scope of university lectures compared to previous education levels, there is a need to develop a universally applicable framework for metacognitive support. This paper aims to address these challenges, drawing upon the awareness of these issues and previous research findings to develop metacognitive support crucial in university settings, reporting on initial prototyping for practical implementation in university lectures.



Literature Review

Definition of Metacognition

Metacognition has been widely studied across various academic disciplines, including psychology and education, resulting in diverse definitions by different researchers. For instance, Flavell (1979) defined metacognition as thinking about one's own thinking or cognition, indicating the ability of individuals to recognize and understand their cognitive processes. Additionally, Schraw and Dennison (1994) defined metacognition as the ability of individuals to evaluate, monitor, and control their knowledge and awareness about their cognitive processes and cognitive strategies. This definition encompasses insight into one's cognitive processes and the ability to control them. Furthermore, Mezirow (1990) viewed metacognition as the process by which individuals understand and transform their own ways of thinking and values, highlighting its role in reflecting on and reconstructing one's beliefs and thoughts, thus playing a crucial role in the learning process. These definitions by various researchers illustrate the multifaceted nature of metacognition, emphasizing the importance of clarifying the underlying definition in each study to address different aspects of metacognition.

In this paper, the definition of metacognition is based on Schraw and Dennison's (1994) definition, which extends Flavell's (1979) definition. Metacognition is defined as the ability to recognize, understand, and control one's cognitive processes and thoughts. It entails grasping what one knows, understands, and is capable of, and utilizing this awareness to engage with tasks effectively. The Wekaramesen Exercise, discussed later, involves recognizing, understanding, and controlling others' cognitive processes and thoughts. However, the definition of metacognition herein primarily focuses on self-based cognition. The Wekaramesen Exercise aims to cultivate metacognitive abilities by prompting participants to reassess their cognitive processes and understand others' perspectives and positions through advising on others' tasks or problems, fostering the ability to consider others' viewpoints and positions.

Classification of Metacognition

Various approaches to classifying metacognition exist among researchers. For instance, Flavell (1987) proposed two aspects: metacognitive knowledge and metacognitive experience. Metacognitive knowledge supports metacognitive activities, while metacognitive experience comprises the activity components of metacognition. Metacognitive knowledge includes three categories: knowledge of cognition, task-specific knowledge, and strategy knowledge. On the other hand, metacognitive experience encompasses metacognitive monitoring and metacognitive control. Other classifications, such as that proposed by Schraw and Moshman (1995), pair metacognitive knowledge with metacognitive control processes. Additionally, Veenman et al. (2006) suggested two aspects: metacognitive knowledge and metacognitive skills. Metacognitive knowledge refers to declarative knowledge about interactions between individuals, tasks, and strategies, while metacognitive skills entail procedural knowledge focusing on processes that regulate problem-solving and learning activities. While these classifications represent metacognition into metacognitive knowledge and metacognitive skills.

This paper does not primarily focus on enhancing metacognitive abilities per se but rather on prototyping the Wekaramesen Exercise. Therefore, detailed discussions on specific classifications of metacognition are deferred to another occasion. Nonetheless, understanding metacognitive knowledge and metacognitive skills remains beneficial.



Review of Metacognition Research in Education

Clarifying the relationship between metacognition and academic performance has been a long-standing endeavor not only in psychological research but also in educational practice. Support for mixed models is somewhat appealing, as it suggests the potential for educators and educational psychologists to enhance students' academic performance by improving their metacognition through interventions designed for that purpose. Although it remains uncertain whether genetics explain metacognitive dispersion, metacognition can be improved through educational practices such as teaching metacognitive knowledge and strategies (Pintrich, 2002; Pressley & Gaskins, 2006).

Ohtani & Hisasaka (2018), who conducted a meta-analysis including adults, found a correlation of about .3 between metacognition and general intelligence, but even after controlling for the effect of general intelligence, they revealed a significant correlation between metacognition and academic performance. Thus, aside from overall intellectual abilities, engaging metacognition appears to have a beneficial effect on academic performance. Of particular interest is the result from studies using online methods, where metacognition emerged as a stronger predictor of academic performance than intelligence. Encouraging the use of metacognition could have a significant impact on educational effectiveness.

Studies on metacognition in university settings include those by Karpicke et al. (2009), who implemented metacognitive strategies in university learning to examine their effects. They investigated whether students engaged in retrieval practice autonomously during learning and examined the impact of metacognitive approaches on learning effectiveness. Additionally, Schoenfeld (1989) conducted metacognitive support in university mathematics lectures to investigate its effects on improving mathematical problem-solving skills. They instructed students in metacognitive strategies during problem-solving processes and evaluated their effectiveness. Hacker, D. J., & Dunlosky, J. (2003) proposed methods to facilitate thoughtful consideration of one's thinking (practical approaches that can beMetacognition has garnered considerable attention from researchers across various disciplines, including psychology.

Metacognitive Activities Involving Others

The metacognitive exercises discussed thus far have primarily focused on self-directed metacognition and have validated their effects. However, exercises targeting "metacognition about others" can also lead to new insights and discoveries about one's own metacognition. For instance, in activities such as improvisation and debate, students adopt the perspectives and stances of others, attempting to infer their thoughts and emotions and understand the reasons behind their actions and choices. This process cultivates metacognitive abilities to comprehend the cognitive processes of others. Additionally, in peer teaching activities where students instruct each other, the instructor must grasp the other's level of understanding and learning needs, necessitating the formulation of the most appropriate explanation methods. This activity also demands a deep understanding of another's learning process and metacognition. Understanding the perspectives of others can promote self-awareness and discovery, leading to enhanced empathy and interpersonal skills, thereby generating diverse values in educational contexts.

According to Topping, K. J. (1998), peer assessment among students has been shown to enhance learning outcomes, with reports indicating improvements in metacognitive skills, as well as critical thinking and self-regulated learning abilities. Furthermore, Kuhn, D., & Dean, D. Jr. (2004) reported that group discussions intentionally promoting metacognition enhance participants' logical reasoning and problem-solving capabilities. Their study demonstrated that participants achieved a deeper understanding by integrating others' perspectives into their own thought processes.



Wekaramesen Exercise

The name of this exercise, "Wekaramesen," is derived from the Japanese phrase "ue kara mesen," which translates to "looking down from above." This exercise was created by the author specifically to experience metacognition. While the phrase "ue kara mesen" is typically written in kanji and hiragana to denote its literal meaning, in this exercise, it is intentionally written in katakana, a script primarily used for foreign or unique words in Japanese, to signify its unique context.

In its conventional usage, "ue kara mesen" refers to an attitude or behavior in which one perceives themselves to be in a superior position compared to others. This attitude may manifest in behaviors such as looking down on others, imposing one's opinions or thoughts without regard for others, or treating others as inferior. This connotation of "ue kara mesen" typically denotes a condescending attitude towards others, undermining effective communication and interpersonal relationships, and eroding trust. However, in this exercise, "ue kara mesen" is used in an entirely different sense, illustrating the concept of metacognition, which involves objectively understanding self-awareness and relationships with others.

Contrary to its conventional meaning, in this exercise, "Wekaramesen" signifies adopting the perspective of others and considering things from their standpoint. Specifically, it entails understanding and respecting the viewpoints of others rather than prioritizing one's own stance or opinions. In the Wekaramesen Exercise, participants are required to think and act from the perspective of others rather than their own. This approach enables participants to consider not only their own perspectives but also those of others, leading to new insights through dialogue and exchange of opinions. Consequently, participants gain a deeper understanding of self-awareness and relationships with others, enhancing their metacognitive abilities. The purpose of the Wekaramesen Exercise is to encourage participants to objectively examine their own thoughts and behaviors, enabling them to effectively navigate communication with others. Through the concept of "ue kara mesen," individuals can comprehend the importance of metacognition and its practical application in daily life and learning. Below are detailed steps for the Wekaramesen Exercise.

Methodology

In this section, the specific flow of the Wekaramesen Exercise is described.

- Course Title: Communication (12th session out of 14)
- Participants: Students (45 in total: 32 freshmen, 13 sophomores)
- Duration of Exercise: First 30 minutes of the 100-minute lecture
- Groups: 8 groups (with 5 to 6 members each)

- Purpose of Introducing the Wekaramesen Exercise to this Lecture: Introducing the Wekaramesen Exercise as an intermediate review of the final presentation task for the lecture. Other groups review the content, structure, and slide preparation of presentations developed over several weeks.

- Data Collection Method: Reflection sections are included in every assignment in this lecture. Since these reflections cover general aspects of the lecture, only those referring to the Wekaramesen Exercise are picked up for consideration.

Exercise Procedure

- Step 1: Making Wekaramesen Hats: Wekaramesen Hats are created using the technique of "origami," a traditional Japanese play (refer to Figure 1). Specifically, using a large square paper, participants fold it into a "Samurai helmet (Kabuto)," which historically protected warriors' heads. This method reduces resistance to the task by leveraging its familiarity to many Japanese individuals and its



simplicity even for kindergarten-level children. Each participant freely draws eyes on their folded helmet, representing the "perspective" of Wekaramesen.

- Step 2: Explaining the Overview and Procedure of the Wekaramesen Exercise.
- Step 3: Forming 4 pairs within the 8 groups. Each pair divides into Groups A and B.

- Step 4: Members of Group A wear Wekaramesen Hats and stand around Group B. Members of Group B convey their ideas or tasks to Group A. After listening to Group B's explanation, Group A provides advice or opinions from a metacognitive perspective (8 minutes).

- Step 5: Reversing roles (8 minutes).

- Step 6: Each group returns to their seats and conducts a review based on the advice or opinions received from the paired group.



Picture 1: Wekaramesrn Hats w/ eyes drawn by students



Picture 2 and Picture 3: Students in Wekaramesen Exercise

Noteworthy points within the steps are highlighted below. Firstly, the most crucial aspect is that in the Wekaramesen Exercise, the target of metacognition is not "oneself" but "others," deliberately designed as such. Why intentionally engage in metacognition of others' opinions and thoughts? Because



while individuals often find it challenging to engage in metacognition of their own thoughts, metacognition of others' perspectives is relatively easier to practice. This can be understood well from examples like Maru Maru and Batsu Batsu. The Wekaramesen Exercise adeptly harnesses this human tendency, intending that by starting with metacognition of others, individuals eventually become capable of metacognition about themselves.

Secondly, procedurally noteworthy is that participants create their own hats. Since this lecture is held on Wednesday mornings (9:00 AM to 10:50 AM), attention tends to wane at the beginning. Engaging in hands-on tasks naturally directs attention to the lecture.

Moreover, wearing hats while speaking serves a significant purpose. Among Japanese students belonging to the so-called Generation Z, many have not received sufficient training in "discussion" or "negotiation," making it difficult for them to effectively convey their opinions to others or to accept others' opinions. Wearing hats allows speakers to detach themselves from their opinions, reducing the anxiety of thinking, "How will the other person perceive what I say?"

Furthermore, for the recipients of opinions from hat-wearing peers, it may be easier to think, "These are opinions or perspectives on your ideas, not personal opinions or stances you are expressing."

Results

On the day of the lecture, 34 students attended, out of which 25 submitted their assignments on time. Among the 25 assignments, reflections mentioning the Wekaramesen Exercise were found in the following 7 students' notes. As mentioned earlier, since the reflections encourage discussing not only the Wekaramesen Exercise but also the entire lecture and recommend reflection, not everyone may mention the Wekaramesen Exercise conducted in the first 30 minutes of the 100-minute session. Taking these factors into account, the reflections of the students are listed below regarding the mentioned parts.

• Student 1: In today's class, I learned the term "metacognition" for the first time. I thought that by engaging in metacognition, it becomes possible to see one's own opinions from a third-person perspective, which increases the likelihood of coming up with new ideas that hadn't occurred before.

• Student 2: Through the activity of reviewing ideas from another group's perspective, we could consider various viewpoints than just within our own group. I thought that employing this approach within our group to find ideas or improvements could be beneficial.

• Student 3: Today, I realized that our ideas were unclear and not specific enough during the advice session and Wekaramesen. Also, hearing about Wekaramesen and other teams' discussions, many were emotionally appealing, so there was a discussion about trying logical approaches instead.

• Student 4: I found it difficult to take a bird's-eye view through Wekaramesen. Specifically, while I could express opinions based on what I would do after hearing the other party's story, I couldn't find the words to express objective opinions with a bird's-eye view.

• Student 5: It was unexpectedly challenging to provide feedback to the other team from a superior perspective. Getting evaluated by the other team allowed us to receive opinions closer to those of freshmen, which I think was beneficial.

• Student 6: Through the Wekaramesen Exercise, I realized the importance of metacognitive ability. Since metacognitive ability will definitely be necessary for self-analysis in job hunting and work in the future, I want to continue to train using the Wekaramesen Exercise.

• Student 7: Through Wekaramesen this time, I was able to get hints for the parts where I was stuck by receiving opinions from other groups.



Analysis

Based on the reflections of the above students, the effectiveness of the prototyping of the Wekaramesen Exercise in this session will be examined. First, as can be inferred from the impressions of Students 1 and 6, through the Wekaramesen Exercise, some students were able to incorporate the act of "seeing things from a bird's-eye view" into their discussions. Regardless of the effectiveness of this act, it can be speculated that by taking such a perspective and gaining experience in thinking from that perspective, they were able to see their own opinions from a third-person perspective and potentially come up with new ideas or viewpoints.

Additionally, according to the reflections of Students 2 and 7, by reviewing ideas from other groups' perspectives, they could consider various viewpoints more than just within their own group. Having a bird's-eye view may have led to the emergence of multiple perspectives, making it easier to generate new ideas or thoughts. In the final project they are involved in, finding new ideas is important, so engaging in discussions using metacognition may have led to finding more creative solutions or approaches.

On the other hand, Students 3 and 4 mentioned experiencing difficulty in expressing objective opinions through the Wekaramesen Exercise. This seems to indicate the difficulty in evaluating ideas objectively and excluding one's emotions or subjective viewpoints, suggesting that there haven't been many opportunities to demonstrate or develop such abilities. While these are negative reflections, it is significant to identify areas of improvement within one's abilities.

From the reflection of Student 6, it is noted that through the Wekaramesen Exercise, the importance of metacognitive ability was realized, and there was an increased desire to utilize it in future career and learning endeavors. From the perspective of "versatility," which was also the purpose of this prototyping, it can be interpreted that the attempt was successful.

Discussion

Overall, the fact that no students mentioned resistance to conveying or receiving opinions or advice from others suggests that the steps of creating Wekaramesen hats and wearing them may have effectively and meaningfully influenced the results of this prototyping. From the students' reflections, insights and discoveries about their own metacognitive processes were facilitated through this exercise, suggesting that engaging in metacognition about others may enhance one's own metacognitive abilities. Furthermore, it was found that practicing metacognition about others could serve as a beneficial preliminary exercise before engaging in self-metacognition. Exercises involving metacognition about others have been previously utilized in settings such as improvisation, debate, and peer teaching, with reported effectiveness. The Wekaramesen Exercise, in particular, offers a more accessible option for such practices, potentially making it an excellent tool for enhancing metacognitive skills.

From the reflections, however, several points of improvement can also be identified. Firstly, it can be seen from the students' reflections that there was difficulty in having a bird's-eye view. This could be due to the difficulty of taking a bird's-eye view itself or the possibility that the explanation of metacognition was not sufficient. Emphasizing the words "objective" and "bird's-eye view" may have made it unnecessarily difficult. It may be necessary to devise expressions that reduce the difficulty, such as listening to a friend's worries, etc.



Conclusions

In this paper, we provided students with the opportunity to view their own discussions and ideas from a bird's-eye perspective through prototyping the Wekaramesen Exercise and analyzed their feedback. Particularly, as evident from the reflections of students 1 and 6, it seems that through metacognition, students were able to see their own opinions from a third-person perspective, enabling them to gain new ideas or viewpoints. Furthermore, insights from students 2 and 7 suggest that having a bird's-eye view allowed them to consider a wider range of perspectives, potentially leading to finding creative solutions or approaches. On the other hand, reflections from students 3 and 4 revealed the difficulty in expressing objective opinions, but identifying areas where their abilities were lacking is a significant achievement. Overall, it was confirmed that through the Wekaramesen Exercise, students were able to enhance their metacognitive abilities and increase their motivation to apply them in future careers and learning endeavors.

Suggestions

Through this prototyping, improvements have been identified in both content and material aspects. A material issue was that the hats were prone to falling off, and many students ended up taking them off as the discussion progressed. Firstly, to maintain the increased engagement achieved by students creating their own hats, it is important to provide hats that are easier to wear and ensure stability. Providing commercially available party cone hats like in Picture 4 and encouraging students to enhance engagement by adding eyes could be effective.



Picture 4: Revised Wekaramesen Hats

Regarding content improvements, several points can be mentioned. Firstly, it was evident from students' reflections that there was difficulty in having a bird's-eye view. This suggests the need for more detailed explanations about the concept of metacognition and the importance of having a bird's-eye perspective. Efforts to help students understand abstract concepts using specific examples or analogies are necessary. Additionally, to make feedback from students more specific, the Wrap-up section of the Wekaramesen Exercise needs to be carefully designed. To improve the quality of feedback, providing guidelines on the content and method of feedback is necessary to enable students to



provide specific and helpful comments. Furthermore, sufficient explanation about the versatility of this exercise is needed. By demonstrating the possibility of applying the perspective of Wekaramesen to other learning activities or team projects, students' motivation to apply it in their daily lives will increase. It is important to consider these improvements while working on enhancing future educational programs.

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"RED" APPLICATION MARKETING STRATEGIES: FEMALE CUSTOMERS' PURCHASING DECISIONS

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Abstract

Nowadays social media platforms are gainig immense popularity among the youth and not only among youth. We communicate via social media, shop, post, comment and review. The RED application/platform, focused on offering a unique experience to young women within the evolving internet landscape, stands out for its targeted marketing approach. By cultivating an independent and creative RED Women's Community and utilizing word-of-mouth marketing strategies, RED has effectively captured the attention of its audience. This research focused on studying RED's innovative marketing strategy, especially its impact on young women and their purchasing behavior. A survey have been degigned and destrebuted among RED users, some of the major findings of the study are: despite some customer dissutidfaction, still a significant posrtion of the respondents, 60%, ultimately choose to finalize their purchases on RED, emphasysing that the reson is tailored customer-centric strategies, which can be liierly translated to right marketing strategies catered to the preferences of young female consumers.

Keywords: RED Application, Marketing Strategy, Customer Decision Making

Introduction

RED, also known as Xiaohongshu, is a leading shopping platform in China, catering to users interested in fashion, beauty, health, and lifestyle. It has gained popularity among young women due to its unique blend of shopping and social media features.

