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BEYOND HAIR LOSS: EXPLORING THE EVOLUTION OF ANDROGENETIC ALOPECIA RESEARCH BASED ON TEXT MINING AND BIBLIOMETRICS

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Abstract: In this study, word dynamics, co-occurring phrases, and keyword frequency in the area of androgenetic alopecia were thoroughly analysed during a ten-year period. The study tracks changes in word usage, frequency, and context and identifies variations in the distribution and usage patterns of keywords, subjects, and co-occurring phrases using natural language processing techniques and graph theory-based approaches. The research reveals hidden linkages and patterns between diverse ideas, shedding light on the co-occurrence patterns of numerous phrases in the literature on androgenetic alopecia. The study emphasises the value of clearly visualising and disseminating findings to a large audience. In order to communicate the findings of the 10-year trend analysis to patrons, legislatures, and other pertinent audiences, data visualisation tools, infographics, and reports are used. This makes sure that the results are useful, effective, and easily accessible so that they can guide the creation of policies and decisions pertaining to androgenetic alopecia. The results of this study may have substantial ramifications for academics, medical professionals, policymakers, and other industry participants. The research can lead future research paths, prioritise research areas, and suggest areas that require additional examination by highlighting key research challenges and pointing out gaps in the study of androgenetic alopecia. Identifying emergent study issues, analysing the changing patterns in the area, and establishing research strategies can all benefit from an analysis of word dynamics and correlations among terms. The results reveal hidden relationships and patterns, advance knowledge of the research environment in this area, and influence androgenetic alopecia research objectives and policies.

Keywords: Hair loss; Androgenetic alopecia; Bibliometric; Text citation; Data visualizations

1 INTRODUCTION

Male pattern baldness, also known as androgenetic alopecia, is a prevalent disorder marked by hair loss that follows a particular pattern, usually beginning at the hairline and crown of the scalp. Men and women are also affected, albeit men are more likely to experience it [1]. A hormone termed dihydrotestosterone (DHT), an androgen hormone, is thought to have a major role in the development of androgenic alopecia [2].

On the other side, bibliometrics is the quantitative examination of scholarly works, such as journals, articles, and citations, in order to identify patterns and trends in scientific inquiry. Bibliometrics can shed light on a researcher's publishing output, influence, and patterns of collaboration in addition to the development of their study topics over time [3]. In order to comprehend the research landscape, identify relevant research areas, and monitor research trends, there has been an increase in interest in studying androgenic alopecia in recent years [1]. Such an analysis can point out regions of high effect, identify research gaps, and suggest future research initiatives in the area of androgenic alopecia.

Text mining in bibliometrics involves the automated extraction and analysis of data from text-based sources, such as scholarly articles, to uncover patterns and trends. Recent studies have utilized text mining techniques to analyze research on alopecia, a common hair loss condition, to identify research trends, influential publications, and research gaps, providing valuable insights for further research and clinical practice [4].

Using bibliometrics and trend analysis, this report seeks to give a broad picture of the state of androgenic alopecia research today [5]. The tries to review the body of knowledge on androgenic alopecia, emphasise important areas for future research, and go over the methods and conclusions of current bibliometric studies [6]. Using bibliometric techniques also highlight new trends and research gaps in the area and offer suggestions for further investigations. This work intends to contribute to a better understanding of the research landscape in this area and offer insights for academics, clinicians involved in androgenic alopecia research and management by analysing the bibliometric trends in research on androgenic alopecia [3, 7].

2 LITERATURE REVIEW

A useful tool for evaluating research trends and determining key publications in a certain topic is bibliometric analysis. Numerous studies have examined the scientific literature and the state of the research landscape using bibliometric methodologies.

Bai et al. performed a bibliometric analysis on research related to myocardial ischemia/reperfusion injury from 2012 to 2021[8]. They employed bibliometric techniques, including keyword co-occurrence and citation analysis, to identify

research trends and influential publications in this field. Their results highlighted the most productive countries, institutions, and journals, as well as key research topics and research trends, providing insights into the research landscape of myocardial ischemia/reperfusion injury.

Du and Hou conducted a hotspots analysis and provided perspectives on Prussian Blue Analogues (PBAs) in the field of environment and energy research [9]. They utilized the CiteSpace tool to identify research hotspots, key authors, and research trends in the field of PBAs. Their findings revealed the emerging research areas, influential publications, and research collaborations related to PBAs, providing insights into the current research landscape and potential future research directions.

Lei et al. conducted a bibliometric analysis of the top 50 most influential articles on external ventricular drains, as published in the World Neurosurgery journal [10]. External ventricular drains are widely used in neurosurgical practice to manage intracranial pressure in patients with various neurologic conditions. Lei et al. identified and analyzed these top 50 articles based on citation counts, publication years, authors, countries, and journals. The authors found that these influential articles were published between 1951 and 2019, with the majority of them published in the past two decades. The United States and Canada were the most productive countries in terms of published articles, and the most prolific authors and institutions were also identified. Furthermore, the study revealed the journals that published the most influential articles, highlighting the significance of specific journals in the field of neurosurgery.

This bibliometric analysis by Lei et al. provides valuable insights into the historical and geographical trends in the literature on external ventricular drains. By identifying the most influential articles, authors, institutions, and journals, this study sheds light on the key contributors and publications that have shaped the field of neurosurgery in this particular area. The findings of this study may be useful for researchers, clinicians, and policymakers to understand the current state of the literature and to identify important research directions in the field of external ventricular drains.

In a different field of research, Nabgan et al. conducted a bibliometric analysis of the application of non-precious materials for the pyrolysis reaction of plastic waste, as published in the Arabian Journal of Chemistry [11]. Pyrolysis is a thermochemical process that can convert plastic waste into valuable products, such as fuels and chemicals, and non-precious materials are catalysts used in pyrolysis reactions. The authors analyzed the publications on this topic based on citation counts, publication years, authors, countries, and keywords. The study revealed the trends in research on non-precious materials for plastic waste pyrolysis, including the evolution of research interests over time, the most influential authors and institutions, and the most commonly used keywords in the literature.

This bibliometric analysis by Nabgan et al. provides a comprehensive overview of the research landscape on non-precious materials for plastic waste pyrolysis. By identifying the key trends, authors, institutions, and keywords, this study offers insights into the current state of the research in this field and can serve as a useful reference for researchers and practitioners interested in plastic waste management and circular economy.

Hou et al. conducted a knowledge-map analysis of percutaneous nephrolithotomy (PNL) for urolithiasis, as published in the Urolithiasis journal [12]. PNL is a minimally invasive surgical procedure used to remove kidney stones and has become a common treatment option for urolithiasis. The authors used bibliometric analysis to analyze the knowledge map of PNL research, including the co-occurrence of keywords, authors, institutions, and countries in the publications. The study revealed the research hotspots, knowledge trends, and collaborations in the field of PNL. The authors also identified the most influential authors, institutions, and countries in this area of research, providing insights into the global landscape of PNL research.

This knowledge-map analysis by Hou et al. provides a comprehensive overview of the research landscape of PNL for urolithiasis. By identifying the research hotspots and trends, as well as the key contributors and collaborations, this study offers valuable insights into the current state of the literature and can help researchers and clinicians to identify important research directions in the field of PNL.

In a different field of medicine, Kirubalingam et al. conducted a bibliometric analysis of trends in otolaryngology publications, specifically focusing on articles published in the Journal of Otolaryngology - Head & Neck Surgery [7]. Otolaryngology is a medical specialty that deals with the diagnosis and treatment of conditions related to the ears, nose, throat, and neck. The authors analyzed the publications in this journal over a 9-year period to identify the publication trends, including the publication volume, authorship patterns, research topics, and citation trends. The study revealed the most productive countries, institutions, and authors in the field of otolaryngology research, as well as the most frequently cited articles and research topics.

This bibliometric analysis by Kirubalingam et al. provides valuable insights into the publication trends and research topics in the field of otolaryngology. By analyzing the publication volume, authorship patterns, and citation trends, this study highlights the key contributors and research directions in the field, providing a comprehensive overview of the literature published in a specific otolaryngology journal.

3 OBJECTIVES

1. In research on androgenetic alopecia, analyse word dynamics year-by-year to spot variations in word usage, frequency, and context over a ten-year period.
2. Create networks of co-occurring terms and keywords in the study of androgenetic alopecia, then analyse the network's features to find hidden correlations and patterns.
3. Through the analysis of keyword, topic, and co-occurring terms for frequency and distribution, it is possible to pinpoint important research issues and gaps in the study of androgenetic alopecia.

- Spread the results of the 10-year trend study to a large audience, including stakeholders and policymakers, by effectively visualising and communicating findings using data visualisation tools, infographics, and reports.

4 METHODOLOGY

R programming is used to get pertinent data from PubMed databases. In order to find scholarly publications, this may include conducting a database search. R programming is used to clean and pre-process the collected data as necessary. A number of procedures are included in the bibliometric analysis utilising R programming (version-4.3.0) and biblioshiny packages.

To conduct bibliometric analysis on the gathered data using biblioshiny, an R programme for bibliometric visualisation and statically analysis. To investigate the connections and trends in the data, interpret the results of the bibliometric study and derive important conclusions from the information. Validating the findings of bibliometric analysis by utilizing appropriate statistical techniques.

The search criteria for the bibliometric study were "androgenetic alopecia" in the title or abstract, "English" as the language of publishing, "journal article" as the form of publication, and publications released between January 1, 2013, and December 31, 2022. By doing this, it was made sure that the analysis was limited to recently published, excellent, peer-reviewed studies on androgenetic alopecia. These criteria were used in the analysis to capture pertinent papers and trends in the area, and to provide a thorough overview of the scholarly literature on androgenetic alopecia.

For example: "androgenetic alopecia"[Title/Abstract] AND "english"[Language] AND "journal article"[Publication Type] AND 2013/01/01:2022/12/31[Date - Publication]

5 DATA ANALYSIS AND INTERPRETATION

From Table 1 & Figure 1, the data used for this analysis spans the years 2013 through 2022 and consists of 1107 documents from 313 sources, including books and periodicals. The average age of the documents is 4.62 years, and the annual growth rate is 8.27%. The documents' content lists 1889 Author's Keywords and 1282 Keywords Plus, which represent the keywords that writers chose to characterise their research. The records list a total of 4057 writers, with 53 entries having just one author. With an average of 5.27 co-authors per document is observed.

Table 1 Study main information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2013:2022
Sources (Journals, Books, etc)	313
Documents	1107
Annual Growth Rate %	8.27
Document Average Age	4.62
Average citations per doc	0
References	1
DOCUMENT CONTENTS	
Keywords Plus (ID)	1282
Author's Keywords (DE)	1889
AUTHORS	
Authors	4057
Authors of single-authored docs	53
AUTHORS COLLABORATION	
Single-authored docs	67
Co-Authors per Doc	5.27
International co-authorships %	0
DOCUMENT TYPES	
biography	1
case reports	14
clinical study	1
clinical trial	14
clinical trial, phase i	1
clinical trial, phase iii	2
clinical trial, phase iv	1

comparative study	24
controlled clinical trial	2
dataset	1
evaluation study	2
guideline	1
journal article	1029
meta-analysis	2
multicenter study	3
observational study	1
randomized controlled trial	3
review	3
systematic review	2