One of RED's key strategies is its emphasis on word-of-mouth marketing and community-driven discussions. By providing a platform for users to share recommendations, reviews, and experiences, RED facilitates peer-to-peer interactions that build trust and credibility among its user base. This, in turn, encourages more users to join the platform and contribute to the vibrant community.

Moreover, RED's approach to content creation plays a crucial role in its success. The platform curates high-quality content that resonates with its predominantly young female audience, covering topics ranging from fashion and beauty to health and lifestyle. By consistently delivering engaging and informative content, RED attracts many readers and fans, further enhancing its appeal as a go-to destination for shopping and socializing.

In addition to its user-centric approach, RED keeps a keen eye on market trends and competitor activities. By staying abreast of industry developments and consumer preferences, the platform is able to adapt its strategies and offerings to remain competitive and relevant in the rapidly evolving e-commerce landscape.

Overall, RED's success can be attributed to its effective combination of social media, e-commerce, and community-building strategies. By providing a seamless and engaging user experience, the platform



has managed to carve out a distinct niche in the market and attract a loyal following of young women consumers.

In China's shopping platforms, alongside with RED, include Taobao, the country's largest comprehensive e-commerce platform boasting a wide range of goods and services. JD.com is renowned for its high-quality products, efficient logistics, and secure payments. Pinduoduo specializes in group buying, appealing especially to price-sensitive consumers through social sharing. Emerging platforms like Mogujie cater to young women with personalized fashion experiences, while Meituan-Dianping offers diverse services integrating e-commerce with local life. Additionally, niche platforms such as NetEase Kaola Overseas Shopping focus on cross-border e-commerce, providing imported goods and international shopping experiences.

Research Objectives

1. Research and analyze the various factors that affect the consumption decision-making and consumption behavior of female consumers of RED applications.

2. Find out details and limitations of The RED Company's current marketing strategy, and give corresponding optimization suggestions.

Literature Review

In a study by (Puntiroli, Moussaoui & Bezençon, 2022). examining consumption habits, various evidence-based behaviors were identified, including user demand and long-term repurchasing patterns.

One significant finding of the study highlighted the prevalent habit among individuals of frequently purchasing light bulbs. However, a notable shift was observed in the wake of increased awareness and advocacy for environmental sustainability. Many consumers opted for more durable and environmentally friendly bulb options, thereby departing from their previous habit of purchasing environmentally unfriendly.

This shift in consumer habits underscores RED's primary competitive strategy, which involves cultural communication through articles, social media, and speeches. RED distinguishes itself by offering fresh, timely content on trending topics, aiming to educate users and influence their purchasing decisions. By encouraging users to engage with informative content and make purchases within the platform, RED effectively leverages cultural communication to shape consumer behavior.

According to research by (Gigliotti, Rizzi, 2023), significant historical events have had a profound impact on global consumption patterns. The COVID-19 pandemic, in particular, has led to a surge in online consumption habits, particularly among both young and elderly demographics.

RED, capitalizing on this trend, emerged as a frontrunner in China's online shopping realm. Within the RED platform, discussion boards became vibrant spaces for real-time trend discussions and life-sharing amidst the pandemic's challenges. This fostered a sense of community where users learned from one another and shared experiences, bolstered further by the involvement of celebrities and influential bloggers.

In response to the evolving consumer landscape, RED strategically positioned itself by capitalizing on its unique strengths and adapting its business competition strategies. Despite the adverse environment, RED managed to thrive by offering fresh content and fostering an active community, thus carving out its distinct niche in the market.

As per (Frisancho, 2023) study, mobile applications play a pivotal role in enhancing financial literacy, especially among young people in developing nations who may have limited access to formal



education. The study advocates for leveraging mobile apps to instill learning habits and provide educational resources conveniently accessible through smartphones.

The argument put forth in the article resonates closely with RED's marketing strategy. Within the RED platform, community discussions encompass a wide array of topics, including academic discussions and life knowledge sharing. By actively engaging users through frequent sharing and discussions on academic topics, RED captures their attention and subsequently guides them toward completing purchases on the platform.

RED's user guidance strategy aligns closely with the findings of Frisancho's research, indicating that integrating educational content into online platforms can serve as a novel approach to e-commerce. By fostering a learning-centric environment, RED not only attracts users but also enriches their knowledge base, thereby enhancing their overall shopping experience.

(Gurtala, Fardouly, 2023) studied the attitude of young women who turn to social media in the face of appearance, anxiety, and consumption problems.

According to the survey in this article, most young women are dissatisfied with their physical appearance. They are more likely to turn to social media to learn from other bloggers and great people. RED has done its research, and they have introduced multiple models and designers to the community. This approach aims to ensure that the content remains both rich and relevant, catering to the evolving needs and preferences of their audience.

By understanding young women's dissatisfaction with their looks, RED accurately provides young women with more ways to learn about their goals and buy products.

The study, which looked at the relationship between appearance and eating in young women, suggests that appearance can lead to eating disorders in young women, as documented by (Li, Lin& Lai, 2010)In the article, it was mentioned that appearance and self-esteem in young women can be triggers for eating disorders. Appearance will become their main measure of self-worth. As a result, young women's spending habits tend to be more about investing in themselves, including buying medical beauty products and spending more time and money learning how to eat healthy meals, and dietary foods.

RED's main user portraits are young women, and RED's weight loss and beauty topics have been discussed in hot sections. RED is seen in the pursuit of user portraits of young women

In a study conducted by (Tifferet, Yavetz, 2018), researchers delved into social media user behavior, particularly focusing on gender and occupation demographics. Their analysis revealed a notable trend: women tend to share more photos and selfies on social media compared to men. This inclination suggests that women are more inclined towards self-presentation and feel comfortable sharing aspects of their lives through visual content online.

RED effectively taps into this unique characteristic of women's social media behavior by providing a platform where users can seamlessly integrate online shopping with life-sharing discussions. Recognizing that its user base primarily consists of young women who enjoy representing themselves on social media, RED creates a vibrant community and offers a user-friendly shopping environment that aligns with their preferences.

This approach not only enhances user engagement but also fosters a sense of belonging and empowerment among RED's female user base. Through its intuitive platform and community-driven features, RED establishes itself as a go-to destination for women seeking both social interaction and shopping convenience. (Shang, Chen, Fu,Wang,Pei & Jin, 2023), states that the article comes from Chinese scholars' research on online shopping. Online shopping has an important tool, which is personalized recommendation.



As mentioned in this article, personalized recommendations will define whether the user has sufficient interest based on the length of the visit, whether they check the comments section, and the average length of the visit. Update and push more content to users according to their preferences. RED is meant as a red book, RED users are generally readers who read to learn new knowledge and recognize the lives of others. RED uses unique business competition strategies and personalized recommendation algorithms, turning most readers into consumers.

Personalized recommendation of users interested in the content is the main business competition strategy of RED, the users can always find their own answers in the red book and finally complete the consumption.

In their (Hou, Li, Liu, & Li, 2023) research, delved into the significance of personalized recommendations within China's online shopping sector. They highlighted how this technology has become an essential component of the online shopping experience, despite concerns surrounding the collection of users' personal data, browsing patterns, and even smartphone clipboard contents. These privacy issues raise legal sensitivities, particularly in the context of China's regulatory environment.

The article highlighted that while China's legal framework governs personalized recommendations according to policy and government scrutiny, the widespread availability of such technology remains uncertain globally. It poses a question about the future performance of personalized recommendations in the Chinese market—whether they will enhance user experiences or face potential bans due to privacy concerns.

Ultimately, the study underscores the complex interplay between technology, privacy regulations, and consumer preferences within China's online shopping landscape. It highlights the need for careful consideration of these factors to ensure the responsible and ethical implementation of personalized recommendation systems in the future.

(Bailey, Ricciardelli, 2010), studied the definition of word-of-mouth marketing. This is a very important aspect of the RED platform for studying the impact on user loyalty.Word-of-mouth marketing primarily aims to influence user loyalty, especially given the intense competition among mobile applications in today's market.

As users are presented with a plethora of homogenized mobile apps to choose from, determining the suitability of a product becomes pivotal. To make informed decisions, users frequently turn to the online comment section to glean real insights and feedback from fellow users. Consequently, the vibrancy and authenticity of these comments serve as crucial factors influencing user purchase decisions.

Recognizing the significance of online feedback, RED has prioritized the creation of a harmonious and civilized discussion board and comment section. The platform adheres to strict community civilization conventions and implements rigorous measures against misleading advertising, setting industry standards for maintaining authenticity and integrity in user interactions.

The focal point of the article revolves around elucidating the user incentive model, which serves to bolster user engagement and loyalty. A prominent case study highlighted within the discourse is RED, a platform that uniquely allows users to consume and generate content interchangeably. Within the ecosystem of RED, users are encouraged to partake in the incentive program put forth by the mobile application, wherein they complete designated tasks to unlock rewards.

RED APP places a strong emphasis on providing content creators with valuable incentives to increase their visibility and recognition. Through tailored programs and promotion strategies, creators are encouraged to maximize their potential and creativity and contribute to a vibrant and diverse content environment. Additionally, readers on RED also stand to benefit from the incentive program. Users



receive rewards such as vouchers or equivalents upon engaging with content and making purchases within the platform.

This user incentive framework emerges as a pivotal component of RED's business strategy, contributing significantly to its burgeoning popularity and mainstream acceptance. By offering concrete benefits to content creators and readers, RED cultivates a positive feedback loop, fortifying user engagement and loyalty. Consequently, RED solidifies its stature as a preeminent platform in the market landscape (Wu & Li, 2023).

(RED,2023) Customer service Contract, the article comes from the latest community contract of RED. RED's community contract is by far the strictest of any social media contracts, because the majority of the users are young women, who are often disadvantaged in social status and are more vulnerable to malicious and offensive comments online. RED has multiple regulations and checks on malicious reviews, false information, fraudulent advertising, and discriminatory speech. Strong audit efforts and intensive community discussions with administrators, as well as very strict privacy regulations. To help a large number of female users bravely discuss their own shortcomings in the community discussion and seek help. The user contract also clearly states the conditions for becoming a creator and the speaking regulations to be followed. This also ensures high quality content and intellectual property protection in RED.

As documented by (Chu, Lv & Zhao, 2019), the article elucidates how RED has innovatively fused "content + e-commerce" by leveraging its distinct content ecosystem and marketing strategy. This approach revolves around word-of-mouth, branding, innovative user-generated content (UGC), and self-operated e-commerce, collectively termed as the "grass-planting" marketing model. The objective of this model is to captivate users' attention, stimulate their interest in products, and ultimately drive direct purchase transactions on the platform.

As outlined by (Wang, 2022), RED was established amidst a highly competitive landscape, particularly within the cross-border e-commerce market. Competitors in this domain include Tmall International, Kaola Global, and other similar platforms. Despite the intense competition, RED has managed to carve out a successful niche for itself, attributed to its unique design and strategic positioning in the market.

Methodology

This research method encompasses several steps, beginning with a questionnaire design focused on female customers in Kunming City, Yunnan Province, China. The aim is to gather data on women's online shopping behavior and the impact of RED application on their daily purchases. 400 responses were collected, with male participants answering on behalf of female family members if necessary (in case being unable to fill out the survey due to age, health, etc...). The Questionnaire Star software was used for survey.

To ensure the quality and direction of the study, a pilot test was conducted with 10% of the respondents (40 individuals), and feedback from this test was used to refine the questionnaire. The survey was distributed online to female residents of Kunming City. After filtering out invalid data, 400 responses were deemed suitable for analysis.

The questionnaire is structured into three sections: demographic analysis, opinions about the RED application, and evaluation of RED's recommendations and approach. Structured questions are utilized to minimize open-ended responses, with answers categorized into five levels to gauge respondents' perceptions. The focus is on variables such as age, income, and occupation, as well as RED's marketing strategies and user satisfaction levels.



Statistical analysis was conducted using SPSS, identifying significant trends and differences across demographics and providing insights into RED's impact on consumer behavior.

As this research aims to provide a comprehensive understanding of how RED influences consumer decisions and drives revenue, an in-depth data analysis is needed.

Results

According to the research Objectives, two research hypotheses are proposed:

The RED Company's marketing strategy has a positive effect on the consumption decision-making behavior of female consumers who use the RED application, resulting in the improvement of The RED Company's revenue.

The marketing strategies of RED Company have a positive effect on the consumption behavior of female users who use RED applications, which impacts profitability.

A descriptive analysis and frequency analysis were carried out on 400 valid survey responses to examine the gender, age, occupation, and income distribution of the respondents. Additionally, a correlation analysis was conducted to explore the relationship between occupation and income using the chi-square test. Furthermore, an average analysis was performed on the questionnaire responses to derive insights from the data.

General information

400 femaile took part in this Study/Survey.

This section reflects on the study's focus, understanding the consumption behaviors and preferences of women in the modern era, who are using RED for shopping. With women exerting considerable influence on consumer trends and possessing substantial purchasing power, they are the central demographic under investigation in this study.



Picture 1: Age Group of Respondents

The survey data revealed that the predominant age group among respondents was women aged 25-34. Individuals aged 18 and under comprised 8.25% of the sample, while those aged 18-24 accounted for 21.50%. The largest cohort was individuals aged 25-34, constituting 33.25% of the



respondents. Additionally, those aged 35-44 represented 18.75% of the sample, individuals aged 45-54 accounted for 11.50%, and those aged 55 and above comprised 6.75% of the respondents. (Picture 1)



Picture 2: Profession

The frequency analysis of the collected occupational data indicates that the majority of respondents in the survey are employed full-time. Specifically, 18.75% of respondents identified as students, 29% as full-time workers, 14.00% as part-time workers, 21.5% as self-employed, 16.50% as housewives, and 0.25% selected "other". (Picture 2)



Picture 3: Monthly income

Based on the survey's monthly income frequency analysis, it's evident that the majority of respondents have a monthly income of less than 5,000 RMB. Specifically, 40% of respondents fall into this income bracket. Additionally, 33.25% of respondents reported monthly incomes ranging from



5,001 to 10,000 RMB, while 17.50% reported incomes between 10,001 and 20,000 RMB. Those with monthly incomes exceeding 20,001 RMB constituted 9.25% of the respondents. These findings underscore the significant spending power wielded by the majority of female consumer groups surveyed. (Picture 3)

		Q4	4 - Monthly	income ra	nge:				
Торіс	Name	5001- 10000 RMB	Less than 5000 RMB	10001- 20000 RMB	More than 20001 RMB	Total	Inspection method	X²	Р
Q8- Do you	Frequently	11	18	4	4	37			
	Seldom	34	49	15	9	107			
often shop	Occasionally	43	27	19	8	97	pearson Chi-	31.67	0.002***
RED APP?	Sometimes	25	17	21	8	71	square test		
	Never	20	49	11	8	88			
Т	otal	133	160	70	37	400			

Table 1: Difference analysis pearson Chi-square tes	st
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Note: ***, ** and * represent significance levels of 1%, 5% and 10% respectively

The table above shows the results of the model test, including the frequency of the data, the chi-square value, and the significant p-value.

1. Analyze whether the model is significant (p < 0.05).

2. If it is significant and the null hypothesis is rejected, it means there is a significant difference between the samples. Detailed descriptions are based on the percentage difference between categories. On the contrary, there is no significant difference in the data.

The results of the Pearson chi-square test analysis show that based on Q4 and Q8, the significance p-value is 0.002, which is significant at the level and rejects the null hypothesis. Therefore, there is a significant difference in the data for Q4 and Q8.

	Ν	Minimum	Maximum	Mean	Std.Deviation
Q5. How likely are you to make a purchase based on promotions or recommendations you see through the RED application?	400	1	5	2.28	1.149
Q6. Do you find the product recommendations provided by the RED application align with your preferences and needs?	400	1	5	2.31	1.121
Q7. How important are user reviews and ratings in influencing your decision to make a purchase through the RED application?	400	1	5	2.25	1.109
Q8. How often do you shop through RED?	400	1	5	2.66	1.257
Q10. How satisfied are you with the overall shopping experience on the RED application?	400	1	5	2.23	1.132
Q11. Rate the effectiveness of the promotional campaigns run by the RED Company in capturing your attention.	400	1	4	1.93	0.919
Q12. Which shopping advice would you rather trust?	400	1	3	1.63	0.695

Table 2: Average value



	Ν	Minimum	Maximum	Mean	Std.Deviation
Q14. How to get shopping inspiration?	400	1	4	2.11	1.027
Q15. Are you satisfied with RED's user interface and design	400	1	5	2.13	1.101
Q16. How often do you use community features like forums or user discussions on the RED program?	400	1	5	2.23	1.116
Q17. Do you think the community interaction in the RED application will influence your purchasing decisions?	400	1	5	2.27	1.162
Q18. How familiar are you with brands and products recommended by influencers or content creators on the RED application?	400	1	5	2.58	1.274
Q19. To what extent do you trust recommendations from influencers or content creators on the RED application when making a purchase?	400	1	5	2.74	1.570

In response to the question "How likely are you to make a purchase based on promotions or recommendations you see through the RED application? In the investigation, the average value of its data is 2.28, which is close to 2= "likely" in the questionnaire. That is, most respondents are likely to make a purchase based on promotions or recommendations through the RED application. In response to the question "Do you find the product recommendations provided by the RED application align with your preferences and needs? In the survey, its average value is 2.31, which is close to 2= "Mostly align" in the questionnaire. This is explained by respondents' tendency to mostly align find the product recommendations provided by the RED application with preferences and needs. in response to "How important are user reviews and ratings in influencing your decision to make a purchase through the RED application?" In the interview survey, the average value of the data is 2.25, which is close to 2= "Very important" in the questionnaire. A representative of respondents' attitudes towards the issue is that user reviews and ratings influence the decision to make a purchase through the RED application, which is very important. In "How often do you shop through RED? In the survey, the average value of the interview data is 2.66, which is close to 3= "Occasionally" in the questionnaire, that is, the respondents' frequency of shopping through RED is occasionally. Later, the question "How satisfied are you with the overall shopping experience on the RED application?" In the survey, the average of its data is 2.23, which is close to 2= "Somewhat satisfied" in the questionnaire. That is, respondents are somewhat satisfied with the overall shopping experience on the RED application. in the survey "Rate the effectiveness of the promotional campaigns run by the RED Company in capturing your attention." The average value is 1.93, which is close to 2= "generally" in the questionnaire, that is, respondents believe that there is still room for improvement in RED's promotional activities. In response to "Which shopping advice would you rather trust? In the survey, the average data of respondents is 1.63, which is between 2= "recommendation of network celebrities" and 1= "real comments and sharing of users" in the questionnaire, that is, the trust channels of respondents are more inclined to the recommendation of network celebrities and the real comments and sharing of users. In response to "How to get shopping inspiration? In the survey, the average value is 2.11, which is close to 2= "reading fashion magazines and information websites" in the questionnaire, that is, respondents usually get shopping inspiration from reading fashion magazines and information websites. In response to the question "Are you satisfied with RED's user interface and design? In the survey, the average value is 2.13, which is close to 2= "relatively satisfied" in the questionnaire, that is, the overall respondents are relatively satisfied with



the design of RED. The average value of "How often do you use community features like forums or user discussions on the RED program" is 2.23, which is close to 2= "often" in the questionnaire. Respondents frequently use community features such as forums or user discussions on the RED program. The average for "Do you think the community interaction in the RED application will influence your purchasing decisions" was 2.58, 2= "agree" and 3= "neutral" in the questionnaire, which is interpreted to mean that respondents believe that the impact of community interaction in RED applications on purchasing decisions is somewhere between agreement and neutrality. "How familiar are you with brands and products recommended by influencers or content creators on the RED application?" The average of "Somewhat familiar" and "somewhat familiar" in the questionnaire is 2.58, which is somewhere between 2= "somewhat familiar" and 3= "Neutral", that is, respondents are somewhat less familiar with brands and products recommended by influencers or content creators on the RED application when making a purchase?" The average value was 2.74, which was close to 3= "Neutral" in the questionnaire, which explained that respondents believed that they trusted the recommendations of influential people or content creators on the RED app only moderately.

Conclusion

In conclusion, the investigation into consumer behavior regarding the RED application underscores its strong appeal among the target audience. The platform's effective marketing strategies, particularly the word-of-mouth approach, significantly impact consumers across various dimensions. Influential factors such as influencer celebrity recommendations, user-generated content, and shopping inspiration play crucial roles in respondents' choice of the RED application. Moreover, RED garners high ratings for user experience and interface design, indicative of its commitment to user satisfaction. Community interactions, ranging from neutral to agreeable, highlight authenticity and transparency in user comments and opinions. Despite occasional customer dissatisfaction, a substantial 60% of users ultimately complete their purchases on RED. Overall, these findings underscore RED's success in implementing customer-centric marketing strategies tailored to the preferences of young female consumers. Recommendations for the RED application team include utilizing diverse marketing approaches and expanding presence across multiple platforms to further enhance customer acquisition and satisfaction.

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THE IMPACT OF AR TECHNOLOGY ON CUSTOMER EXPERIENCE TOWARDS VIRTUAL 3D HOUSES OF POTENTIAL HOMEBUYERS

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Abstract

With the rapid development of digitization and the Internet, businesses are challenged to adapt to the global economy while focusing on meeting the customers' ever-changing demands. Changing to a customer-focused approach from a product-oriented one has become imperative. This study mentioned above was essential in understanding the factors influencing Thai consumers' home purchasing behavior. They provided consumers with more convenience and choices, promoting the development of the real estate market. This study focused on Bangkok homebuyers and aimed to 1) assess how AR affects customer satisfaction, decision-making confidence, and overall engagement with the home-buying process, 2) identify key factors contributing to positive or negative customer experiences with AR house tours, considering cultural and market-specific nuances, and 3) provide recommendations for optimizing AR technology and virtual 3D house tours to enhance the customer experience for Bangkok homebuyers. The sample group in the research consisted of 400 consumers who have purchased housing developments in Bangkok. The questionnaire was used as a research tool, and descriptive statistics and inferential statistical analysis were used to analyze the data to test hypotheses with regression analysis. The study found that 1) the factor that received the highest overall mean was intention to use, followed by attitude toward using, actual use, perceived usefulness, perceived ease of use, and perceived risk. All factors except for perceived risk received an overall agreement level, while most participants neither agreed nor disagreed with the statement related to perceived risk. 2) The perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, and actual use positively influenced the purchase decision of a house in Thailand. 3) The research findings provided theoretical and practical support for developing AR technology and the virtual 3D house industry in the real estate market and using AR technology, also known as virtual reality. To attract the attention of residential project customers so that they can open the AR program to see a representation of the home design of the residential project that the user wants.

Keywords: AR technology, Virtual 3D, Homebuyer, Customer experience, Thailand

Introduction

Currently, the world is evolving rapidly, and businesses are challenged to adapt to the global economy while focusing on meeting the ever-changing demands of the customers (Schmidheiny, 1992). Changing to a customer-focused approach from a product-oriented one has become imperative. Business transformation is becoming challenging as customers are increasingly discerning and well-informed. Customers nowadays expect various options and provide a sense of value and worth in personalized services. As the concept of Thailand's real estate market, customers' expectations are no different. Potential homebuyers seek unique experiences beyond conventional property viewing (Hussin & Bakar, 2023). They desire a more personalized and immersive way to visualize the potential



homes, allowing them to visualize and assess properties that align with their needs and unique preferences. The environment in the real estate industry is highly competitive, with a growing number of developments on virtual 3D houses being shown to the limited pool of potential customers (Ullah et al., 2018). Real estate industry competition is fierce, with companies vying for pricing, quality, quantity, and brand image advantages, which result in challenges compounded by high fixed costs. In this dynamic landscape, adopting innovative technology like augmented reality (AR) could provide an advantage for various businesses, including real estate businesses. AR technology can potentially revolutionize the way potential homebuyers virtualize their properties. AR technology can improve consumer experience, lessen the need for in-person property visits, and give real-time information about properties and their surroundings by providing immersive and interactive virtual tours.

Thailand's real estate market is expanding at a fantastic rate as more and more purchasers understand the value of first impressions and the assurance of owning a stunning property. Current technology makes creating and displaying beauty in homes more accessible than ever. Because augmented reality (AR) technology can significantly impact customers' satisfaction with their house-buying experience, more and more Thai consumers are considering using it when searching for a property. This study explores how prospective Thai homebuyers' experiences are affected by using augmented reality (AR) technology for virtual 3D houses. (Wisittigars & Siengthai, 2019)

This research attempts to shed light on how this creative approach might provide unique selling factors for real estate developers and improve the general satisfaction of potential house purchasers by investigating the integration of AR technology into the real estate market. The study will also consider elements like resource-based theories, agency dynamics, transaction costs, innovation dissemination, and technological acceptance for a thorough grasp of the topic.

Research Objectives

1. To assess how AR affects customer satisfaction, decision-making confidence, and overall engagement with the home-buying process.

2. To identify key factors contributing to positive or negative customer experiences with AR house tours, considering cultural and market-specific nuances.

3. To provide recommendations for optimizing AR technology and virtual 3D house tours to enhance the customer experience for Bangkok homebuyers.

Literature Review

The literature review was conducted through academic and professional journals recommended by Rangsit University. The review covered the last ten years to the current time. Table 1 shows the summary of the literature review.

Authors	Aim	Theories	Methodologies	Findings
Laeieddeenun (2016)	Study the technology acceptance and online consumer behavior affecting e-book purchase decisions of customers in Bangkok.	Technology acceptance, Online consumer behavior	Survey research	Technology adoption The actual use affects the purchasing decision of electronic books. Most consumers were in Bangkok.

Table 1: Summary of literature review.



Authors	Aim	Theories	Methodologies	Findings
Pongsa ((2021	Develop an application for sales management and marketing promotion.	Technology acceptance	Survey research	Using AR technology, also known as VR, attracts the attention of residential project customers so that they can open the AR program to see a representation of the home design of the residential project that the user wants.
Prayoonsak (2021)	Benefits of AR technology to business after COVID-19	Technology acceptance	Survey research	Businesses can apply AR technology to marketing communications activities to attract customers and increase sales.
Santi et al. ((2021	Study the AR in Industry 4.0	Technology acceptance	Survey research	AR is recognized worldwide as one of the leading technologies of the 21st century and one of the pillars of the new industrial revolution envisaged by Industry 4.0.
Thiptiangtae (2022)	This study has studied the characteristics of AR technology that affect the value users receive in choosing products.	Technology acceptance	Survey research	Attitude has a significant positive relationship with the intention to purchase products in the cosmetics group.

The authors reviewed the literature on AR technology, consumer behavior, and technology acceptance into two groups: one that focuses on the technology acceptance and characteristics of AR technology affecting purchase decisions and another that studies augmented reality in Industry 4.0 and develops an application.

First, the following authors focused on the acceptance of technology and AR technology's characteristics affecting purchase decisions. Laeieddeenun (2016) studied the technology acceptance and online consumer behavior affecting the e-book purchase decisions of customers in Bangkok and found that technology acceptance in terms of actual use had the most substantial influence on the customer's decisions to purchase e-books in Bangkok. In addition, Thiptiangtae (2022) studied the impact of augmented reality technology (virtual try-on) on the purchase intention of cosmetic products: the mediating effect of customer attitude and found that characteristics of AR technology affecting the value that users receive in choosing products, the attitude has a significant positive relationship with intention to purchase products.

Next, the following authors studied augmented reality in Industry 4.0 and developed an application. Santi et al. (2021)studied augmented reality in Industry 4.0. They found that Augmented Reality (AR) is worldwide recognized as one of the leading technologies of the 21st century and one of the pillars of the new industrial revolution envisaged by Industry 4.0. In addition, Pongsa (2021) studied and developed an application for sales management and marketing promotion. In this study, the author found that using Augmented Reality or AR technology, also known as virtual reality. It was used to attract the attention of residential project customers so that they could open the AR program to see a representation of the home design of the residential project that the user wants. There are many benefits



of AR technology. For example, businesses can apply augmented reality technology to various marketing communications activities to attract customers and increase sales (Prayoonsak, 2021).

Methodology

Research Framework



Figure 1: Research Framework

Research Design

A combined, or mixed-methods, approach was employed in this study, utilizing quantitative and qualitative data collection methods to understand the research question comprehensively. This involved conducting an online survey among Bangkok residents considering buying a home within the next year, providing quantitative data about their preferences and intentions.

Data Collection:

A survey was employed to gauge user experience comprehensively. This survey utilized a combination of Likert-scale and open-ended questions. Likert-scale questions let participants rate their satisfaction, confidence, and engagement with the AR experience on a defined scale. Additionally, open-ended questions allowed them to elaborate on cultural factors that might have influenced their experience, giving the researcher a deeper understanding of the user perspective.

Sampling

This research used a convenience sampling method to reach a target audience of 400 consumers who had recently purchased housing developments in Bangkok. To do this, the researcher located a relevant website for selling houses in Bangkok and posted the survey link directly on their web webboard. This allowed potential respondents, likely interested in the housing market, to access the questionnaire page quickly by clicking the provided link. This approach offered a readily available pool of participants from the desired demographic.

Data Analysis

The study implemented a two-pronged approach to analyze the collected data, utilizing both quantitative and qualitative methods. On the quantitative side, descriptive statistics were employed to



summarize central tendencies and variability within the data. Additionally, regression analysis was applied to build predictive models to anticipate future trends or outcomes based on the collected data.

The study also employed qualitative analysis, specifically thematic analysis. This method involved identifying recurring themes and uncovering cultural nuances within the open-ended responses and other qualitative data. By analyzing these themes, the research aimed to understand better the factors influencing participants' experiences, providing a more comprehensive picture beyond the numerical data.

Statistics

The study employed a two-step analytical approach to understand the collected customer data thoroughly. Descriptive statistics presented key metrics like customer satisfaction, decision-making confidence, and engagement. This involved measuring the mean, median, standard deviation, and range to depict the data distribution. Following this initial analysis, regression analysis was then employed to delve deeper. This allowed the study to identify the most significant cultural and market-related factors that influence and potentially predict whether a customer will have a positive or negative experience. By delving into these areas, the study aimed to uncover the key drivers shaping customer experiences and provide valuable insights for improvement.

Research Timeline:

The research process unfolded over four months, following a structured timeline. The initial month (Month 1) was dedicated to conducting a comprehensive literature review to establish a solid foundation for the research. This was followed by the finalization of the research design and the development of the questionnaire, which would serve as the primary tool for data collection.

Month 2 marked the active data collection phase. The developed questionnaire was piloted on a smaller sample to identify potential issues and refine them further. The primary survey and interview data collection activities gathered valuable insights from the target participants.

Month 3 focused on the analysis of the collected data. Using appropriate methods, the researcher meticulously analyzed the information, drawing out key findings and uncovering valuable insights. These preliminary findings were then utilized to draft an initial report, laying the groundwork for the final research product.

In the final month (Month 4), the research process culminated with refining the findings.

The instrument

The research employed a self-administered questionnaire as the primary data collection tool. This questionnaire utilized a 5-point rating scale and was divided into four sections:

Part 1: This section gathered basic demographic information about the respondents.

Part 2: This section focused on the respondents' experience with 3D technology and its impact on their perception of home buying in Thailand. It employed a 5-point rating scale to assess factors related to "Technology Acceptance."

Part 3: This section delved into the decision-making process of home buying in Thailand, again using a 5-point rating scale to capture responses.

Part 4: This final section invited open-ended responses from participants, allowing them to share their suggestions regarding the impact of AR technology on virtual 3D houses and the customer experience for potential homebuyers in Thailand.

To ensure the relevance of our research questions, three experts independently assessed each question using the Item Objective Congruence (IOC) index. Only questions scoring above 0.5 on this index, indicating strong alignment with the research objectives, were included in the study. To protect anonymity, the identities of the experts are not disclosed.



The experts and advisors did the verified questionnaire. It had a similar nature to 40 people, and the confidence (reliability) of the questionnaire was analyzed by finding the alpha coefficient (Cronbach's alpha) equal to 0.68 overall (almost 0.70). The questionnaire of this research was accurate and reliable.

Descriptive and inferential statistical methods were employed to analyze the collected data. Descriptive statistics were used to summarize and describe the data. Additionally, inferential statistical analysis, specifically multiple regression analysis, was conducted to test pre-defined hypotheses and identify any significant relationships between the variables under investigation. This comprehensive approach provided valuable insights into the research objectives.

Results

Results of descriptive statistics

Table 2 shows the demographic information of 400 respondents. The majority of the participants were female (56.5%), from the Millennials generation (47.25%), residing in Bangkok and metropolis (58.25%), and with an average monthly income of 25,001 THB and above (78.25%). Regarding the highest education level, most participants achieved a bachelor's degree or equivalent (66.25%), while the most common occupation was self-employed/entrepreneur (42%).

Demographic Information	Number of Respondents	Percentage
Gender		
Male	162	40.50
Female	226	56.50
Prefer not to say	12	3.00
Birth year		
Born 1946 – 1964 (Baby boomers)	16	4.00
Born 1965 – 1980 (Generation X)	142	35.50
Born 1981 – 1996 (Millennials)	189	47.25
Born 1997 – 2020 (Generation Z)	53	13.25
Region of residence		
Bangkok and metropolis	233	58.25
The central region of Thailand	108	27.00
The western region of Thailand	30	7.50
The northern region of Thailand	9	2.25
Northeast region of Thailand	8	2.00
The southern region of Thailand	8	2.00
Eastern region of Thailand	4	1.00
Average monthly income		
Less than 5,000 THB	2	0.50
5,001 – 10,000 THB	8	2.00
10,001 – 15,000 THB	17	4.25
15,0001 – 20,000 THB	22	5.50
20,0001 – 25,000 THB	25	6.25
25,001 THB and above	313	78.25
Highest education level		
Less than high school	5	1.25
High school or equivalent	38	9.50
Bachelor's degree or equivalent	265	66.25
Master's degree or equivalent	87	21.75
Doctor of Philosophy	7	1.75

Table 2: Demographic information of all respondents



Demographic Information	Number of Respondents	Percentage
Occupation		
Self-employed/entrepreneur	168	42.00
Employee in a private company	124	31.00
Civil servants	32	8.00
Lawyer	8	2.00
Engineer	17	4.25
Medical professional	23	5.75
IT professional/specialist	25	6.25
Others	3	0.75

Results of factors influencing the experience of homebuyers in Thailand

Descriptive statistics were utilized to investigate independent variables affecting purchase intention. The result is shown in Table 3. The factor that received the highest overall mean was intention to use, followed by attitude toward using, actual use, perceived usefulness, perceived ease of use, and perceived risk. All factors except for perceived risk received an overall agreement level, while most participants neither agreed nor disagreed with the statement related to perceived risk.

Table 3:	Descriptive	Statistical	Analysis	of	different	independent	variables	related	to	using	3D
	technology	and its effect	ct on the e	xpe	rience of I	homebuyers in	n Thailand	l			

Using 3D Technology to Affect the Experience of Homebuyers in Thailand	Overall Mean	Standard Deviation
Perceived usefulness	4.06	0.83
Perceived ease of use	4.04	1.20
Intention to use	4.72	1.08
Perceived risk	3.17	1.27
Attitude toward using	4.56	1.20
Actual use	4.22	1.36

Results of the decision to purchase a house in Thailand analysis

Regarding the decision to purchase a house in Thailand, the overall mean identified in this study was 4.03, meaning that most participants agreed that they had bought a new home after using AR technology. Only 10.25% of the respondents stated that they did not make the purchase. Multiple regression was used to assess the causative relationships between the factors above and the decision to purchase a house in Thailand.

Table 4 displays the outcomes of a multiple regression study investigating the correlation between variables: perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, and actual use and purchase decision of house in Thailand.

The multiple regression model summary in Table 4 indicates that the F-test equals 207.027, with a p-value of less than 0.01. These values indicate substantial correlations between independent variables and participants' decision to purchase a house in Thailand with a 99% confidence level. The modified R-squared value, indicating the accuracy of the predictive model, was 0.608. This means that the independent variables in this study effectively describe 60.8% of customers' decision to purchase a house in Thailand.



Table 4:	Model Summary
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Model Significance						
Model R square Adjustee		Adjusted R square	F	Sig		
1	0.781	0.608	207.027	<0.01**		

Dependent Variable: Purchase decision of house in Thailand

Predictors: (Constant), Perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, actual use

The results displayed in Table 5 indicate a substantial association between independent factors (perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, and actual use) and the purchase decision of a house in Thailand.

 Table 5:
 Multiple Regression Results

Model		Beta	t	Sig
1	(Constant)			
	Perceived usefulness	.313	5.429	<0.01**
	Perceived ease of use	.465	11.371	<0.01**
	Intention to use	.286	8.249	<0.01**
	Perceived risk	.247	6.318	<0.01**
	Attitude toward using	.414	9.495	<0.01**
	Actual use	.435	4.339	<0.01**

Dependent Variable: Purchase decision of house in Thailand

** Statistically significant below the 0.01 level

Discussion

This study found that perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, and actual use positively influenced the purchase decision of a house in Thailand. Past studies have also found a positive relationship between VR technology and the intention to purchase a home (Ibrahim et al., 2023). Regarding perceived usefulness, VR technology may perform the same function as a communication medium, just like the three-dimensional mock-up model used traditionally in the real estate industry. In the real estate sector, property developers commonly use offline marketing channels such as 3D mock-up models, showcasing completed houses on-site, promoting at property exhibitions, and utilizing printed media like brochures, newspapers, magazines, and billboards.