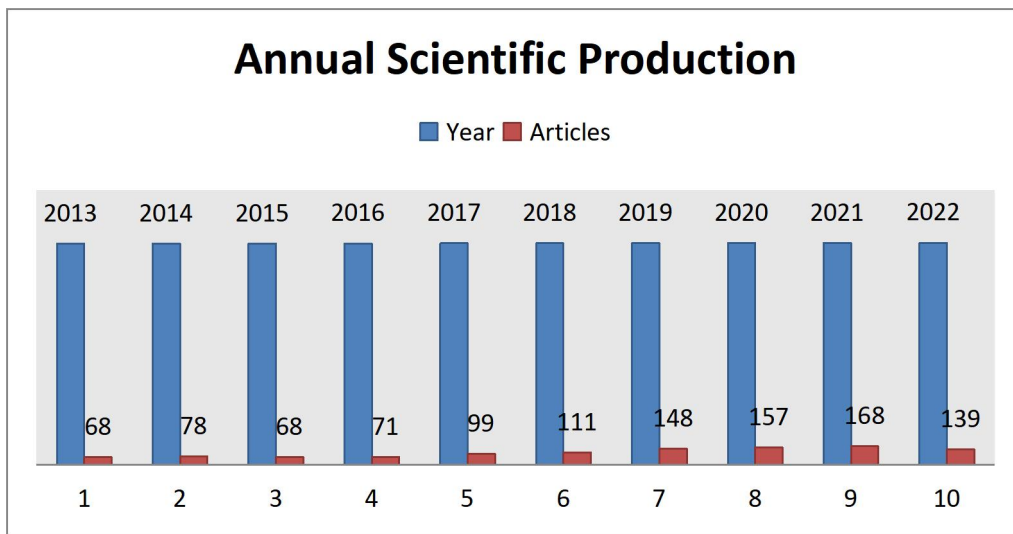


Figure 1 Annual Scientific Productions

A constructive trend is indicated by an increase in the number of papers published from 68 to 78 between 2013 and 2014. Only 68 papers were published in 2015, a sign of a plateau or a little decline. A slight growing trend was evident in 2016 with a small increase to 71 articles. The most notable growth occurred from 2016 and 2017, when there were an additional 99 articles, indicating a significant growth trend. 111 articles were published in 2018, continuing the trend of upward growth.

5.1 Words Mining

A bibliometric analysis that examined the presence and frequency of certain phrases connected to hair loss and treatment outcomes appear to have produced the list of words that is supplied below. A quantitative research technique called bibliometric examines patterns and trends in published literature by looking at word usage and frequency. As shown in Figure 2.



Figure 2 Top ten most frequently used words

In this instance, the study most likely involved the evaluation of a sizable corpus of scientific literature, including articles, research papers, or other pertinent works on the subject of alopecia and hair loss. The words on the list are those that appear the most frequently in the literature, showing their relative prominence and significance in the area. The usage of the word "humans" suggests that the study's main focus was on studies involving people as opposed to animals or other living things. In relation to the subject of hair loss, the phrases "alopecia," "male," "female," "adult," "hair," "middle-aged," "treatment outcome," "hair follicle," and "minoxidil" are all used. "Alopecia" is a medical term for hair loss, and "minoxidil" is a common medicine used to treat hair loss. These phrases appear frequently in the bibliometric study, indicating that they are frequently used and might have an impact on alopecia research. According to reported treatment outcomes, the study may have sought to uncover trends, patterns, and correlations between these terms, such as the prevalence of hair loss in various age groups (e.g., adults, middle-aged people), or the efficacy of therapies (e.g., minoxidil). The study probably sought to offer insights into the alopecia and hair loss research landscape based on the frequency of particular words used in pertinent literature, which can aid researchers in better understanding the current state of research in the field and identify areas for additional investigation.

5.2 Dynamically Words Moving

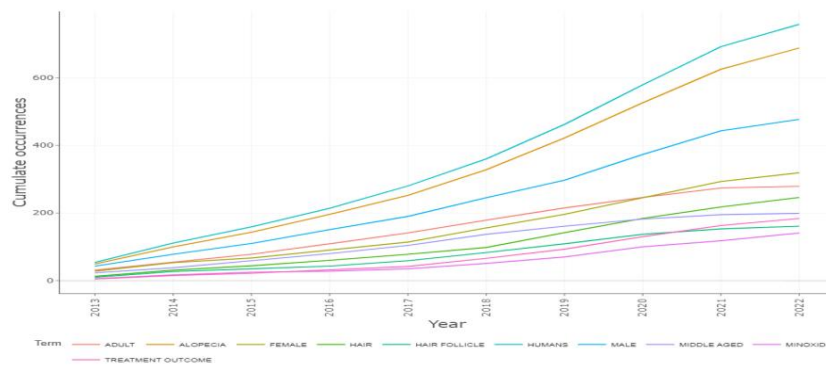


Figure 3 Top ten most frequently used words

From 54 in 2013 to 758 in 2022, the human appears to have grown steadily, which may reflect a growing research or rising interest (Figure 3). The prevalence of alopecia may be rising, or there may be more attention being paid to this condition in relation to source clustering or author productivity, as seen by the general higher trend in alopecia instances, which increased from 49 in 2013 to 688 in 2022.

Both genders (Male and Female) may be relevant to the subject of source as evidenced by the increasing trend in both the number of men and women over time.

Adults and people in their middle aged are becoming more predominant, which suggests that they could have a big impact on author productivity. The patterns in the variables relating to hair, hair follicles, and minoxidil consumption over time indicate probable changes in the particular characteristics author output under reflection. The statistics on treatment outcomes fluctuate with time, which could be a sign of changes in treatment efficiency or results in terms of bibliometric analysis.