Although traditional marketing channels are more interactive, they have drawbacks. For instance, potential house buyers must physically attend property exhibitions or peruse brochures to obtain information about the houses for sale. House buyers may not receive detailed information and photographs regarding the residences they are interested in because of the limitations in showcasing information through the marketing methods utilized by property developers. Potential home purchasers struggle to understand the house's quality and see themselves living in it through these marketing strategies (Mark & Larceneux, 2019). This situation arose because these marketing channels had several constraints, such as limited data and a lack of consumer engagement (Behzadan et al., 2015). Printed media relies on consumers' ability to view the actual environment of the selling house. The interaction between the consumer and the product is static, as it is based solely on visual perception without the option of manipulating the product from multiple angles (Alcañiz et al., 2019; Katsioloudis et al., 2014). Major residential real estate agencies in the United States, like Redfin and Sotheby's, have implemented a new strategy to promote their properties by focusing on virtual tours. These tours enable viewers to explore the property through 3D virtual walkthroughs, providing an immersive experience.



A recent study discovered that virtual reality positively influences home buying by saving substantial time for homebuyers and real estate agents. This enables homebuyers to explore properties in different locations virtually. Virtual reality can visualize residences in development or during construction, which is particularly beneficial for properties sold off-plan through the sell-then-build approach (Azmi et al., 2021). Researchers recently conducted a study comparing the intention to purchase a house in actual and virtual environments, focusing on pleasure and arousal emotions. Mohamad Kamil and colleagues investigated the impact of VR technology on buyer's purchasing intention, explicitly focusing on interior layout and design (Kamil et al., 2021).

Conclusions

An investigation was conducted in this study to understand the influencing factors of Thai consumers' intention to purchase houses. A comprehensive view of the Thai real estate market was provided by analyzing key indicators such as perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, and actual use. According to the findings, perceived usefulness, perceived ease of use, intention to use, perceived risk, attitude toward using, and actual use positively influenced the purchase decision of a house in Thailand. In this study, there were multiple limitations. First, the study did not consider the decision-making process of consumers purchasing a house in Thailand. Even though the study found that the independent variables significantly influence the decision to buy a home in Thailand, the findings cannot be used to conclusively answer which step of the decision-making process each factor impacts, i.e., the factors could have implications.

For a more practical finding, future research could be done to investigate different factors across the purchase decision-making process. Second, this study did not consider other factors influencing the purchase of a house. For example, the features and functionality of the house with or without AR technology to showcase them may be enough for consumers to decide to purchase a house. Thus, future studies could be done to identify the important factors in the decision-making of new home purchases among Thais. Other future research that could be done to improve the practicality of the findings include focusing on different types of AR technology and real-estate types, as each technology has its unique features and utility. In contrast, each real estate type has other characteristics the owner may want to showcase to attract customers.

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THE IMPACTS OF DIGITAL LEARNING PLATFORMS ON NON-DEGREE LEARNERS AND FREELANCE PROFESSIONAL TEACHERS in Thailand

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Abstract

Digital technology has revolutionized traditional learning and assisted learners and teachers in using various digital learning platforms anytime, anywhere, and globally. Thailand is one of the countries that embraces innovation in the digital learning environment. The research gap analysis indicated that more research is needed to explore the digital learning platforms in the specific context of Thailand, including factors like resource requirements and cultural considerations. The impact on non-degree learners and freelance teachers using digital learning platforms remains unascertained. Therefore, this research aims to identify the various digital learning platforms used by non-degree learners and freelance professional teachers, explore the benefits and challenges of digital learning platforms, and evaluate the effectiveness of digital learning platforms on the economic well-being of the target users in Thailand. Accordingly, three hypotheses are formulated to align with the objectives. The research applied a mixed-method approach and collected primary data through in-person interviews using a structured checklist. Descriptive analysis was applied to quantitative data, whereas the thematic analysis technique was used to analyze qualitative data. The research identified 17 common digital learning platforms among 46 respondents. More benefits over the constraints were witnessed, and higher ranks were given to economic well-being indicators. Since the positive impacts dominate over the limitations and bring effectiveness to well-being, access to digital learning platforms should be promoted to increase education equity among learners and teachers in Thailand.

Keywords: Digital Learning Platform (DLP), Non-Degree Learner, Freelance Professional Teacher, Learning Environment, Thailand

Introduction

Learning, an essential process for human beings, has evolved in different forms over time. One prominent means nowadays is learning through digital platforms with the effective use of digital technology. With advancements in technology and internet accessibility, digital learning platforms have revolutionized the learning environment by providing cost-effectiveness to educators and convenience to learners compared with conventional education systems (Aydin, Yazici, 2020). The digital learning platforms benefit learners of various kinds and educators from different professional backgrounds to deliver the courses in real-time or digitalized pre-recorded videos across the globe, including in Thailand.

To produce higher quality human capital, in 2020, the Institute for Research and Development in Teaching Professionals for ASEAN (IRDTP) became one of the recipients of the non-degree project focusing on soft skills, financially funded by the Ministry of Education, Thailand. The participants include undergraduate and postgraduate students, novice and experienced teachers, school principals, educational advisors, and university lecturers. (IRDTP, 2020). Besides the low enrolment and high



dropout rate, the education budget as a proportion of GDP has decreased because of the allocation to the newly established Ministry of Higher Education, Science, Research, and Innovation (MHESI) in 2019 for designing 500 non-degree programs to build hard skill and soft skills for Thai workforce required by 12 industries. One of the milestones of MHESI is the formation of the Thailand Massive Open Online Course (Thai MOOC), an online course aimed at unlimited participation and open access via the web (Chunwijitra, 2020). In the IMD World Competitiveness Ranking, Thailand was 33rd in 2022 and increased to 30th out of 64 countries in 2023.

A non-degree-seeking student takes courses without working toward a degree or attending the institution's program full-time. Today, individuals can pursue various interests outside of a traditional university degree, which must be recognized as a strength to thrive in society (Ratnatunga, 2023). In the case of Thailand, developing better human capital means encouraging Thai people to go to college and graduate with higher degrees or receive professional/technical training in specific areas. According to a Galludtudy from Gallup, Strada, and Lumina, 60% of non-degree-certificate holders believe it has added value to their professional profiles (Friszman, 2021). Post-COVID-19, the labor market has tightened, and companies are less likely to insist on degrees.

A freelance teacher is a professional tutor offering specialized mentoring support to learners about specific topics, usually under the payment of some price (Capuano, 2005). Online courses are all the rage in Thailand; one can learn anything from a foreign language to knitting via online courses. One could set up a YouTube channel and create lessons that people could subscribe to or use sites like <u>Udemy</u> and <u>Skillshare</u>. Alternatively, one can teach live via Skype or another platform (Heaton, n.d.) (Heaton, 2023). Teaching is no longer confined to a physical classroom; it should be grateful to technology. The online education industry has grown significantly, triggering many professionals to start online businesses, share their knowledge and expertise with those eager to enhance their skills and careers (Clayton, 2021), and scale up the freelance teaching environment.

Digital learning (e-learning), proposed by Jay Cross in 1999, appeared with different explanations and terminology with the advance and development of technology tools, such as Internet-based training, web-based training, online learning, network learning, and distance learning (Ajip Rosyidi, 2020). Using a platform, a learning environment that includes a curriculum, supporting tools, and services, digital learning is possible (Songkram, Chootongchai, 2022). Digital learning platforms are commonly used and provide flexible and interactive e-learning tools. The latest digital technology models support distance education and training by providing interactive and social learning environments (Alardan, 2020; Alwan & Jeraisy, 2022).

According to previous studies, learners and educators from formal education settings such as international schools, colleges, and universities are assumed to have better access to standard digital learning platforms and benefit from their excellent impacts. However, the same impacts perceived by non-degree learners and freelance teachers are obscure. Therefore, this study aims to determine the impacts of digital learning platforms on non-degree learners and freelance professional teachers and to support with recommendations to the stakeholders in the digital learning environment. Moreover, the limitations and potentials in the usage of digital learning platforms by non-degree learners and freelance professionals, as well as the transformation of technology in the educational landscape, can be identified in this study.

Research Objectives

1. To identify the various digital learning platforms used by non-degree learners and freelance professional teachers in Thailand



2. To explore the benefits and challenges of digital learning platforms for non-degree learners and freelance professional teachers in Thailand

3. To evaluate the effectiveness of digital learning platforms on the economic well-being of non-degree learners and freelance professional teachers in Thailand

Literature Review

Digital Learning System in Thailand

In Thailand, Songkram et al. (2023) have identified the success factors in promoting digital learning platforms from instructors' perspectives, with 788 Thai instructors using confirmatory factor analysis. The CFA construct revealed four success factors in promoting digital learning platforms. The study explained the influences of each factor and suggested that policymakers offer digital learning models to learners so that the advantages of practical learning activities can be developed in the simplest forms.

Vicheanpanya (2014) used a mixed-method approach to study Thai society's e-learning management system model. The study included in-depth interviews with experts and executives in e-learning at academic institutions, including government sectors and committees under the Thai Senate. The study revealed three main components: general management, e-learning management, and e-learning management-driven strategy for Thai society. The study contributes recommendations or guidelines for determining e-learning policy related to e-learning management systems in operations networks and the standard of learning management systems.

Digital learning platforms

Boozer et al. (2020) studied teaching effectiveness and digital learning platforms. Digital learning tools like Cengage MindTap offer a platform for measuring learning effectiveness through grade outcomes. The study analyzed homework, quizzes, and exams using MindTap by applying a simple regression approach. The results highlighted the importance of features of the online digital platform as they have a more positive relationship with how well students perform. The research further offered opportunities to explore behavioral areas of pedagogy and the positive traits of a tool in a learning-centered environment. The study also identified biases between students who embrace technology and how well they integrate the tool within a curriculum.

Faustmann et al. (2019) studied the factors that make digital learning platforms successful and identified that the thriving learning environment strongly depends on the participants' personal, social, and institutional backgrounds, among other aspects. On the contrary, some factors, such as interaction between the learners or a teacher's reputation, lose their importance as the study model requires physical presence. The study suggested customizing digital learning tools for learners that align with their needs. Since there is no one-size-fits-all approach to be successful, DLPs are to be developed based on participants' backgrounds, needs, and behavior.

Non-degree education

Okoye et al. (2022) investigated the impacts of digital technologies on teaching and learning in higher education in Latin America, analyzing the reach, barriers, and bottlenecks of applying mixed methodology. The results indicated that the users emphasized the lack of training, infrastructures, resources, and access to the internet and digital platforms as the main challenges to the teaching-learning process. The study also highlighted that the critical factors of the HEIs should be resolved and adopted in support of the decision-making strategies, operational policies and governance, financial investments, and policy-making when digital technologies have become an inevitable part of education and learning.



A study by Mohammadi et al. (2023) explored the leading factors in online education due to COVID-19 in four EU countries. The transactions were smooth in some organizations and disciplines, but pitfalls and problems were identified in other programs. The study argued that activities are more accessible to digitalize in some educational domains than in others. Students at a private university said online education did not meet expectations compared to traditional education. The study suggests that there is always an option of going online. However, blended learning will likely become an essential approach.

Freelance professional teachers

Govaerts et al. (2015) indicated the crucial role of teachers in the successful learning journey and highlighted the importance of online labs that enhance the teachers' knowledge and skills. The study introduced a project called Go-Lab, an online tutoring platform implemented for tutoring teachers by bringing online laboratory experiments into the classroom. The platform offers teachers a peer assistance and expertise-sharing platform among peers. It was found that the platform brings promising ways to support teachers.

Kisanjara et al. (2017) studied the impacts of e-learning on students' achievement in developing countries by building an integrated model and validating it to measure the impact. It has been identified that indicators such as students' engagement, cognitive skills, performance expectancy, control, satisfaction, continued use, enjoyment, self-esteem, and confidence in e-learning have a significant positive relationship with students' achievement. In addition, the integrated model is recommended to other stakeholders to understand the impacts of e-learning.

Challenges faced by the participants

Khan (2023) researched the factors that influence MOOCs along with their impact and comparison with on-campus education in Finland using a mixed-method approach. The study findings highlighted the challenges the participants faced and future improvements, including the features and functions of the app. The limitations include low completion rates, lack of time and motivation, and difficulties with course materials and engagement. However, the benefits perceived by the learners and the teachers include connecting students and professors through forums and webinars and promoting collaboration.

On the other hand, Aroonsrimarakot et al. (2022) studied the online learning challenges in Thailand and strategies to overcome them from the students' perspectives with 465 students from two public universities. The challenges revealed include temptations to browse other internet websites, difficulties understanding the lesson context, poor internet connectivity, time management issues, low motivation level, and distraction in the home learning environment. Students suggested improvements in evaluation, connectivity, interactivity, content, and accessing materials. Table 1 shows the research gaps and a list of literature reviews classified by the authors.

Authors	Aims	Theories	Methodologies	Findings	Research gaps
Songkram et al. (2023)	Success factors for DLPs in Thailand	Confirmatory factor analysis, four-factor model	Survey research	Requirement of primary resources among the learners in Thailand.	Further research should include study samples from other CLMV countries to promote digital learning platforms.

Table 1: Literature Reviews Classified By The Author	ors
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Authors	Aims	Theories	Methodologies	Findings	Research gaps
Vicheanpanya (2014)	Develop an e-learning management system model for Thai society	E-learning management system model	Qualitative method	Found an e-learning management system model for Thai society with three main components.	Found an e-learning management system model for Thai society with three main components.
Boozer & Simon (2020)	Teaching effectiveness and digital learning platforms	MindTap by Cengage Publishing	Data collection	Online digital platforms have a more positive relationship with how well students perform.	To further explore the positive traits of a tool in a learning-centered environment in the areas of pedagogy.
Faustmann et al. (2019)	Factors that make digital learning platforms successful	Self-determinati on theory	Survey research	DLP has to be developed individually based on the participants' backgrounds, needs, and behaviors.	This study is the starting point for conceptualizing a successful human-centered digital learning platform.
Okoye et al. (2022)	Digital technologies in teaching and learning	Sentiment and emotional valence analysis, Kruskal-Wallis H test	Mixed method	Shed light on critical factors for higher education and decision-making strategies.	Potential barriers and bottlenecks to technology-based teaching and learning in higher education exist.
Mohammadi et al. (2023)	Factors that work in online education	Systematic mapping	Survey research	Online courses are not necessarily unviable in any educational domain.	Further studies should explore the advantages and disadvantages of online learning.
Govaerts et al. (2015)	To build an online tutoring platform for teachers	Usability and usefulness assessment	Survey research	It found promising solutions to support teachers.	To build a STEM teacher community for online labs and inquiry learning in the future.
Kisanjara et al. (2017)	Measuring the impacts of e-learning	Confirmatory factor analysis, Multiple regressions technique	Mixed method	Student motivation has a positive relationship with the impact of e-learning.	The results call for more research on evaluating the impact of e-learning in teaching and learning.
Khan (2023)	Significance of MOOCs	Impacts comparison	Mixed method	There were low completion rates, lack of time and motivation, and engagement.	Further studies should investigate the potential of MOOCs.
Aroonsrimara kot et al. (2022)	to understand online learning challenges in Thailand post-COVID and find strategies to overcome them from the student's perspective	Problem Confrontation Index (PCI)	Mixed method	Challenges/temptation s to browse the web, difficulties in understanding the lesson context, poor internet, time management issues, low motivation level, and distractions.	Suggested to implement the strategies and findings before implementing the online classes successfully.



Methodology

The research applied descriptive analysis for a quantitative data set to evaluate how digital learning platforms affect the educational experiences and professional development of Thailand's non-degree learners and freelance professional teachers. The descriptive analysis includes percentage and frequency distributions, graphical representations, and mean and estimated degree measures. The thematic analysis method, a process of deriving high-quality information from the responses, was used to analyze the qualitative data. With the analyses, the research aimed to answer all three following hypotheses: 1. various digital learning platforms are already accessible by non-degree learners and freelance professional teachers in Thailand, 2: Digital Learning Platforms have a positive effect over constraints on non-degree learners and freelance professional teachers in Thailand and 3: using Digital Learning Platforms brings economic well-being to non-degree learners and freelance professional teachers in Thailand.



The following picture 1 illustrates the framework for this research.

Picture 1: Research Framework

Research Instrument

Thirty-five questions (30 quantitative and five qualitative) were developed based on the research objectives and hypotheses. The questions were classified into multiple choice questions, using the five-point Linkert Scale, and open-ended questions based on the ten indicators. Initially, three experts thoroughly evaluated all questions using the Item Objective Congruence (IOC) index, and only the questions above 0.5 were included in this research. The research also conducted pilot testing with ten respondents, and the questions were accordingly modified for final data collection. Regarding the Central Limit Theorem ($n \ge 30$), a total sample size of 46 was interviewed. Table 2 illustrates the ten indicators under each model when designing the questionnaire.

The data collection process began with the invitation procedures as follows. First, invitation letters or e-mails were sent to randomly selected participants before the interview. The interview



schedule was sent to interested participants. Prospective participants were then contacted by e-mail, line, letter, or telephone to arrange an interview appointment at a time that suited them.

The interviews were conducted in January 2024. At the initial meetings, the researcher presented the participants with an explanatory statement followed by a detailed verbal explanation of the project. The participants then had an opportunity to ask questions. Once the participants were explained, on average, an interview took approximately half an hour to complete.

Table 2: Indicators for designing the questionnaire	;
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Technol	Technological Acceptance Model (Davis, 1989)				
>	Perceived usefulness	Indicator 1			
\rightarrow	Perceived ease of use	Indicator 2			
Extensio	Extension of Technological Acceptance Model (Venkatesh, Davis, 2000)				
\checkmark	Experience	Indicator 3			
\succ	Job relevance	Indicator 4			
\succ	Output quality	Indicator 5			
\checkmark	Result demonstrability	Indicator 6			
Econom	Economic well-being concept (Totor2u, 2023)				
\checkmark	Income	Indicator 7			
\succ	Employment opportunities	Indicator 8			
\succ	Access to essential goods and services	Indicator 9			
>	Overall satisfaction with life	Indicator 10			

Results

The demographic information and the different periods of adoption and usage of DLPs across various fields by non-degree learners (learners) and freelance professional teachers (teachers) are shown in Table 3.

Statistical merickles	Classification	Learners (n=23)		Teachers (n=23)	
Statistical variables	Classification	Frequency	Percentage	Frequency	Percentage
Genders	Male	8	34.78	11	47.83
	Female	15	65.22	12	52.17
Age	Below 20	1	4.35	-	-
	21-30	12	52.17	13	56.52
	31-40	8	34.78	6	26.09
	41-50	2	8.7	2	8.70
	51 - 60	-	-	2	8.70
Highest Education	Secondary	-	-	2	8.70
	High school	5	21.74	6	26.09
	College	1	4.35	-	-
	Bachelor	16	69.57	7	30.43
	Master	1	4.35	6	26.09
	Doctorate	-	-	2	8.70
Occupation	Student	13	56.52	-	-
	Salaried	3	13.04	-	-
	Self-employed	6	26.09	-	-
	Temporary Job	1	4.35	-	-

Table 3: Demographic information of the respondents



		Learner	rs (n=23)	Teachers (n=23)	
Statistical variables	Classification	Frequency	Percentage	Frequency	Percentage
Profession	Computer Programmer	-	-	1	4.35
	Engineer	-	-	1	4.35
	IT Professional	-	-	4	17.39
	Researcher	-	-	1	4.35
	Teacher	-	-	14	60.87
	Translator	-	-	1	4.35
	Writer/Trainer/Influencer	-	-	1	4.35
Residential province	Ang Thong	-	-	1	4.35
	Bangkok	3	13.04	4	17.39
	Chanthaburi	1	4.35	1	4.35
	Chiang Mai	1	4.35	3	13.04
	Kalasin	1	4.35	-	-
	Nakhon Phanom	1	4.35	-	-
	Nonthaburi	-	-	1	4.35
	Pathum Thani	13	56.52	10	43.48
	Phetchaburi	-	-	2	8.70
	Phra Nakhon Si Ayutthaya	2	8.7	-	-
	Prachuap Khiri Khan	-	-	1	4.35
	Ubon Ratchathani	1	4.35	-	-
Period using DLPs	1-3 years	14	60.87	16	69.57
	4-6 years	7	30.43	5	21.74
	7 – 10 years	1	4.35	1	4.35
	More than ten years	1	4.35	1	4.35
Fields for use DLPs	Accounting and administration	2	4.76	1	3.13
	Digital business	1	2.38	-	-
	Engineering	-	-	1	3.13
	Finance	-	-	1	3.13
	Food and beverages	3	7.14	1	3.13
	Hotel & tourism	1	2.38	1	3.13
	Information technology	10	23.81	8	25.00
	Language skills	19	45.24	16	50.00
	Marketing and branding	-	-	1	3.13
	Research Methodology	1	2.38	-	-
	Sales and marketing	5	11.90	-	-
	Social development	-	-	1	3.13
	Soft skills and self-development	-	-	1	3.13

The results show a balanced gender distribution, with females slightly more represented. Most participants are in their 20s and 30s, with a majority holding Bachelor's degrees. Learners are mainly students, while teachers come from diverse professions, notably teaching and IT. Usage of DLPs spans 1-3 years for most, focusing on language skills and information technology. These findings highlight the diverse user base and professional applications of DLPs in Thailand.

Results of Hypothesis 1: Various digital learning platforms are already accessible to non-degree learners and freelance professional teachers in Thailand.



Preferred learning and teaching types

Among the various learning types, blended learning, which includes mixed traditional classroom learning and online learning, is the most preferred learning type by 39% of the learners, followed by classroom learning at 35% and online learning (mobile learning) at 26%. In the teachers' opinions, classroom teaching is the most preferred at 48%, followed by blended teaching at 33% and online teaching at 19%. Pictures 2 and 3 demonstrate the preferred learning type.







The respondents added that though online learning is convenient, blended learning makes them more productive as discussions and clarifications can be made among peers and teachers, and they can submit the assignments online. On the other hand, online learning brings benefits such as flexibility and avoiding traveling.

Mode of using DLPs for online learning and teaching

In online learning, synchronous (live learning) is the mode of using DLPs, which was responded to by 76% of the learners, followed by asynchronous (distance learning) at 24%. Similarly, teachers stated that live teaching is used at 74%, followed by distance teaching or teaching through video content. The different modes used by the target respondents are expressed in pictures 4 and 5.









Distance learning comprises complete self-learning or instructor-led learning, whereas live learning is directly with the instructor and can be one-on-one or in groups. Live learning is started to be the preferable mode along with its significant features of DLPs reported as collaboration, interactive learning (Forums, Webinars, Live chats), group tutoring sessions, one-on-one tutoring sessions, Real-time feedback, Video conferencing (live classes), Virtual classroom, Online tutoring (live tutorials). Distance learning and features comprising offline mode, personalization, video-based content, and assessment tools are preferred.

Digital learning and Digital Learning platform types applied by learners and teachers

The learners responded using virtual classrooms at 35.56%, mobile learning at 24.44%, MOOCs and personalized learning at 15.56%, and gamified learning at 8.89%. On the other hand, digital learning platform types applied by the teachers were found to be led by Video Conferencing Platforms at 38%, followed by Virtual learning environment (VLE) at 27%, Learning Management System (LMS) at 17%, MOOCs at 13% and Learning content management system at 4%.



Picture 6: Digital learning types applied by learners **Picture 7:** DLP Types applied by teachers

As presented in pictures 6 and 7 above, the virtual classroom is widely used among learners, and direct communication with peers and teachers is always the preferred learning type. Virtual learning environments and video conferencing platforms are stated to be the most preferred ones by teachers as they enhance direct interaction with learners.

Digital learning platforms used by Learners and Teachers

The research identified various digital learning platforms accessible by non-degree learners and freelance professional teachers. The target users use a total of 17 common digital learning platforms. In both cases, Zoom is led at 22% and 18% by the learners and teachers, respectively, followed by other DLPs, including Google Classrooms, Canva, and Microsoft Teams.

Pictures 8 and 9 show that video conferencing platforms, including Zoom and Google Meet, are the most widely used DLP among the target users in Thailand. In the case of non-degree, the DLPs have been used in the last 12 months at the time of interviews, whereas the teachers can currently use them for delivering online courses.









Results of Hypothesis 2: Digital Learning Platforms will have a positive effect over constraints on non-degree learners and freelance professional teachers in Thailand.

The learners and the teachers strongly expressed their confidence in using digital learning platforms despite the technical constraints and limitations. The following pictures, 10 and 11, showed the constraints faced by the learners and teachers and their level of confidence while using the DLPs to meet the purpose.



Types of Barriers	Learners	Teachers	Total
Distractions	9		9
Internet connectivity	10	14	24
Lack of direct contact	7	4	11
Lack of knowledge	4	3	7
Language	4	5	9
Low digital literacy skilled learners		9	9
Low digital literacy skilled teachers	2		2
Motivation	5		5
Self-discipline	4		4
Technological assets	6	1	7
Technological constraint	5	4	9
Total	56	40	96

Picture 10: Confidence Level

Picture 11: Types of Barriers

In addition, the research also explored the perceived ease of use, perceived usefulness, and impacts of DLPs on target learners and teachers. According to the 5 Point Linkert Scales, the positive implications for learners and teachers are significant and are captured in Tables 4 and 5.

Table 4 : Mean value and estimation	legree on a 5-point Likert scale	e regarding the general impacts of
DLPs on learners.		

Items	Mean Value	Estimation Degree
Digital learning platforms are useful for me in general.	4.26	Very High
The digital learning platforms I use are relevant to my job or career.	4.22	Very High
Digital learning platforms are useful for my learning purpose.	4.17	High
I am satisfied with using digital learning platforms in general.	4.17	High
Digital learning platforms are easy to use.	4.09	High
My experience in using digital learning platforms is positive.	4.09	High
Using digital learning platforms has increased my job output.	4.09	High



Items	Mean Value	Estimation Degree
Digital learning platforms are easy to access.	4.04	High
After having access to digital learning platforms, I have gained more confidence in expressing my abilities.	3.96	High
Using digital learning platforms is helpful to me in demonstrating my knowledge in the job environment.	3.87	High
Mean Total	4.10	High

Similarly, the impacts on freelance professional teachers using DLPs are identified as follows.

Table 5:	Mean value and estimation degree on a 5-point Likert scale regarding the general impacts of
	DLPs on teachers.

Items	Mean Value	Estimation Degree
Digital learning platforms are useful for my teaching profession.	4.43	Very High
Digital learning platforms are useful for me in general.	4.35	Very High
The digital learning platforms I use are relevant to my job or career.	4.30	Very High
Using digital learning platforms has increased my job output.	4.22	Very High
I am satisfied with using digital learning platforms in general.	4.09	High
Digital learning platforms are easy to access.	4.04	High
My experience in using digital learning platforms is positive.	4.04	High
Using digital learning platforms is helpful to me in demonstrating my	4.04	High
knowledge in the job environment.		
Digital learning platforms are easy to use.	3.96	High
After having access to digital learning platforms, I have gained more	3.96	High
confidence in expressing my abilities.		
Mean Total	4.14	High

In both cases, the findings are significant and align with the hypothesis that digital learning platforms have a positive effect over constraints on non-degree learners and freelance professional teachers in Thailand.

Results of Hypothesis 3: Using Digital Learning Platforms brings economic well-being to non-degree learners and freelance professional teachers in Thailand.

Regarding the responses from the target non-degree learners and freelance professional teachers, it was found that DLPs uplift their economic well-being. Tables 6 and 7 present the results from the 5-Point Linkert Scale questions answered by the target respondents.

Table 6: Mean value and estimation degree on a 5-point Likert scale regarding the impacts of economic well-being on learners.

Items	Mean Value	Estimation Degree
Digital learning platforms are free of charge/cost-effective.	4.00	High
Using digital learning platforms has increased my access to essential	3.87	High
goods and services.		
Using digital learning platforms has increased my income.	3.48	High
Using digital learning platforms opens more job opportunities or career	3.70	High
enhancement to me.		
Using digital learning platforms positively increases wealth (savings,	3.61	High
assets, etc.)		
Mean Total	3.73	High



Understandably, not all the target non-degree learners have yet to be engaged in economic activities. However, the above results represent the positive effects on the learners already engaged in income-generation activities, including employment. Table 7 illustrates the same for teachers.

Table 7: Mean value and estimation degree on a 5-point Likert scale regarding the impacts of economic well-being on teachers.

Items	Mean Value	Estimation Degree
Using digital learning platforms opens more job opportunities or career enhancement to me.	4.30	Very High
Using digital learning platforms has increased my income.	4.09	High
Using digital learning platforms has increased my access to essential goods and services.	4.04	High
Using digital learning platforms positively increases wealth (savings, assets, etc.)	3.70	High
Digital learning platforms are free of charge/cost-effective.	3.43	High
Mean Total	3.91	High

In addition, the teachers' qualitative findings also supported the idea that DLP teaching offers flexibility and saves time for commuting to the physical classroom. It provides opportunities to strengthen their technical knowledge and enhance their career prospects in the future. Therefore, the results from the research support the hypothesis that using DLPs does bring economic well-being to non-degree learners and freelance professional teachers.

Discussions

As shown by the results of Hypothesis 1 in Pictures 2 through 9, various learning platforms were widely used among the teachers and learners. Blended learning was preferred due to experience having the benefits of online learning and the advantages of face-to-face classroom exposure, in line with the recommendation of Mohammadi et al. (2023) that blended learning would likely become an essential approach over going online. Among the different learning modes, synchronous (live learning) dominates asynchronous (distance learning), and hence, the target respondents used virtual learning environments and video conferencing platforms.

On the other hand, the quantitative and qualitative results for Hypothesis 2 also revealed limitations in access to many different digital learning platforms. The respondents described their lack of knowledge of accessing the DLPs available in the current market, citing language barriers and complex features as significant obstacles. This finding is supported by the literature that states the importance of the features of the DLPs to have a more positive relationship with the users, and the students who embrace the technology can perform well (Boozer et al., 2020). Khan (2023) highlighted the improvements for MOOCs type DLP's features and functions and, as Faustmann et al. (2019) suggested, to design customized digital learning platforms to adjust the users' needs. Therefore, the features of the DLPs should align with the needs of the non-degree learned and the freelance professional teachers to increase access and performance.

As revealed by Khan (2023) and Aroonsrimarakot et al.(2022) in the literature, this research also identified common challenges faced by the target users in the study, including low interaction, unstable internet connection, privacy and security concerns for using a video camera, background distractions and technical know to get access to updated features of the DLPs. Independent online learners and teachers face additional challenges such as fees, confusing functions, complicated features, students' attention, technological constraints, and technological assets. However, the significant



benefits, such as personalized learning experiences perceived by online users using digital learning platforms, have positive impacts and contribute to the economic well-being of the target users. Teachers are more confident in overcoming obstacles, per the findings in pictures 10 and 11 above. Also, according to the results in Tables 4-7, teachers were exposed to more benefits and hands-on experience in using DLPs, promoting their teaching profession and job output. Hence, the results showed that teachers were more engaged in economic activities than learners in answering Hypothesis 3.

To support non-degree education through online learning, the DLPs should be more user-friendly and promote interactions among the learners and the teachers. Additionally, sufficient digital knowledge and teachers' professional skills are also crucial. The teachers revealed that the digital literacy of Thai people outside Bangkok who do not attend the university is not quite good. Therefore, such types of non-degree learners should receive support not only financially, such as by providing MOOCs-type DLPs for free, but also in uplifting their technological enhancements as the significant benefits identified extend to increased knowledge, more flexibility, and enhanced professional and personal skills encourages and promotes increase access in DLPs to new users.

Conclusions

The research identified the impact of access to various DLPs on Thailand's non-degree learners and freelance professional teachers. It was found that 17 common DLPs are widely used among the target users, led by video conferencing platforms such as Zoom and Google Meets, followed by Canvas, Google Classrooms, Thai MOOC, etc. The research also explored the key benefits and challenges faced by the target users and revealed that the positive perceived dominates over the constraints. Furthermore, the ranking results highly affirmed that using DLPs has positive effects on the economic well-being of non-degree learners and freelance professional teachers. The findings in this research will help the respective stakeholders, including the software developers, educators, learners, and policymakers, better understand the overall constraints of using DLPs. They may find ways to mitigate the limitations and enhance productivity. In addition, further study should focus on the impacts of technological innovation on the non-degree education system to promote educational equality and a more dynamic and adaptable learning ecosystem.

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北京 A 公司施工项目桩基工程风险管理研究 BEIJING COMPANY A CONSTRUCTION PROJECT PILE FOUNDATION ENGINEERING RISK MANAGEMENT ANALYSIS

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摘要

随着城市建设的不断推进,桩基工程作为一种常见的地基处理方法,在建筑和基础设施项目中得到广泛应用。然而,桩基工程存在着诸多风险,如地质条件不确定性、施工工艺复杂性、施工现场环境复杂性等,这些风险可能对项目的安全性、质量和进度产生严重影响。因此,进行有效的风险管理对于保障桩基工程施工的顺利进行和项目的成功完成至关重要。

本研究以北京 A 公司的施工项目桩基工程为研究对象,旨在探讨桩基工程风险管理的 方法和实践。首先,通过文献综述和实地调研,对桩基工程中存在的主要风险进行了分析和总结。 其次,采用风险识别、风险评估和风险应对三个步骤的风险管理流程,对北京 A 公司施工项 目桩基工程的风险进行了识别、评估和应对,并提出了相应的管理措施。最后,通过案例分析 和对比研究,评估了风险管理措施的有效性,并提出了进一步完善桩基工程风险管理的建议。

关键词:北京A公司施工项目桩基工程风险管理

Abstract

With the continuous progress of urban construction, pile foundation engineering, as a common method of ground treatment, has been widely used in construction and infrastructure projects. However, pile foundation engineering involves various risks, such as geological uncertainty, complexity of construction technology, and complexity of construction site environment, which may have a serious impact on the safety, quality, and progress of the project. Therefore, effective risk management is crucial to ensure the smooth construction of pile foundation engineering and the successful completion of the project.

This study takes the pile foundation engineering of Beijing A Company's construction project as the research object, aiming to explore the methods and practices of risk management in pile foundation engineering. Firstly, through literature review and field investigation, the main risks existing in pile foundation engineering are analyzed and summarized. Secondly, the risk management process of risk identification, risk assessment, and risk response is adopted to identify, assess, and respond to the risks of Beijing A Company's construction project pile foundation engineering, and corresponding management measures are proposed. Finally, through case analysis and comparative study, the efeffectiveness of risk management measures is evaluated, and suggestions for further improvement of pile foundation engineering risk management are proposed.