5.3 Topic Trend

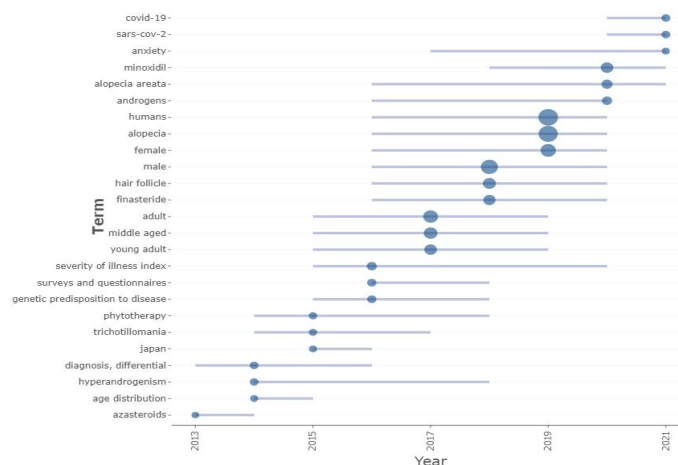


Figure 4 Top ten most frequently used words

The data from Figure 4 interpretations provide details on a range of issue trends and occurrences. "Azasteroids" frequently appears between 2013 and 2014, whilst "Diagnosis, differential" gradually increases from 2013 to 2016. While "Hyperandrogenism" was frequently noticed between 2014 and 2018, "Phytotherapy" exhibited an upward trend during that same time. The term "severity of illness index" is most frequently used and shows an upward trend between 2015 and 2020.

It has changed throughout time how frequently "Surveys and questionnaires" and "Genetic predisposition to disease" are conducted. Between 2015 and 2019, the terms "adult," "middle-aged," and "young adult" are used regularly. The prevalence of "Male," "Hair follicle," "Finasteride," "Humans," "Alopecia," and "Female" fluctuates between 2016 and 2020. There are some variations in "Minoxidil" and "Alopecia areata" occurrence between 2018 and 2021.

This bibliometric analysis can also give a more comprehensive picture of the demographics and traits of the research population, including the age categories ("Adult," "Middle aged," "Young adult"), gender ("Male," "Female"), and interventions or therapies ("Finasteride," "Minoxidil") under study. This knowledge can help drive future research efforts, point out prospective intervention areas, and help develop healthcare plans that are tailored to the needs of particular groups. Moreover, by spotting patterns, trends, and evolving research interests in a particular area throughout time, analysis might increase our understanding of science. This data can act as the basis for developing hypotheses and conducting more research projects. By giving representatives, monitoring organizations, and funding organisations data-driven insights, the analysis can also support evidence-based decision making and policy adjustments. In accordance with the discovered research trends and interests, it can aid in determining research priorities, allocating resources, and forming plans and procedures. This bibliometric study offers several advantages, including insight generation, decision-making support, scientific knowledge advancement, and future research direction guidance in the area of interest.

5.4 Co-Occurrence Network

In a term co-occurrence network for bibliometrics, this looks to be a table or list of nodes (keywords or terms), together with the accompanying cluster assignments, betweenness centrality, closeness centrality, and PageRank values. There are multiple columns in the Table 2.

Node, the specific term or keyword in the co-occurrence network is defined. The cluster assignment of the term or keyword in the network denote as cluster here. Closeness, the closeness centrality value, which is a measure of how closely connected a term or keyword is to other terms or keywords in the network.

PageRank, the PageRank value, which is a portion of the importance or centrality of a term or keyword in the network based on the concept of random steps. These values are used to analyse and assess the centrality and importance of each term or keyword in the term co-occurrence network, which can provide insights into the relationships and patterns among the terms or keywords in the bibliometric data. The betweenness centrality score is an indicator of the frequency with which a term or keyword acts as a link along the shortest route between other terms or keywords in the network.

Table 2 Co-occurrence Network

Node	Cluster	Betweenness	Closeness	PageRank
hair follicle	1	6.925224395	0.018867925	0.02699581
animals	1	1.410036578	0.013888889	0.01325049
androgens	1	0.32146174	0.014492754	0.00849303
receptors, androgen	1	0.837521177	0.014705882	0.00925615
mice	1	0.16043895	0.012658228	0.00792028
skin	1	0.095313228	0.013333333	0.00619316
signal transduction	1	0.066611381	0.012987013	0.00602147
testosterone	1	0.078133684	0.012987013	0.00604422
dihydrotestosterone	1	0.097959345	0.013333333	0.00622343
cells, cultured	1	0.038909514	0.0125	0.00570192
humans	2	143.9319161	0.020408163	0.10884467
alopecia	2	121.1504869	0.020408163	0.10345088
male	2	63.82704915	0.020408163	0.08013735
female	2	27.75294547	0.020408163	0.05578458
adult	2	24.75950655	0.019607843	0.05622055
hair	2	12.85828733	0.019230769	0.04282205
middle aged	2	12.58270049	0.019230769	0.04221905
treatment outcome	2	5.113842217	0.017241379	0.03480038
young adult	2	6.954564656	0.019230769	0.03225043
scalp	2	2.869777884	0.017857143	0.02265387