Keywords: Beijing A Company, Construction Project, Pile Foundation Engineering, Risk Management



引言

桩基工程是建筑、土木工程中常见的一种基础处理方式。然而,在桩基工程中存在着 各种潜在的风险因素,地质条件复杂、施工技术难度大、设备材料质量控制不当等风险,这些 对项目的进展和质量造成一定的负面影响。

北京 A 公司作为一家在桩基工程领域具有丰富经验的施工公司,对于项目的开展有着 极高的施工质量和风险管理水平。分析北京 A 公司的优秀经验,以具体案例作为实践依据, 探讨实际项目中的风险管理实践,清晰桩基项目风险管理,明确桩基项目的主要特点,落实桩 基项目的主要风险及评价。

再结合北京地铁 6 号线这一轨道交通施工项目实例,进行项目风险识别,以及确立项 目风险评价及应对策略。验证模糊综合评价法在施工项目风险管理研究领域有一定的适用性, 提出若干针对性风险控制措施,最终确立通过采取科学的风险管理措施和持续监控,可以降低 项目风险,为公司提供有针对性的管理策略和方法,提高项目的施工效率和质量。

研究目的

提高施工项目管理水平:通过对桩基工程风险进行科学的管理和控制,可以减少项目 中潜在风险的发生概率,从而提高施工项目的管理水平,保障项目的顺利进行。

优化施工流程: 合理的风险管理可以帮助识别和解决施工过程中可能出现的问题,从 而优化施工流程,提高施工效率,减少资源浪费。

提升工程质量:风险管理有助于提前识别和消除潜在的质量风险,确保施工过程中符 合设计要求和相关标准,从而提升工程的质量,降低质量事故的风险。

保障工程安全:风险管理可以帮助识别并采取措施来减少施工现场的安全风险,保护 工人的生命和财产安全。

提高企业声誉:通过科学的风险管理,避免项目中的事故和质量问题,有助于提升北 京 A 公司的声誉,增强在市场竞争中的竞争力。

本研究报告主要有以桩基施工项目风险的概念和特点,结合北京地铁 6 号线这一轨道 交通施工项目实例,明确项目风险评价指标体现构建的原则,验证模糊综合评价法在施工项目 风险管理研究领域有一定的适用性,提出若干针对性风险控制措施,为项目风险管理提供了可 靠的理论依据,整体架构如图 1:





图1: 技术路线架构图

文献综述

在桩基工程风险管理领域,已经有很多学者和专业人士进行了大量的研究和实践,涉 及了不同类型的风险管理方法和策略。

一方面,有关风险识别和评估的研究已经取得了显著的进展。例如,通过地质勘探和 测试技术,可以对地质条件进行详细调查和评估,识别地质灾害风险;通过施工方案设计和施 工过程模拟,可以对施工过程中的技术和操作风险进行评估。此外,还有一些定量化的风险评 估方法,如层次分析法、灰色关联法、模糊综合评价等,可用于对桩基工程风险进行定量分析 和评估。陈某等人基于韧性理念与地铁施工安全管理间的关联,分析影响地铁施工安全系统韧 性的因素。明确了各因素间的关系,构建地铁施工安全系统韧性评价体系。然后结合武汉地铁 12 号线青菱站,通过 AHP-多级模糊综合评价法计算量化韧性值,并提出相关的韧性优化与提 升策略。王某用现代风险管理方法,结合国内轨道交通的特点对运营保障项目的风险管理进行 了全流程的分析。在风险识别阶段主要采用历史资料法结合人、设备、环境及管理四要素进行 系统性识别。并通过"LEC"法与信息扩散理论对识别的危险源进行定量分析,并比选出对地铁 运营危害最大的危险源,完成常规风险的应对方案后,再结合分析结果制定重大危险源的专项应 对计划,将地铁运营风险降到最低。

另一方面,针对桩基工程风险管理的策略和方法也得到了广泛研究。根据 Kudszus et al. (2020)的研究,例如引入风险转移、风险分担和保险等方法,可以通过合同和保险方式将



风险分散或转移给其他相关方;参考 Wang X. (2020)和 Yi et al. (2023)研究,采取风险预防、风险控制和风险应对等措施,可以在施工过程中降低风险的发生概率和影响程度;建立风险管理体系和标准,可以对风险管理进行规范和指导。Almeida 和 Dias (2015)人介绍了设计和开发能够识别建设项目符合性评估结果的管理框架的概念背景和所采取的方法。它还将这种管理框架的外延贯穿于建筑项目的规划、规划、设计、施工和使用阶段。Zhang et al. (2023)提出了一种多源数据融合与水动力学相结合的城市内涝风险识别框架 (MDF-H)该框架由源数据层、模型参数层和计算层组成。利用多源数据融合技术,对城市气象信息、地理信息、市政工程信息进行统一面向计算的处理,形成全球化多数据层级深度融合。

综上所述,已有的文献研究为北京 A 公司施工项目桩基工程风险管理提供了一定的理 论和实践基础,但在实际应用中仍存在一些挑战和待解决的问题。因此,本文研究旨在通过对 北京 A 公司施工项目桩基工程风险管理的深入研究,结合实际情况,提出有效的管理策略和 方法,为公司的项目管理和工程质量提升提供有关的引导和参考,为桩基工程风险管理领域的 学术研究和实践应用作出贡献。

研究方法

文献综述:通过查阅国内外相关文献,对桩基工程风险管理领域的理论、方法和应用 进行综合梳理和分析,了解当前研究状况和存在的问题。

实地调查:对北京 A 公司施工项目桩基工程进行实地调查,收集项目相关资料,包括 设计文件、施工记录、质量验收报告等,以获取项目的实际情况和项目风险的具体表现。

专家访谈:通过与项目参与方的专家进行深入访谈,了解他们在桩基工程项目风险管理方面的认知、经验和实践,包括风险识别、处理和沟通等方面的观点和建议。

统计分析:基于收集到的实际数据和专家访谈的资料,采用定性和定量的统计方法, 对桩基工程项目的风险进行分析和评估,包括风险概率、影响程度、严重性等方面的评估。层 次分析法思路清晰,可以促进管理者自身思维的模块化、系统化、数据化、量化。如图 2 和表 1:



图 2: 层次分析结构模型图



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标度	定义
1	i、j两元素之比为1,表明i较j同等重要
3	i、j两元素之比为3,表明i较j轻微重要
5	i、j两元素之比为5,表明i较j明显重要
7	i、j两元素之比为7,表明i较j非常重要
9	i、j两元素之比为9,表明i较j极端重要
如 i 、j 两元素重要 为重要性介于中间	性相反,则使用 1/3 、1/5 、1/7 、1/9 的标度进行表明如出现 2 、4 、6 、8 的标度数值则意 情况

案例分析:通过对北京 A 公司施工项目桩基工程的案例进行深入分析,探讨实际项目中的风险管理实践,包括风险识别、处理和沟通等方面的策略和效果。

通过以上的研究方法,具体事实和操作,在进行汇总分析,在和案例相结合,为研究 结果提供依据和方向。细致方向在方面:

项目简介及风险识别

桩基项目风险管理框架的设计

桩基项目是建筑和土木工程中的一种重要基础工程,涉及复杂的地下工程,因此在桩 基项目的管理过程中,风险管理是至关重要的。设计一个有效的桩基项目风险管理框架可以帮 助项目团队识别、评估、应对和监控项目中的潜在风险,以确保项目的顺利进行。

1. 风险识别

项目团队应该在项目初期进行全面的风险识别,包括对项目涉及的各个方面进行风 险识别,例如地质条件、土壤性质、地下水位、桩基设计和施工等。参考 王珂等. (2016) 研究, 可以利用专业知识和经验,进行文献研究、现场勘察、地质勘探和实地测试等方式,识别可能 的风险源。

2. 风险评价

对于识别到的潜在风险,项目团队应该进行定性和定量的风险评估。定性评估可以 通过专家评审、头脑风暴等方法,评估风险的概率、影响和严重性等。史小 丽等. (2018) 对公 路隧道施工安全重大风险源风险等级评估方法研究时,定量评估可以通过数学模型、仿真分析 等方法,对风险进行量化,计算风险的风险值或风险指数,以便于比较和排序风险的优先级。

3. 风险应对

在识别和评估风险后,项目团队应该采取适当的应对措施,以减轻或消除风险的影响。应对措施可以包括技术措施、管理措施和合同措施等。根据 孙长文和朱海斌. (2014) 研究, 对于地质条件复杂的项目,可以选择更合适的桩基类型,增加检测措施,调整施工顺序等;对 于施工过程中可能出现的问题,可以加强施工管理,提高施工人员的技能培训等;对于合同中 的风险条款,可以进行谈判和合同修订等。

4. 风险监控

在项目的整个生命周期中,项目团队应该进行持续地风险监控,及时跟踪项目的风 险状况,确保应对措施的有效实施,并根据实际情况进行调整和改进。监控可以包括定期的风 险评估,实时地风险监控,以及与项目干系人的沟通和合作,确保他们对项目风险的认知和参 与。



项目风险评价

桩基项目是一种基础工程,用于在土地较软或不稳定的地区建造建筑物或其他工程结构。在桩基项目中,存在一些潜在的风险,需要进行评价和管理,以确保项目的顺利进行

1. 桩基项目的主要特点

承载力增强: 桩基是一种通过将桩深入地下来增加地基的承载力的方法。通过桩的 承载能力和抗侧力,可以有效地增强地基的承载能力,使得在不稳定的土地上能够建造较大的 建筑物或工程结构。

深层处理:相较于浅层地基处理方法(如挖土换填、加固地基等),桩基一般深入 地下较深的位置。参考陈盛.(2013)研究,桩可以通过不同的形式,如灌注桩、钻孔灌注桩、 钢筋混凝土桩等,深入地下的稳定层或者较硬土层,从而提供更好的承载力和稳定性。

多样性的桩型: 桩基项目可以采用多种不同类型的桩,例如灌注桩、德国橡木桩、 钢筋混凝土桩、螺旋桩等,以满足不同地质条件和工程要求。不同类型的桩具有不同的特点和 适用范围,可根据具体情况选择合适的桩型。

高度专业化: 桩基项目通常需要高度专业化的施工技术和设备。例如,钻孔、灌注、 振动等作业需要特殊的工艺和设备,且对施工人员有较高的技术要求。桩基施工通常需要经验 丰富的专业施工队伍和合适的设备,以确保施工质量和安全。

施工监测: 桩基施工通常需要进行实时的监测和测试。例如,需要监测桩的承载力、 沉降、偏斜等参数,以确保桩基的设计和施工符合要求,并进行必要的调整。施工监测对于确 保桩基的质量和稳定性至关重要。

相互影响: 桩基施工可能对周边环境和现有结构产生影响。例如,施工振动可能影 响邻近结构的稳定性,施工噪音和灰尘可能对环境和居民造成干扰。因此,在桩基项目中需要 进行相应的环境影响评价和监测,并采取必要的措施来减少不良影响。

2. 桩基项目的主要风险及评价

经济风险: 桩基项目可能受到经济因素的影响,如市场需求下降、资金紧张、材料价格波动等。

政治风险: 桩基项目可能受到政治因素的影响, 如政策法规变化、政府审批延迟等。

社会风险: 桩基项目可能涉及到社会利益相关者的关切, 如居民抗议、社会舆情等。

自然风险: 桩基项目可能受到自然因素的影响, 如地震、泥石流等自然灾害。

技术风险: 桩基项目可能面临技术上的困难和风险,如设计不合理、施工难度大、 质量控制不到位等。

北京地铁六号线桩基案例分析

1. 项目背景简介

北京地铁六号线是北京市地铁网络中的一条城市轨道交通线路,连接了北京市西南 的草桥站和北部的金安桥站,全长约 50.1 公里,共设立 38 个车站,是一条重要的城市轨道交 通干线。六号线是北京地铁网络中的一条横向线路,穿越了北京市的多个区域,对于改善城市 交通拥堵、提高交通效率和便捷性,促进城市经济发展具有重要意义。

在六号线的建设过程中,桩基工程是其基础工程之一。桩基工程主要涉及到在地下 深层钻孔、灌注混凝土或者安装钢筋混凝土桩,以支撑轨道交通线路的轨道、车站、站台等重 要结构,并保障线路的安全和稳定运营。如表 2:



工程描述							
结构形式	三层三跨局部四跨	檐高	(米)	80		建筑面积	19130
						(m^2)	
预计合同额 (万元)	23500	地上	二层数	0		地下层数	4
注册建造师							
注册建造师专业类别	市政公用工程		注册	主册建造师资格等级		建造师一级	
对投标人的资质要求							
资质序列	要求资质专业		等级		与下一条关系		
施工总承包	房屋建筑		特级			并且	
施工总承包	市政公用		一级		j	或者	
专业承包	城市轨道交通		不分等级		或者		

表 2: 北京地铁 6 号线二期工程桩基工程合同段组成一览表

2. 项目风险识别

在进行北京地铁六号线桩基项目时,风险识别是项目管理的重要环节之一。政治风险和经济风险自然风险技术风险社会风险是项目可能面临的五种类型的风险。

政治风险:政治风险包括政府政策、法律法规、社会稳定等因素对项目的影响。在 六号线桩基项目中,可能存在政府政策调整,例如土地使用政策、环保政策等可能对项目造成 不利影响。此外,法律法规的变化,如土地征用、环境保护等法律法规的调整也可能对项目产 生风险。社会稳定因素如社会抗议、社会事件等也可能对项目的顺利进行产生影响。

经济风险:经济风险包括宏观经济环境和市场供需情况对项目的影响。在六号线桩 基项目中,宏观经济环境的变化,如经济周期、利率、汇率等的波动,可能对项目造成经济风 险。市场供需情况,如建筑材料价格、施工服务市场等的波动也可能对项目造成影响,从而导 致项目成本、进度等方面的风险。

社会风险:社会风险包括项目对周边居民和社区的社会影响,如噪音、振动、尘土、 交通拥堵等,可能引发社会抗议、诉讼或投诉,从而对项目产生负面影响。在六号线桩基项目 中,如果没有充分考虑和管理社会风险,可能会导致项目受到居民和社区的反对,从而影响施 工进度和项目的声誉。

自然风险:自然风险包括地震、洪水、地质灾害等自然灾害对项目的影响。北京地 处地震多发区,地震对六号线桩基项目可能造成的影响需要充分考虑和评估。根据刘凯斯等 人.(2018)的研究,北京地区还可能面临洪水、地质灾害等自然灾害,这些灾害对项目的设 计和施工也需要特别注意。

技术风险: 技术风险包括项目所采用的技术、工艺和设备的可靠性、适用性等方面 的风险。在六号线桩基项目中,可能存在施工技术难度较大、设备可靠性不高、工艺适应性不 足等技术风险。这些风险可能对项目的施工进度、施工质量和工程成本产生影响。如图 2:





图 2: 北京地铁六号线施工项目的风险因素模糊递阶层次模型

3. 项目风险评价及应对策略

基于以上风险,参考查阅的文献,项目管理团队应采取一系列措施进行风险管理, 对政治风险的应对策略:1)对政治形势的及时关注和分析,制定针对性的风险管理计划: 2)加强政治风险管理的组织领导,建立专门的风险管理团队;3)制定相关政策法规,明确 企业在政治风险管理方面的责任; 4)与政府及政治组织建立合作关系,做好沟通和协商工作, 及时解决问题; 5)在风险管理计划中加入风险应对措施,保证企业的持续发展。对经济风险 的应对策略:1)建立健全的风险管理体系,对各种经济风险进行分类、评估、预测和管理; 2)提高企业对经济环境的敏感度,密切关注经济环境变化,及时调整企业发展战略;3)建 立合理的资金管理体系,做好资金预算、控制和使用;4)加强供应链管理,降低供应链风险, 保证物资供应的连续性; 5) 建立财务风险管理制度,规范财务管理流程,确保财务安全和稳 定。对社会风险的应对策略:1)建立和谐稳定的企业文化,加强员工教育和管理,提高员工 的社会责任感和公民意识;2)建立有效的社会风险评估机制,预测和识别潜在的社会风险; 3)加强企业与社会的沟通和协商,积极回应社会关切,及时解决社会问题;4)建立公正、 透明的企业管理制度,加强企业社会责任管理;5)加强对安全、环保等方面的管理,降低社 会风险。对自然风险的应对策略:1)建立完善的自然灾害应急预案,提前进行风险评估和防 范措施: 2)提高企业对自然环境的敏感度,加强环境保护和资源管理: 3)建立灾后恢复和重 建机制,加强与相关机构的合作:4)建立自然灾害风险管理制度,加强对自然灾害风险的管 理和控制;5)积极参与自然灾害应对和救助工作,为灾民提供帮助和支持,提高企业的社会 责任感和形象。对技术风险的应对策略: 1) 建立完善的技术风险管理体系, 对技术风险进行 评估、预测和管理 2)加强技术人才培养和管理,提高技术人员的素质和能力; 3)定期对技 术设备进行检测和维护,及时更新设备;4)加强对技术风险的监测和预警,及时采取措施; 5)加强对知识产权的保护,避免技术风险产生。

需要注意的是,参考霍双龙.(2019)研究,以上只是简要的项目风险评价,实际项目风险评价应该根据具体项目的特点和环境进行详细地分析和评估,并在项目管理过程中持续进行监控和调整,以确保项目的可持续发展和成功实施。如何应对安全风险之一是在隧道内布置"三管、三线一走道",三管即φ100的冷却水管、φ100的排污管和φ1000的通风管。三线即10KV高压电缆、380/220V动力照明线和43Kg的运输轨线,以保证安全。



研究结果

经过对北京地铁六号线桩基项目的风险评价,得出以下结论:

政治风险:政治风险较低,目前北京市政府对地铁项目有稳定的政策支持,并积极推动项目的推进。但仍需关注政府政策变化、地方政府层级变动等可能对项目进展和投资环境带来的潜在影响。如表 3:

序号	工法	作业活动	重大危险源	可能导致的事故
1	明挖车站	土方开挖	塌方	塌方伤人
2		边坡支护	管线	管线断裂
			建筑物	建筑物沉陷
3	盾构区间	开仓作业,更换刀具	刀具	机械伤害

经济风险:经济风险较中等,项目需要大量资金投入,资金来源和成本控制对项目的 顺利实施具有重要影响。目前资金供给相对充足,但需要关注宏观经济环境变化、融资成本上 升等可能对项目融资和资金利用带来的潜在影响。

社会风险:社会风险较高,项目可能对周边居民和社区产生噪音、振动、尘土、交通 拥堵等社会影响。项目管理团队需要加强社会沟通和公众参与,采取有效措施减轻社会风险, 并保障项目顺利推进。

自然风险:自然风险较中等,北京地区位于地震多发区,地震对项目的影响需要充分 考虑和评估,并采取相应的地震防范措施。此外,项目还需要应对洪水、地质灾害等自然灾害 的风险。

技术风险: 技术风险较高, 桩基施工技术要求较高, 地质情况复杂, 施工空间狭小, 可能增加项目的技术难度。项目管理团队需要加强技术监控和优化设计, 确保施工技术的合理 应用和项目的顺利实施, 因技术问题引发的工程延期, 综合以上因素风险总结如表 4:

一级评价指标	指标权重	二级指标评价	指标权重
经济风险 Ui		预算风险 U11	0.34
	0.4	物价上涨风险 U12	0.51
		业主支付风险 U13	0.14
政策风险 U2		土地使用风险 U21	0.36
	0.14	政策风险 U22	0.24
		环保风险 U23	0.14
社会风险 U3		社区负面影响风险 U31	0.07
	0.24	劳动力短缺风险 U32	0.13
		U ₃₃	0.2
自然风险 U4		地质条件风险 U41	0.3
	0.08	环境保护风险 U42	0.7
		自然灾害风险 U43	0.4
管理风险 U5		技术风险 U51	0.34
	0.14	进度风险 U52	0.51
		质量风险 U53	0.14

表 4: 北京地铁六号线轨道交通项目风险评价指标权重汇总



综合以上评估,项目管理团队应采取一系列风险管理措施,包括:定期监测政治、经 济、社会、自然和技术风险,制定相应的应对计划;加强社会沟通和公众参与,减轻社会风险; 建立健全的风险监控和应急响应机制,及时识别和应对潜在的风险事件;加强技术监控和施工 控制,确保施工技术的合理应用和项目的质量和安全;加强与政府、投资方、承包商等各利益 相关方的沟通和合作,确保项目的资金供给和合同履约;做好项目团队的组织管理和人员培训, 提升团队的综合管理能力。

综上所述,北京地铁六号线桩基项目面临着一定的政治、经济、社会、自然和技术风险,但通过采取科学的风险管理措施和持续监控,可以降低项目风险,确保项目的顺利实施和成功完成。

讨论

在北京地铁六号线桩基项目的实施过程中,面临着多种风险,包括政治、经济、社会、 自然和技术等方面的风险。这些风险可能对项目进展、投资回报、社会和环境影响等产生不良 影响。因此,项目管理团队需要采取一系列的风险管理措施,以最大限度地降低这些风险的发 生概率和影响程度。

第一,政治风险在地铁项目中可能涉及到政府政策变化、政治环境不稳定等方面。项 目管理团队应密切关注政府的政策动态,与政府保持良好的沟通,及时了解政策变化对项目的 影响,并制定相应的应对措施。

第二,经济风险主要包括资金供给和成本控制两个方面。项目需要大量资金投入,因此资金供给和资金成本对项目的顺利推进和投资回报至关重要。项目管理团队应合理规划项目的资金需求,与投资方保持密切的合作,确保资金的及时到位。同时,还应加强成本控制,合理管理项目的运营成本和施工成本,以确保项目的经济可行性和可持续性。

第三,社会风险在地铁项目中可能涉及到对周边居民和社区的影响,如噪音、振动、 尘土、交通拥堵等。项目管理团队应加强社会沟通和公众参与,及时回应居民和社区的关切和 需求,采取有效措施减轻项目对社会的负面影响,确保项目在社会层面得到支持和认可。

第四,自然风险主要包括地震、洪水、地质灾害等自然灾害的风险。北京地区位于地 震多发区,因此项目在设计和施工阶段需要充分考虑地震风险,并采取相应的地震防范措施。 此外,还需要对项目所在地区的洪水和地质灾害进行充分评估,并采取相应的防灾措施,以确 保项目在自然环境中的安全实施。

最后,技术风险在地铁桩基项目中也是一个重要的方面。包括设计、施工、监测和质 量控制等多个环节都存在技术风险,如地质条件复杂、土层不稳定、基坑开挖困难等。项目管 理团队应充分了解项目的技术要求和技术难点,与专业团队密切合作,确保施工技术的合理应 用,并进行监测和质量控制,以确保项目的技术可行性和稳定性。

总结与建议

1. 总结

北京地铁六号线桩基项目面临政治、经济、社会、自然和技术等多个风险。其中, 政治风险主要涉及政策变化、法律法规、政府审批等方面;经济风险包括资金来源、资金成本、 经济环境等;社会风险涉及社会舆情、社会稳定、社会影响等;自然风险包括地质灾害、气候 变化等;技术风险涉及设计、施工、监测、质量控制等多个方面。



为了有效管理和应对这些风险,项目管理团队应采取综合的风险管理措施,包括风 险识别、风险评估、风险控制和风险监测等。在风险识别方面,应细化项目的风险来源和风险 事件,并定期进行风险识别的更新和补充。在风险评估方面,应采用科学的方法对风险进行定 量和定性的评估,确定风险的概率和影响程度,以便合理的排序和优先处理。在风险控制方面, 应采取相应的控制措施,如合理规划项目时间、预留足够的预算、制定合理的合同和保障措施 等。在风险监测方面,应建立健全的监测体系,及时监测项目风险的变化,并根据实际情况进 行调整和应对。

2. 建议

充分了解项目风险:项目管理团队应在项目启动前充分了解项目可能面临的风险, 包括政治、经济、社会、自然和技术等方面,并制定相应的风险识别计划。

科学评估风险:在风险评估方面,应采用科学的方法对风险进行定量和定性的评估,确保评估结果客观、准确,并合理地排序和优先处理风险。

制定风险管理计划:项目管理团队应根据风险评估结果,制定相应的风险管理计划, 包括风险控制和风险监测措施,并将其纳入项目管理的整体计划中。

定期监测和调整:项目管理团队应建立健全的风险监测体系,定期监测项目风险的 变化情况,并根据实际情况进行调整和应对措施。风险管理不应仅停留在项目启动阶段,而应 贯穿整个项目周期。

建立跨部门合作机制:对于涉及政治、经济、社会、自然和技术等多个方面的风险,项目管理团队应建立跨部门合作机制,确保各相关部门之间的沟通和协调,以共同应对项目风险。

加强人员培训和能力建设:项目管理团队成员应具备风险管理的专业知识和技能,定期进行培训和学习,不断提升风险管理的能力和水平,从而更好地应对项目风险。

合理规划预算和时间:充分考虑项目风险可能带来的额外成本和时间延误,并在项目预算和时间计划中进行合理规划和预留,以应对可能的风险事件。

与相关利益相关方保持良好沟通:与政府、业主、承包商、社会组织等相关利益相 关方保持良好地沟通和合作,及时了解他们的关切和需求,并在项目中采取措施,以减少可能 引发的社会风险。

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人工智能应用与劳动力结构转换对制造企业创新绩效的影响研究

THE IMPACT OF ARTIFICIAL INTELLIGENCE APPLICATIONS AND LABOR STRUCTURE TRANSFORMATION ON THE INNOVATION PERFORMANCE OF MANUFACTURING ENTERPRISES

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摘要

创新是企业的灵魂,是企业永葆生机和活力的源泉,创新绩效的提升对于制造业的转型 升级起着重要的作用。人工智能的应用对于企业提质增效有一定的促进作用,对劳动力就业和 劳动力结构也会产生一定的影响。但是现有研究大多基于宏观经济层面,且较多侧重于单一方 面研究,缺乏对人工智能应用影响企业创新绩效的微观机理研究。本文通过采用实证研究法, 以中国制造业 A 股上市公司为研究对象,利用 2013—2022 年非平衡面板数据,验证人工智能 应用对创新绩效的影响,并引入劳动力结构转换作为中介变量。研究结果显示: (1)人工智能 应用正向影响企业创新绩效; (2)人工智能应用显著提升内部员工的雇佣数量,减少对常规低 技能劳动力的雇佣占比,增加对非常规高技能劳动力的雇佣占比,对中等技能劳动力影响较小; (3)劳动力结构转换在人工智能应用和创新绩效之间起着中介作用。在研究结论的基础上提出 管理启示,以期对制造业智能化转型提供借鉴。

关键词:制造企业人工智能应用劳动力结构转换创新绩效

Abstract

Innovation is the soul of an enterprise and the source of its vitality and competitiveness. The improvement of innovation performance plays a crucial role in the transformation and upgrading of the manufacturing industry. The application of artificial intelligence (AI) has a certain promoting effect on enhancing the quality and efficiency of enterprises and also has an impact on employment and labor force structure. However, existing studies mostly focus on the macroeconomic level and tend to study single aspects, lacking micro-mechanism research on the impact of AI application on firm innovation performance. In this paper, we adopt an empirical research method, focusing on



Chinese A-share listed companies in the manufacturing industry and utilizing unbalanced panel data from 2013 to 2022 to verify the impact of AI application on innovation performance. We also introduce labor force structure transformation as an intermediate variable. The research results show that: (1) AI application has a positive impact on firm innovation performance; (2) AI application brings about labor force structure transformation, reducing reliance on low-skilled labor and increasing demand for high-skilled labor, with minimal impact on medium-skilled labor; (3) Labor force structure transformation plays an intermediary role between AI application and innovation performance. Based on the research conclusions, managerial implications are proposed to provide insights for the intelligent transformation of the manufacturing industry.

Keywords: Manufacturing Enterprises, Artificial Intelligence Applications, Labor Force Structure Transformation, Innovation Performance

引言

近年来,人工智能技术的快速发展和广泛应用已经引起了社会的高度关注和热议。"人 工智能"一词从 2017 年首次被写入中国政府工作报告,连续几年"人工智能"、"智能制造"、"数 字经济"等词语均在政府工作报告中出现,可见中国对智能技术的重视程度。中共十九大报告中 已经明确指出:"中国经济已由高速增长阶段转向高质量发展阶段,正处在转变发展方式、优化 经济结构、转换增长动力的攻关期。"中国的工业结构正经历着历史性的转型升级,需要在挑战 和机遇中不断创新发展,推进制造业高质量发展,以应对外部冲击产生的压力和影响。面对当 前复杂多变的国际经济环境,高质量发展已经成为中国全面建设社会主义现代化国家的首要任 务。制造企业是中国高质量发展的重要引擎。制造企业在激烈的市场竞争环境中要谋求发展, 需要依靠转型升级抢占市场。随着新一代信息技术的发展,物联网、云计算、区块链等成为了 推动智能发展的重要推动力量,这些技术使得机器有了感知、处理和决策的能力,从而成为智 能化设备,可以更加精准、有效地进行各种任务和处理各种复杂问题。制造业智能化升级不仅 可以提高生产效率,也能够显著地减少"用工荒"带来的劳动力成本上涨,并通过技术进步、生 产力迅速增强的方式推动增长模式升级。

从技术应用的增长速度上看,人工智能的高速发展也已经成为难以阻挡的趋势。国际机器人联合会(IFR)的报告《世界机器人2022:工业机器人篇》统计数据表明,2021全年全球各行各业总共安装了创纪录的517385台新机器人,比2020年增加了31%。中国在2021年对工业机器人进行了巨额投资,机器人密度排名已经进入前五,首次超过美国。随着人工智能技术的不断普及和应用,越来越多的传统劳动力的工作将被自动化和机器化,而一些新型的技术和方式也将逐渐替代传统的低端劳动力,制造业劳动力结构将发生巨大变化。人工智能替代人力的过程本质上是淘汰制造业中低技能劳动力并培育高技能劳动力的过程。这一转变将对制造企业产生什么样的影响?需要我们深入探究。

创新是企业的灵魂,是企业永葆生机与活力的源泉,创新绩效则是衡量企业创新成功与 否最核心的变量之一,创新绩效的提升对于制造业的转型升级起着重要的作用。本文一方面了



解人工智能技术在制造业中的应用,特别是其对劳动力结构的影响,可以帮助我们更好地把握 未来工业发展的趋势,对制造业的智能化影响提供理论补充和实践指导;另一方面,深入研究 人工智能技术应用对企业创新绩效的影响,可以为制造企业智能化转型提供更为准确的决策支 持和管理方法指导。

研究目的

本文的主要研究目的是探究人工智能应用与劳动力结构转换对企业创新绩效的影响,探 讨制造企业是否可以以技术进步为驱动力,利用企业高技能人才增加的优势,进一步影响企业 创新绩效的发展路径。在现代制造业中,人工智能技术已成为促进发展质量和提高生产效率的 重要手段。然而,如何科学、有效地应用人工智能技术提升创新绩效是制造业发展的关键问题 之一。本文旨在研究人工智能应用对制造业创新绩效的影响,并验证劳动力结构转换在人工智 能应用和企业创新绩效之间的中介效应。通过本文的研究以期找到制造业利用技术外力带动企 业内力的新增长路径。

文献综述

1. 人工智能应用与劳动力就业和劳动力结构的相关研究

人们一直关注技术进步是否会对劳动力市场造成冲击。在工业革命时期,人们就担 心机械化大生产和新技术会导致大量工人失业,这被经济学家称为"技术性失业"。随着人工智 能的迅速发展,学者们开始广泛探讨人工智能与劳动力就业的关系。一些学者从理论层面探讨 了人工智能与就业规模的关系,认为人工智能对就业具有"影响中性",即虽然人工智能替代了 一些岗位,但同时也创造了新的就业岗位,使就业总量保持平衡(Wilson et al., 2017, Bessen, 2018)。另一些学者则认为,与以往的技术进步不同,人工智能可能会替代大量中低技能劳动岗 位,特别是随着工业机器人的普及,可能引发大规模失业问题。例如,周文斌(2017)认为机 器人的规模应用势不可逆,是影响经济转型升级的重大历史机遇,对就业会有一定的替代,机 器人上岗导致部分人下岗,工业机器人的规模使用,就业弹性系数会变小。

梳理人工智能对劳动力就业影响的内在机理主要有三种观点: (1) 替代效应。人工 智能不仅能替代其他非人工智能资本要素,还能直接替代劳动要素,进而导致一部分劳动岗位 的消失(Acemoglu & Restrepo, 2016; Frey & Osborne, 2013); (2) 补偿效应。补偿效应主要 体现在人工智能替代性带来的效率提升将引致相关产业规模的扩大,通过规模扩大来弥补单位 产出就业岗位的减少(蔡跃洲、陈楠,2019); (3) 创造效应。人工智能及其他自动化技术的 推广应用在消灭一部分就业岗位的同时会创造出新的就业岗位(李磊、何艳辉,2019)。

在国外对于劳动力结构的研究比较早,Autoret et al. (2003)提出了区分劳动力的方法,定义了常规低技能劳动力和非常规高技能劳动力的概念与标准。他们定义能够通过执行明确指令、重复性质的固定程序来完成任务的工作为常规工作,从而将执行这些任务的人员归类为常规低技能劳动力。与之相对的是非常规工作,这类工作不仅仅依靠明确的指令完成,而通常需要更高技能或学历的员工来进行复杂的思维分析和沟通交流。在劳动力结构测量维度的研究上,现有研究基本采用员工的学历水平来测度(宁光杰、林子亮,2014; 王永钦、董雯,2020)。



尽管该指标与劳动力结构相关度较高,但其难以直接反映低技能劳动的重复性特征和高技能劳动的复杂性特征,也难有效反映出员工的职位类别。Borjas(2005)和 Acemoglu & Restrepo(2019) 认为随着非常规高技能劳动力在总体劳动力中所占比例的上升,这种变化可以被视为劳动力结构的优化和升级。而赵烁等人(2020)对劳动力结构的优化升级进行了明确定义,即在公司内部非常规高技能劳动力所占比例增加。本文采用赵烁等人(2020)的定义视角,将劳动力结构的转换定义为"公司中非常规高技能劳动力的比例增加"。

2. 人工智能应用与制造企业创新绩效的相关研究

(1)创新绩效的概念。组织管理领域通常以两种不同的角度来理解创新绩效:狭义和广义。在狭义的范畴内,创新绩效被理解为产出的量化结果。例如,Hagedoorn & Cloodt(2003) 把它定义为企业在市场上成功推出的发明成果;在更广义的理解中,创新绩效不只包括产出的 结果,还涵盖了创新的整个过程。例如,Alegre & Chiva(2008)通过市场占有率、新市场拓展 能力和产品替代性来评估创新成效。广义上讲,这个概念不仅映射了企业在知识、技术和经营 管理能力上的创新能力和成果,而且揭示了创新效率,这最终会体现在新产品开发的效率和成 果上。

(2)创新绩效的测量维度。目前,针对创新效果的量化评估主要集中在三大领域: 一是强调实际成效。主要测量维度是采用专利数量来衡量企业创新绩效(Kleis et al, 2012;楼 润平等人,2022),第二个维度涉及公司的创新实践行为,分析其采取的多样创新方式及其效率。 例如,钱锡红等人(2010)采用问卷形式从新产品新服务、新技术、创新流程、市场反应等方 面来综合测度企业创新绩效。第三个维度,则是从公司的创新能力发展的多角度进行研究,综 合预期成果和基础支持来评估创新性能。总体来说,通过这些多样化和复合式的指标,创新的 丰富内涵得以体现,并不断推动实证研究在创新领域的展开。

(3)人工智能应用与制造企业创新绩效之间关系。大部分学者发现智能制造对企业 创新绩效的正向促进作用,学者们提出了不同的绩效衡量维度。应里孟等人(2020)利用实证 分析方法,探究了智能制造对企业绩效的影响。研究发现,智能制造实施的时间越长,其对企 业在财务和创新方面绩效的正面影响也越加显著。王磊等人(2022)通过对工业机器人和中国 制造业专利申请数据的实证分析,探讨了工业机器人的应用对制造业创新的影响及其作用机制。 研究发现,工业机器人的应用显著促进中国制造业创新,对资本密集型行业和高新技术行业创 新影响的边际效应大于劳动密集。

3. 人力资本与创新绩效影响相关研究

一些学者认为,在实现产业转型升级推动制造业创新发展的过程中,人力资本的有效利用对于提升企业绩效有促进作用。Bartel & Lichtenberg(1987)以美国制造业为研究对象,研究发现相比于低教育水平的员工,拥有更高教育水平的员工能更快地接受和应用新技术,从而拥有更高的生产效率和创新绩效。Sun et al. (2020)通过制造企业的数据进行实证研究,发现技术型劳动力对企业创新绩效有着显著正向影响。曲玥(2023)认为在人口发展态势发生转变、劳动力成本上涨的背景下,人力资本对制造业转型升级和创新发展的影响显著。张守凤与刘昊蓉(2023)以2011—2021 年沪深 A 股上市公司为样本数据,分析人力资本结构对企业科技创新



绩效的影响,研究发现:在企业人力资本结构中,学历结构高级化、技能结构多样化对企业科技 创新绩效具有促进作用。

4. 文献评述

人工智能是一种新兴的技术进步,已引起学术界广泛关注。人工智能提供先进的制造技术和智能化生产流程控制方法,使制造业拥有更高自主性,进而提高生产效率、降低成本;国内外学者对人工智能与劳动力市场、就业结构等方面已进行丰富研究,得出替代效用、补偿效应和创造效应对就业的影响;然而,现有研究存在不足和拓展空间:(1)缺乏深入微观研究,重点集中于宏观方面研究;(2)缺乏技术推动下企内在创新机理的机理研究。为填补这些研究空白,本文从微观层面实证分析人工智能对制造业创新绩效的影响,并引入劳动力结构转换作为中介变量,探究技术推动下企业内生增长机理研究。

经过文献研究梳理,本文面向拟解决的研究问题,提出三条理论假设与之对应:

H1:人工智能应用对企业创新绩效存在正向影响。

H2:人工智能应用会导致制造企业减少对常规低技能劳动力的雇佣,增加对非常规 高技能劳动力的雇佣,对常规中等技能劳动力影响波动性较小,促使劳动力结构发生变化。

H3: 劳动力结构转换在人工智能应用对制造业企业创新绩效的影响中起到中介作用。

研究方法

(1) 文献研究法。本文对人工智能、劳动力结构、创新绩效的相关的文献进行了较为 全面的梳理,在对文献的梳理和总结的基础上,明确相关研究趋势和拓展空间。在此基础上构 建研究框架,为实证分析奠定理论基础。

(2)实证研究方法。为了验证理论模型的可靠性,本研究采取实证分析的方式,选取 中国制造业的上市公司为研究对象,收集制造企业 2013-2022 年相关变量数据,利用 Stata15.0 软件进行描述性统计、相关性分析和回归分析等多种分析过程,验证提出的研究假设,得出相 关结论。

研究结果

1. 数据来源及处理说明

鉴于中国制造业智能化推广和应用主要发生在 2013 年之后,所以本文采用 2013-2022 年的 A 股制造业上市公司作为考察样本。数据的来源方面,企业智能化投资、财务 信息、公司治理、股权属性、常规企业低技能劳动力和非常规高技能劳动力数据均来自 Wind 数据库;人工智能应用数据来自上海证券交易和深圳证券交易所官方网站发布的上市公司年度 财务报告文本;区域层面的变量数据来自中国研究数据服务平台(CNRDS)及相关省市的统计年 鉴、统计公报等。本文参考已有研究的做法,剔除了部分样本:(1)已停牌、退市或中止状态 的企业;(2)ST股票和 PT 股票;(3)2013-2022 年考察期重要财务数据非正常原因缺失的 企业。并对连续变量进行双边 1%的 Winsorize 处理。经过以上处理,初步获得 3404 家 A 股制 造业上市公司,共 20063 个数据样本。