platelet-rich plasma	2	0.419883381	0.014705882	0.01536381
adolescent	2	1.76164219	0.017241379	0.0176065
alopecia areata	2	0.314576852	0.014705882	0.01176566
aged	2	0.776955036	0.017241379	0.01506513
retrospective studies	2	0.34847566	0.015151515	0.01250569
prospective studies	2	0.53903331	0.015625	0.01243293
double-blind method	2	0.288976887	0.014492754	0.01292548
cross-sectional studies	2	0.191774032	0.01369863	0.00993342
low-level light therapy	2	0.073350773	0.013888889	0.00942113
severity of illness index	2	0.266846533	0.014492754	0.01059755
case-control studies	2	0.271474824	0.014084507	0.00956639
quality of life	2	0.042247201	0.013513514	0.00794242
dermoscopy	2	0.048895505	0.013513514	0.00839554
risk factors	2	0.094294702	0.013157895	0.00750583
pilot projects	2	0.021974818	0.012820513	0.00730828
biomarkers	2	0.071996569	0.012987013	0.00621636
acne vulgaris	2	0.032020319	0.012820513	0.00567652
child	2	0.01629215	0.012987013	0.00671502
genetic predisposition to disease	2	0.016074546	0.012345679	0.00584621
surveys and questionnaires	2	0.031211271	0.012820513	0.00644629
combined modality therapy	2	0.023301298	0.013333333	0.00696905
photography	2	0.05070329	0.01369863	0.00736248
minoxidil	3	3.612124447	0.01754386	0.02622392
finasteride	3	3.642270672	0.017857143	0.02244875
5-alpha reductase inhibitors	3	1.872341575	0.017241379	0.01651948
administration, topical	3	1.042701011	0.016129032	0.0153487
dutasteride	3	0.091581807	0.013333333	0.00855244
vasodilator agents	3	0.063573716	0.013888889	0.00810898
administration, cutaneous	3	0.108989247	0.013513514	0.00705877
administration, oral	3	0.031729606	0.01369863	0.00688749

For various nodes and clusters, the table gives numerical values for each of these measurements. Depending on the precise context and study subject under investigation, these data will need to be interpreted. However, a few broad conclusions that may be drawn from the data are as follows:

In comparison to cluster 2, cluster 1 has lower values for betweenness, proximity, and PageRank, indicating that its nodes may be less central or significant in the network.

When compared to other nodes in cluster 1, several nodes, including hair follicles, animals, and androgens, have greater values for betweenness, proximity, and PageRank, indicating that they may be more central or significant within cluster 1.

Nodes in cluster 2 exhibit substantially higher values for betweenness, proximity, and PageRank compared to nodes in cluster 1, suggesting that these nodes may be more central or significant in the entire network. These nodes include humans, alopecia, male, female, and adult. Humans, alopecia, and middle-aged nodes, for example, have relatively high scores for betweenness, proximity, and PageRank, indicating that they may be important nodes in the network. Other variables in the data, such as treatment outcome, sickness severity index, and risk factors, may be important for comprehending the subject of the research. As shown in Figure 5.

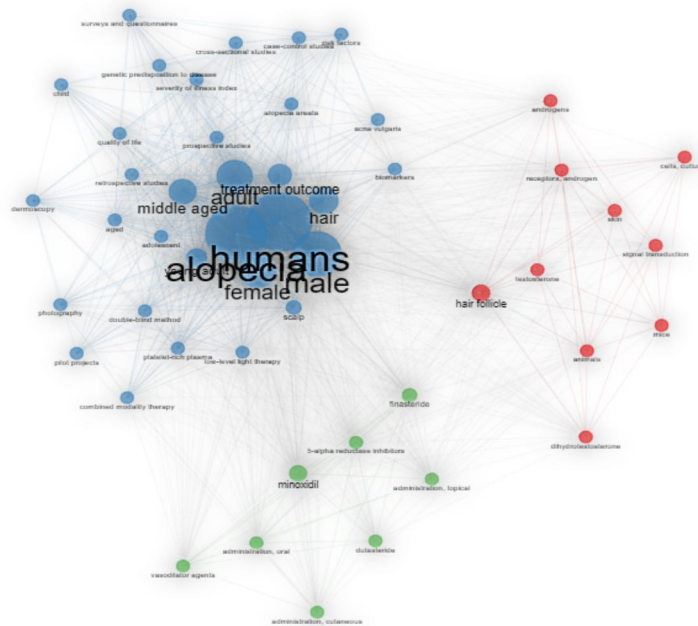


Figure 5 Co-occurrence Network

6 CONCLUSIONS

Ultimately, during a ten-year period, the examination of androgenetic alopecia studies using bibliometric and word mining approaches yielded insightful results. Researchers have been able to make inferences about the evolution of research trends and goals in this field by tracking changes in word usage, frequency, and context across time. The construction of networks of co-occurring terms and keywords has allowed researchers to uncover hidden connections and patterns that relate study themes and concepts together in new ways.

Additionally, the identification of significant research topics and prospective gaps in the study of androgenetic alopecia has been made possible by the analysis of keyword, topic, and co-occurring phrases for frequency and distribution. Researchers and decision-makers can use this data to identify areas that need further research and development, which can guide future research priorities and money allocation.

The 10-year trend study's conclusions must also be successfully communicated to a wide audience, including decision-makers and stakeholders. Making use of infographics, reports, and data visualisation tools can help display the findings in a way that is both aesthetically pleasing and approachable, allowing for more widespread use and distribution of the results.

The application of word mining and bibliometric analyses in the study of androgenetic alopecia has provided valuable insights into research trends, correlations, and potential research gaps. These findings can contribute to advancing the understanding and treatment of androgenetic alopecia, and can inform future research and strategy judgements in this field. Effective communication of these findings to diverse applicants is essential for maximizing the impact and relevance of the research outcomes.

7 LIMITATIONS

It is crucial to recognise the limits of a 10-year trend analysis of androgenetic alopecia utilising word mining and bibliometric methods based on PubMed data. These might include a possible bias in the keyword selection process based on the terminology used in PubMed publications, a lack of coverage of research articles published elsewhere, and a potential omission of unpublished or unreviewed literature.