2. 研究变量定义与测量

(1) 人工智能应用

本文所指人工智能应用是指广义上的应用,是人工智能及相关技术与其他技术 和资源的融合应用。制造企业要实现智能化需要物联网、云计算、大数据等信息技术提供基础 设施和生产资料,制造业的智能化是融合应用的智能化。本文借鉴吴非等人(2021)的做法对 上市公司年报文本信息进行分析作为测量依据,并结合祁怀锦等人(2020)和张远与李焕杰(2022) 等学者的做法,将企业的真实智能化投资水平和年报文本信息相结合,构建企业人工智能应用 水平指标,以更加全面的测度微观企业的人工智能应用水平。本文利用熵权法构建企业人工智 能应用水平指标,有效克服采用工业机器人等方法度量企业智能化水平的弊端,以更加全面、 客观的测度微观企业的人工智能应用水平。表1为人工智能应用水平测度指标体系。

表 1: 人工智能应用水平测度指标体系

一级	二级	测度方法
指标	指标	
智能化	智能软件	与智能化相关的无形资产占总资产的比重。
投资	投资	相应的无形资产为科目名称中包含"智能"、"软件"、"系统"、"信息平台"、"数据"
		等词语的无形资产项目。
	智能硬件	与智能化相关的固定资产占总资产的比重。
	投资	相应的固定资产为科目名称中包含"电子设备"、"计算机"、"数据设备"等词语的
		固定资产项目。
智能化	智能技术	公司年报文本中与人工智能技术相关的关键词数量。
应用	水平	相应的智能技术水平相关的关键词包括:人工智能、智能技术、机器人、机器学
		习、深度学习、自然语言处理、智能软件、云计算、物联网、区块链、智能控制、数
		据挖掘、数字孪生等。
	智能技术	公司年报文本中与智能化应用相关的关键词数量。
	应用深度	相应的智能技术应用深度相关的关键词包括:工业4.0、商业智能、智能创新、智
		能研发、智能设计、智慧城市、智能产品、智能工厂、智能生产、智能营销、智能办
		公、智能系统、智能制造、智能终端、智能转型、智能设备、智能运维、智能服务、
		智能处理、智慧管理、智能客服、应用管理软件等。

(2) 劳动力结构转换

本文借鉴赵烁等人(2020)的定义,将劳动力结构转换定义为:公司中非常规 高技能劳动力的比例增加。本文劳动力结构的相关数据均来自 Wind 数据库。首先对 Wind 数据 库中制造业上市公司员工岗位进行识别和分类,然后依据不同岗位工作的复杂程度,将企业员 工划分为常规低技能劳动力、常规中等技能劳动力和非常规高技能劳动力。Wind 数据库将员工 情况归类为 11 大类:生产人员、行政人员、客服人员、人事人员、销售人员、技术人员、财务 人员、采购仓储人员、风控稽核人员、综合管理人员、其他人员。

在 Wind 数据库原有分类的基础上,部分借鉴了赵烁等(2020)的分类方法,将员工 的岗位归类具体如下:第一类,生产人员(production),将 Wind 数据库中生产人员归入该类; 第二类,职员(staff),将 Wind 数据库中采购人员、人事人员、行政人员、后勤人员、仓储人员、 客服人员等归入该类;第三类,科技人员(tech_R&D),将 Wind 数据库中的技术人员类别归为



该类。第四类,销售及市场人员(S&M),将 Wind 数据库中从事产品销售、营销策划以及公关 等工作的销售员工划分为该类;第五类,财务金融人员(finance),将 Wind 数据库中的财务人员、 风控稽核人员类别员工划为该类。第六类,综合管理人员(manager),将 Wind 数据库中综合 管理人员类别划为该类。第七类,即其他相关人员(others),主要指 Wind 数据库中未归入以上 六类别的员工。

在以上七类员工分类的基础上,将企业员工分为常规低技能员工、常规中技能员工和非常规高技能员工:常规低技能员工包括生产人员(production)类,主要从事常规的、重复性的、容易被人工智能替代的工作岗位的员工;常规中等技能员工包括职员(staff)类,主要从事不需要过高的创造力和创新性常规工作;非常规高技能员工包括科技人员(tech_R&D)、销售及市场人员(S&M)、综合管理人员(manager)和财务金融人员(finance)四类,主要从事非常规的、复杂性的、难以被人工智能替代的工作岗位的员工。"其他相关人员(others)"类别没有归入上述三类。

(3) 创新绩效

本文借鉴 Hagedoorn & Cloodt (2003)的观点,将创新绩效定义为企业的发明创造的最终成果。参考楼润平等人(2022)、Kleis et al(2012)、黎文靖和郑曼妮(2016)的做法,采用制造业上市公司当年专利申请数量来衡量企业创新绩效。

(4) 控制变量

本文参考王永钦和董雯(2020)、赵烁等人(2020)、张远与李焕杰(2022)的研究, 选取企业和区域两个层面的控制变量: (1)企业层面的控制变量包括:企业规模,企业存续年 限,负债水平、总资产收益率、股权集中度、企业所有权属性; (2)区域层面的控制变量为: 产业结构、经济发展水平、人口密度。主要变量定义及测量汇总为表 2。

变量类型	变量符号	变量定义
被解释变量	Patent	创新绩效,LN(1+当年发明专利申请量)
解释变量	AI	人工智能应用水平,熵权法综合测定
	Emp	劳动力数量的自然对数
	Emp_l	常规低技能劳动力数量占比
中介	Emp_m	常规中等技能劳动力占比
变量	Emp_h	非常规高技能劳动力数量占比
	Undergraduate_l	本科及以上学历人数占比(稳健性检验)
	Undergraduate_h	本科以下学历人数占比(稳健性检验)
	Ln_size	企业规模, Ln(总资产)
	Ln_age	企业存续年限, Ln(当期年份-企业成立年份)
	Lev	负债水平,企业总负债/总资产
t六年1	Roa	总资产收益率,息税前利润/总资产
<u></u> 空 问 本	Shrcr	股权集中度,用公司第一大股东持股占比来表示
又里	Soe	企业所有权属性,国有企业为1,非国有企业为0
	Indus	产业结构, 第二产业增加值/城市国内生产总值
	Ln_pgdp	经济发展水平,Ln(城市的人均国内生产总值)
	Ln_popu	人口密度, Ln(城市人口数量)

表 2: 主要变量定义及测量汇总表



3. 描述性统计

从变量描述统计数据表 3 可以看到: 样本量为 20063 个; 创新绩效 (Patent) 变量的 均值 3.312,标准差是 1.536,最小值为 0.000,最大值为 7.161,表明中国上市制造企业创新绩 效偏低,且差异较大;人工智能应用水平 (AI) 变量的均值是 0.064,标准差是 0.077,最小值 为 0.000,最大值为 0.682,说明上市公司的智能化平均水平相对较低,而且智能化水平存在较 大差异;中介变量劳动力结构转换,员工数量 (Emp) 变量的均值是 7.660,标准差是 1.145, 最小值为 5.209,最大值为 10.842,说明样本中上市公司的员工数量也存在比较大的差异。企业 性质 (Soe)企业性质,均值为 0.237,表明样本中非国有企业占比较大。从控制变量的整体描 述性结果可以看出,各个控制变量的相对稳定中包含差异化,这也反映出本文选取的样本较为 合理,能够反映制造业中不同类型企业的情况,并且没有受到极端值的影响,从而使得研究具 有代表性。

表	3:	描述性统计	

变量	样本量	均值	标准差	最小值	中位数	最大值
Patent	20063	3.312	1.536	0.000	3.367	7.161
AI	20063	0.064	0.077	0.000	0.036	0.682
Emp	20063	7.660	1.145	5.209	7.567	10.842
Emp_l	20063	0.533	0.206	0.000	0.573	0.880
Emp_M	20063	0.105	0.066	0.000	0.097	0.322
Emp_h	20063	0.343	0.190	0.066	0.294	0.883
Ln_size	20063	22.061	1.163	20.011	21.899	25.675
Ln_age	20063	2.872	0.322	1.946	2.890	3.497
Lev	20063	0.383	0.189	0.055	0.373	0.856
Roa	20063	0.056	0.066	-0.208	0.054	0.243
Shrcr	20063	0.331	0.140	0.088	0.309	0.716
Soe	20063	0.237	0.425	0.000	0.000	1.000
Indus	20063	0.408	0.100	0.162	0.413	0.615
Ln_pgdp	20063	11.428	0.507	10.170	11.530	12.220
Ln_popu	20063	6.434	0.832	4.395	6.576	7.765

4. 直接效应检验

经过 Hausman 检验,本文确定采用 OLS 回归和固定效应模型进行分析。

表 4 第 (1) 列报告了人工智能应用对企业创新绩效的影响结果。在控制了企业及区 域层面的控制变量之后,列(1)的结果显示,人工智能应用(AI)的估计系数为 0.699,且在 1% 的水平上显著,这说明制造业企业人工智能应用能够显著提升企业创新绩效。假设 H1 成立。

表 4 第(2)、(3)、(4)、(5)列报告了人工智能应用对企业劳动力结构的影响结果。列(2)的结果显示,人工智能应用(AI)对劳动力数量(Emp)的估计系数为 0.591,



且在 1%的水平上显著,说明人工智能应用与劳动力数量呈现同方向变动;列(3)的结果显示, 人工智能应用 (AI) 对常规低技能劳动力 (Emp_1) 的影响系数为-0.090,且在 1%的水平上显 著,说明人工智能应用会减少对低技能劳动力的雇佣;列(4)的结果显示,人工智能应用 (AI) 对常规中等技能劳动力 (Emp_m) 的影响系数为-0.006,未通过显著性检验,说明人工智能应 用对常规中等技能劳动力呈现负向不显著影响;列(5)的结果显示,人工智能应用 (AI) 对非常 规高技能劳动力 (Emp_h) 的影响系数为 0.095,且在 1%的水平上显著,说明人工智能应用会 增加对非常规高技能劳动力的雇佣。以上结果说明,人工智能应用会增加企业劳动力的雇佣数 量,减少对常规低技能劳动力的雇佣比例,增加对非常规高技能劳动力的雇佣比例,对常规中 等技能劳动力影响波动性较小,使劳动力结构发生转换。假设 H2 成立。

	(1)	(2)	(3)	(4)	(5)
变量	Patent	Emp	Emp_l	Emp_M	Emp_h
AI	0.699***	0.591***	-0.090***	-0.006	0.095***
	(4.829)	(12.358)	(-5.590)	(-0.731)	(6.651)
Ln_size	0.595***	0.669***	0.016***	-0.006***	-0.007***
	(34.348)	(116.667)	(8.350)	(-6.379)	(-4.201)
Ln_age	-0.069	0.408***	0.005	0.023***	-0.053***
	(-0.557)	(9.949)	(0.368)	(3.214)	(-4.365)
Lev	-0.204***	0.274***	0.022***	0.010***	-0.047***
	(-3.083)	(12.547)	(3.023)	(2.670)	(-7.203)
Roa	0.211*	-0.022	0.075***	-0.028***	-0.038***
	(1.810)	(-0.576)	(5.779)	(-4.108)	(-3.258)
Shrcr	0.268**	0.215***	-0.015	-0.022***	0.028**
	(2.396)	(5.806)	(-1.244)	(-3.334)	(2.546)
Soe	-0.038	-0.005	-0.004	0.011***	-0.008*
	(-0.911)	(-0.379)	(-0.869)	(4.406)	(-1.937)
Indus	0.122	-0.168**	-0.063***	0.020	0.070***
	(0.592)	(-2.459)	(-2.763)	(1.642)	(3.433)
Ln_pgdp	-0.075	-0.032*	-0.022***	0.000	0.019***
	(-1.438)	(-1.894)	(-3.844)	(0.100)	(3.693)
Ln_popu	-1.496***	-0.355***	0.019	-0.069***	-0.001
	(-4.621)	(-3.311)	(0.533)	(-3.603)	(-0.037)
_cons	0.343	-5.468***	0.348	0.592***	0.410*
	(0.151)	(-7.263)	(1.378)	(4.423)	(1.823)
Firm FE&Year FE	Yes	Yes	Yes	Yes	Yes
N	20063	20063	20063	20063	20063
R2	0.248	0.565	0.018	0.058	0.020

表 4: 直接效用回归结果

注: 括号内为t统计量,*、**、***分别表示在10%、5%、1%的水平下显著,下同。

5. 中介效应检验

表 5 为中介效应检验结果。列(1)中人工智能应用(AI)与非常规高技能劳动力占比(Emp_h)的估计系数为 0.095,且在 1%的水平上显著,说明人工智能应用会带来高技能劳动力的占比增加;列(2)中非常规高技能劳动力数量占比(Emp_h)对创新绩效(Patent)的估计系数为 0.164,且在 5%的水平上显著,人工智能应用的估计系数为 0.683,相对于基础回归模



型的回归系数 0.699 略有下降,但依然在 1%的水平上显著,说明非常规高技能劳动力数量占比 起到部分中介作用。假设 H3 成立。

	(1)	(2)
变量	Emp_h	Patent
AI	0.095***	0.683***
	(6.651)	(4.716)
Emp_h		0.164**
		(2.100)
控制变量	控制	控制
_cons	0.410^{*}	0.276
	(1.823)	(0.121)
Firm FE&Year FE	Yes	Yes
N	20063	20063
R^2	0.020	0.248

表 5: 中介效应检验结果

6. 稳健性检验

本文构造了与劳动力受教育水平相关的变量来衡量劳动力结构作为稳健性检验的替 换变量。本文参考赵烁等人(2020)的做法,将本科及以上的员工视为非常规高技能劳动力,本 科以下学历员工视为常规低技能劳动力。用于检验人工智能对于劳动力结构转换的影响稳定性。 员工学历数据通过 Wind 数据库取得。

表 6 第 (2) 和 (3) 列报告了人工智能应用对以学历水平测度的企业劳动力结构的 影响结果。列(2)的结果显示,人工智能应用 (AI) 对非常规高技能劳动力 (Undergraduate_h) 的影响系数为 0.090,且在 1%的水平上显著,表明人工智能应用会增加对高技能劳动力的雇佣 占比;列(3)的结果显示,人工智能应用 (AI) 对常规低技能劳动力 (Undergraduate_l) 的影响 系数为-0.090,且在 1%的水平上显著,说明人工智能应用会减少对低技能劳动力的雇佣占比。 研究结论与前文验证结果一致。

表 6 第(4)列为中介效应检验结果。列(1)中人工智能应用(AI)与创新绩效(Patent)的估计系数为 0.699,且在 1%的水平上显著,说明人工智能应用与创新绩效呈现同方向显著变化;列(2)中人工智能应用(AI)与非常规高技能劳动力数量占比(Undergraduate_h)的估计系数为 0.090,且在 1%的水平上显著,列(4)中非常规高技能劳动力数量占比(Undergraduate_h)对创新绩效(Patent)的估计系数为 0.427,且在 1%的水平上显著,人工智能应用的估计系数为 0.660,相对于基础回归模型的回归系数 0.699 略有下降,但依然在 1%的水平上显著,说明非常规高技能劳动力数量占比起到部分中介作用,即劳动力结构转换在人工智能应用对制造业企业创新绩效的影响中起到中介作用。研究结论与前文验证结果一致。



	(1)	(2)	(3)	(4)
变量	Patent	Undergraduate_h	Undergraduate_l	Patent
AI	0.699***	0.090^{***}	-0.090***	0.660***
	(4.829)	(7.883)	(-7.883)	(4.558)
Undergraduate_h				0.427^{***}
				(4.357)
控制变量	控制	控制	控制	控制
_cons	0.343	0.107	0.893***	0.297
	(0.151)	(0.596)	(4.995)	(0.131)
Firm FE &Year FE	Yes	Yes	Yes	Yes
N	20063	20063	20063	20063
R^2	0.248	0.139	0.139	0.249

表 6: 稳健性检验——替换变量:直接效应与中介效应检验

讨论

本文利用 2013—2022 年 A 股制造业上市公司面板数据,从微观企业层面探讨了人工智 能应用与劳动力结构转换对企业创新绩效影响。通过实证分析结果可以看出,人工智能不仅直 接提升企业创新表现,还间接通过优化劳动力结构来加强其创新效果。这为理解人工智能如何 影响企业运营与人力资源管理提供了新的视角,同时也对制造业企业有效利用人工智能技术以 实现更高的创新绩效有一定的借鉴意义。

总结与建议

通过实证检验,本文得到如下结论:

(1)人工智能应用对企业创新绩效存在显著正向影响,人工智能应用水平越高企业创新绩效效果越好。

(2)人工智能应用能显著提升内部员工的雇佣数量,显著减少常规低技能劳动力的雇佣占比,显著提升非常规高技能劳动力的雇佣占比,对常规中等技能劳动力影响波动性较小, 促使劳动力结构发生变化。稳健性检验通过替换变量发现,人工智能应用能显著提升本科及以 上员工的雇佣占比,显著减少本科以下员工的雇佣占比。

(3)人工智能应用通过实现劳动力结构转换,进而促进企业创新绩效的增长,劳动力 结构转换在人工智能应用对企业创新绩效的影响着起着中介作用。

基于本文研究结论,得出以下研究建议:

第一,制造业企业应积极推进人工智能的运用,促进制造业高质量发展,增强创新能力。 创新是企业可持续发展的关键力量,没有创新,企业就会失去长期市场竞争力。人工智能应用 可以实现生产过程的智能化管理,提高企业生产效率和产品质量(胡德状,2020),如果企业 仅仅满足于眼前的运营模式,在智能化浪潮的推动下,企业将会失去可持续发展的能力。制造 企业要实现可持续发展就要加大企业智能化转型,在智能化投资和智能化应用上加大投入力度, 优化资源配置,为人工智能发挥创新优势奠定基础。



第二,制造企业智能化推进的过程中要着重优化劳动力结构,加大人力资本的投入。制造企业运用人工智能会减少常规低技能员工的就业岗位,而对非常规高技能人才产生较大的需求,企业必需重新规划其人才架构,以满足智能技术背景下的人才需求。

第三,政府需要构建一个完善的就业培训和职业教育体系,并实施高等教育改革,以减 缓智能化对就业造成的冲击。智能技术的推进是不可逆转的潮流,智能化转型是中国制造业结 构调整的破局点,中国也加紧在智能制造方面进行战略布局,但是这一趋势要与人才的培养相 匹配。这需要政府从宏观层面对教育的知识体系进行优化,要建立多层次的职业教育体系,扶 持和优化职业培训、职业学院、大学等教育机构的课程设置,引导部分教育资源向人工智能及 相关交叉学科倾斜,确保教育内容与时俱进,与产业发展相适应。

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