The reliability and accuracy of the data that was taken from PubMed may potentially have an effect on the results. When interpreting the conclusions based purely on PubMed data, care should be taken to keep them within the parameters of the PubMed database. To gain a more thorough understanding of the scientific landscape of androgenetic alopecia, complementary data sources and research methodologies may be required.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCE

- [1] Rondanelli, Mariangela, Simone Perna, Gabriella Peroni, and Davide Guido. A Bibliometric Study of Scientific Literature in Scopus on Botanicals for Treatment of Androgenetic Alopecia. *Journal of Cosmetic Dermatology*, 2016, 15(2): 120–30. <https://doi.org/10.1111/jocd.12198>
- [2] Ruksiriwanich, Warintorn, Chiranan Khantham, Anurak Muangsanguan, Chuda Chittasupho, Pornchai Rachtanapun, Kittisak Jantanasakulwong, Yuthana Phimolsiripol, et al. Phytochemical Constitution, Anti-Inflammation, Anti-Androgen, and Hair Growth-Promoting Potential of Shallot (*Allium Ascalonicum* L.) Extract. *Plants*, 2022, 11(11): 1499. <https://doi.org/10.3390/plants11111499>
- [3] Han, Guangtao, Ting Liu, and Pengde Kang. Bibliometric Analysis of Ewing Sarcoma from 1993 to 2022. *BMC Cancer*, 2023, 23(1): 272. <https://doi.org/10.1186/s12885-023-10723-7>
- [4] Han, Yu, Sara A. Wennersten, and Maggie P. Y. Lam. Working the Literature Harder: What Can Text Mining and Bibliometric Analysis Reveal?. *Expert Review of Proteomics*, 2019, 16(11–12): 871–73. <https://doi.org/10.1080/14789450.2019.1703678>
- [5] Xiao, Lifei. A Bibliometric Analysis of Global Research Status and Trends in Neuromodulation Techniques in the Treatment of Autism Spectrum Disorder. 2023.
- [6] Bragazzi, Nicola Luigi. Nanomedicine: Insights from a Bibliometrics-Based Analysis of Emerging Publishing and Research Trends. *Medicina*, 2019, 55(12): 785. <https://doi.org/10.3390/medicina55120785>
- [7] Kirubalingam, Keshinisuthan, Agnieszka Dzioba, Yvonne Chan, and M. Elise Graham. Trends in Otolaryngology Publications: A 9-Year Bibliometric Analysis of Articles Published in *Journal of Otolaryngology—Head and Neck Surgery*. *Journal of Otolaryngology - Head & Neck Surgery*, 2023, 52(1): 17. <https://doi.org/10.1186/s40463-022-00619-0>
- [8] Bai, Ming, Jingjing Zhang, De Chen, Mengying Lu, Junfen Li, Zheng Zhang, and Xiaowei Niu. Insights into Research on Myocardial Ischemia/Reperfusion Injury from 2012 to 2021: A Bibliometric Analysis. *European Journal of Medical Research*, 2023, 28(1): 17. <https://doi.org/10.1186/s40001-022-00967-7>
- [9] Du, Xiaohan, and Yongjiang Hou. Hotspots Analysis and Perspectives of Prussian Blue Analogues (PBAs) in Environment and Energy in Recent 20 Years by CiteSpace. *Environmental Science and Pollution Research*, 2022, 30(5): 11141–74. <https://doi.org/10.1007/s11356-022-24600-6>
- [10] Lei, Catherine, Frank A. De Stefano, Cody Heskett, Lane Fry, Kevin Le, Aaron Brake, Kevin Chatley, Jeremy Peterson, and Koji Ebersole. A Bibliometric Analysis of the Top 50 Most Influential Articles on External Ventricular Drains. *World Neurosurgery*, 2023, 172: 35–42. <https://doi.org/10.1016/j.wneu.2023.01.040>
- [11] Nabgan, Walid, M. Ikram, M. Alhassan, A.H.K. Owgi, Thuan Van Tran, L. Parashuram, A.H. Nordin, et al. Bibliometric Analysis and an Overview of the Application of the Non-Precious Materials for Pyrolysis Reaction of Plastic Waste. *Arabian Journal of Chemistry*, 2023, 16(6): 104717. <https://doi.org/10.1016/j.arabjc.2023.104717>
- [12] Hou, Junhui, Zongwei Lv, Yuan Wang, Xia Wang, Yibing Wang, and Kefeng Wang. Knowledge-Map Analysis of Percutaneous Nephrolithotomy (PNL) for Urolithiasis. *Urolithiasis*, 2023, 51(1): 34. <https://doi.org/10.1007/s00240-023-01406-w>

LIBERALIZATION OF SERVICE TRADE, DIGITAL ECONOMY AND THE INTEGRATION OF "M&P INDUSTRIES"

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Abstract: Based on the panel data of transnational industries from 2007 to 2014, this paper studies the impact of service trade liberalization on the integration of manufacturing and producer services (hereinafter referred to as the "M&P industries"), and studies the regulatory role of digital economy in it from both theoretical analysis and empirical test. The results show that the liberalization of service trade has a significant positive promoting effect on the integration of "M&P industries", which is enhanced by digital economy. This conclusion is still valid after a series of robustness tests such as instrumental variable method and alternative variable method. The results of heterogeneity analysis show that the liberalization of trade in warehousing and transportation services and financial and insurance services has a stronger positive promoting effect on the integration of the M&P industries. The digital economy plays a stronger positive moderating role in the liberalization of trade in wholesale and retail, information and communication, and financial and insurance services. The test of nonlinear regulating effect shows that the regulating effect of digital economy on the integration of "M&P industries" also has nonlinear characteristics. The higher the development level of digital economy, the stronger the marginal income of its positive regulating effect is, showing the feature of increasing marginal income.

Keywords: Producer services; Industrial integration; Opening up of the service sector; Digital economy; Regulatory effect

1 INTRODUCTION

China's economy has entered a new phase focused on promoting high-quality development, necessitating a transition from being a manufacturing giant to a manufacturing powerhouse. The 2014 "State Council's Guidance on Accelerating the Development of Producer Services to Promote Industrial Structure Adjustment and Upgrading" highlights that producer services, encompassing multiple sectors such as agriculture and industry, are characterized by strong specialization, active innovation, high industrial integration, and significant driving effects, making them strategic focal points in global industrial competition. Accelerating the innovative development of producer services and achieving organic integration of manufacturing and producer services at a higher level are crucial measures for structural adjustment and promoting stable economic growth, which can elevate industries along the value chain. Thus, exploring how to promote the integration of manufacturing and producer services (hereinafter referred to as the "M&P industries") is of great importance.

In recent years, China's integration of the "M&P industries" has accelerated, yet issues such as development imbalance, weak synergy, and insufficient depth remain. Currently, China's producer services sector has a relatively low share and an unreasonable structure, lagging significantly behind developed countries. Domestic producer services cannot meet the development needs of the manufacturing sector, limiting the extent of the current integration of the "M&P industries" and falling short of supporting manufacturing transformation and upgrading. In recent years, China has adhered to high-level opening-up to promote high-quality development, continuously relaxing market access in the service sector, enhancing cross-border service trade openness, expanding the functionality of foreign opening platforms, and striving to establish a high-standard service sector opening system. Against the backdrop of global high-level opening-up, service trade liberalization can allocate advanced international producer service elements, driving the coordinated development of manufacturing and services, and deepening the integration of the "M&P industries." Furthermore, the digital economy, as the most dynamic field of economic development, is expanding its breadth and depth of integration with various sectors of the economy and society. Alongside introducing advanced international service elements, the innovative application of new-generation digital technologies such as artificial intelligence and 5G in manufacturing and service enterprises is fostering new ecosystems and models for the integration of manufacturing and producer services, providing new directions and paths for the "M&P industries" integration in developing countries. Based on the above analysis, the pertinent questions arise: Does service trade liberalization positively promote the integration of a country's "M&P industries"? Can the digital economy empower this process, enhancing the role of service trade liberalization? Addressing these questions aids in achieving high-quality development of the manufacturing sector, offers new insights for developing countries' service trade liberalization reforms, and provides empirical evidence for countries worldwide to continuously strengthen the development and application of the digital economy.

2 LITERATURE REVIEW

The relevant studies in this context fall into three main categories: The first category focuses on the connotation, characteristics, quantitative methods, and influencing factors of the "M&P industries" integration. In terms of connotation and characteristics, scholars primarily study the basic activities of the value chain, analyzing the dynamic process of "M&P industries" integration from various perspectives such as the integration process, mechanisms, and methods, thus enriching the related research outcomes. The consensus is that the integration of manufacturing and producer services involves the interpenetration, extension, and reorganization of activities along the value chain. The differences in activities and the degree of coordination between them reflect the development of "M&P industries" integration. Regarding quantitative methods, there is currently no unified standard or specific method for measuring the level of "M&P industries" integration. Domestic and international scholars have employed methods such as input-output analysis[1], correlation coefficient analysis[2], and coupling coordination[3] to measure the degree of integration and empirically study its contribution to manufacturing upgrading, generally concluding positive effects. Concerning influencing factors, scholars mostly based on theoretical research, identify technological innovation[4], deregulation[5], and corporate strategic behavior[6] as the main drivers of "M&P industries" integration. The second category pertains to the quantitative methods and economic benefits of service trade liberalization. In terms of quantitative methods, Arnold et al. use input-output analysis, service BOP import, and service FDI data to depict the penetration rate of service openness in the manufacturing sector[7]. Regarding economic benefits, scholars have examined the impact of service trade liberalization on firm performance from various perspectives, including total factor productivity[7], the cost of service intermediates[8], export technology complexity[9], value chain division index, and product quality. The results uniformly indicate that service trade liberalization positively promotes firm performance.

The third category pertains to the connotation of the digital economy, its quantitative methods, and its impact on the integration of the "M&P industries." The concept of the digital economy was first introduced by Tapscott and Don[10], and later refined by scholars such as Fudenberg D and Villas-Boas JM[11], Bukht R and Heeks R[12]. Currently, the prevailing view is that the digital economy is a new economic form that enhances efficiency and optimizes economic structure by using digitized knowledge and information as key production factors, modern information networks as important carriers, and effective use of information and communication technology. In terms of quantitative methods, there is extensive research on measuring the development level of the digital economy and compiling related indices. Some scholars use the entropy method and index method to select relevant indicators from five aspects: information and communication infrastructure, primary ICT applications, advanced ICT applications, enterprise digital development, and the development of the ICT industry, thus constructing a national-level digital economy development evaluation index system for China. Other scholars employ principal component analysis to construct an evaluation index system from the perspectives of internet development and inclusive digital finance. Additionally, some scholars, based on the classification standards in the "Digital Economy and Its Core Industries Statistical Classification (2021)" published by the National Bureau of Statistics of China, have constructed regional-level digital economy development evaluation index systems from four aspects: digital industrialization, industrial digitization, digital infrastructure, and the digital economy industry ecosystem.

The previous text organized literature related to this study from three aspects. Domestic and foreign scholars have conducted in-depth research on the integration of the "M&P industries," the liberalization of service trade, the digital economy, and their interrelationships. However, many issues still warrant further exploration: Firstly, existing research on the impact of service trade liberalization on the integration of the "M&P industries" is relatively scarce. Studies have mostly focused on the openness of the productive service industry and its integration with manufacturing, finding that the openness of the productive service industry enhances the integration between manufacturing and productive services in China. However, these studies have not analyzed the mechanism from the perspective of value chain structure evolution. Furthermore, existing research has not explored the moderating role of the digital economy in promoting the integration of the "M&P industries" through service trade liberalization. Secondly, there are some deficiencies in the current methods of quantifying digital economy development. Most assessments of the digital economy development levels of various countries are based on institutional guarantees and innovation environments, while the two core indicators of digital economy development, digital industrialization and industrial digitization, are often overlooked. Thirdly, the impact of the digital economy on the integration of the "M&P industries" is multi-dimensional and complex, not merely confined to technological empowerment and upgrading. On one hand, the digital economy can create an industrial development ecosystem that combines economies of scale, economies of scope, and long-tail effects, thereby better matching supply and demand and deepening inter-industry cooperation. On the other hand, it drives industrial transformation and upgrading through new input factors, new resource allocation efficiencies, and new total factor productivity, expanding industry boundaries and promoting the integration of the "M&P industries." Therefore, the impact of the digital economy on the integration of the "M&P industries" requires further expansive research. While some literature has discussed the positive effects of digital technology on the integration of the "M&P industries," digital technologies such as information technology and network technology are merely carriers and supports for the operation of the digital economy. They do not fully reflect the overall structure and ecosystem of the digital economy's impact on the integration of the "M&P industries," presenting an opportunity for this study to make a marginal contribution.

In comparison with existing research, this paper proposes to expand and innovate in three aspects: 1. Research perspective: This study elucidates the impact of service trade liberalization on the integration of manufacturing and producer services from the perspective of value chain evolution. It comprehensively considers the moderating role of the digital economy as a new economic form. 2. Empirical research: The study adopts a global approach, using multi-

dimensional panel data from 29 countries (regions) and 18 manufacturing industries from 2007 to 2014 to empirically examine the relationship between service trade liberalization and industry integration. It analyzes the moderating effect of the digital economy in promoting integration through service trade liberalization, testing its non-linear moderating characteristics akin to Metcalfe's Law.³ Variable measurement: Following the "Statistical Classification of Digital Economy and Its Core Industries (2021)" issued by the National Bureau of Statistics, this paper constructs a national-level evaluation index system from three aspects: digitalization of industries, industrial digitalization, and digital infrastructure. It employs principal component analysis to measure the digital economy development level of 68 countries, including the research sample, enriching the measurement methods of digital economy development.

3 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

3.1 Impact of Service Trade Liberalization on Industry Integration

The integration of manufacturing and producer services encompasses two stages: value chain decomposition and value chain integration[13]: In the value chain decomposition stage, manufacturing and producer services sectors decompose their respective value activities through division of labor, forming a production network with inter-industry factor flows and sharing. Manufacturing sectors outsource highly overlapping value activities such as warehousing, transportation, marketing, and after-sales services to producer services sectors, which provide these services more cost-effectively and efficiently. This refined division of labor creates the preconditions for value chain integration. During the value chain integration stage, both sectors extract and reorganize value activity units from the production network based on their industry characteristics and market demands, forming new value chains. Producer service providers penetrate and extend their operations into the manufacturing value chain, developing integrated products related to physical goods upstream or downstream, ultimately leading to value chain restructuring. This study posits that service trade liberalization promotes value chain decomposition by deepening inter-industry division of labor and facilitates value chain integration by fostering industrial agglomeration and innovating inter-industry linkage models. These two stages ultimately achieve the integration of manufacturing and producer services:

3.1.1 Deepening inter-industry division of labor

In the process of integrating "M&P industries," it is essential for the productive service segments to first detach from the manufacturing value chain. Liberalization of service trade continuously amplifies cost and quality gaps in the same productive service segments through cost and demonstration effects, deepening the division of labor between manufacturing and productive service industries, and promoting the decomposition of the "M&P industries" value chain. On the one hand, after introducing high-end and refined foreign productive services, manufacturing enterprises obtain logistics, warehousing, information communication, financial insurance, and other services at costs much lower than those obtained internally through outsourcing, making internalizing various production stages and "large-scale" operations uneconomical for manufacturing enterprises. Moreover, with the continuous expansion of relative cost gaps, the division of labor and specialization between enterprises continues to deepen. On the other hand, foreign productive services generate technology spillovers through horizontal and vertical industry linkages. Domestic productive service providers can promote the refinement and specialization of domestic productive services through the mobility of personnel across enterprises, technology transfer, or learning from foreign advanced service technologies and management experiences. Strengthening the relative competitive advantages of productive service suppliers over manufacturing enterprises in productive service segments compels manufacturing enterprises to specialize and refine their core value activities such as production and research and development. Continuously increasing the breadth and depth of division of labor between manufacturing and productive service industries creates conditions conducive to the integration of "M&P industries."

3.1.2 Promoting industrial agglomeration

The liberalization of service trade has introduced a tendency for foreign productive service industries to cluster towards central cities or industrial parks, and can promote the integration of the M&P industries through agglomeration effects. The productive service industry is mainly concentrated in knowledge intensive and human capital intensive industries, with characteristics such as no physical products, information asymmetry, and high contract intensity. Therefore, compared to trade costs, foreign high-end productive service industries are more sensitive to transaction costs based on institutions and need to gather in large cities or industrial parks with abundant human capital and stable institutional environments. The technology spillover effect it brings will also attract the host country's productive service industry to cluster in specific regions, forming high-end and specialized productive service industry parks, and leveraging the externalities of industrial agglomeration to promote the integration of the M&P industries. Firstly, the agglomeration of productive service industry is conducive to the expansion of the intermediate product service market, forming economies of scale for intermediate inputs, thereby providing specialized and low-cost intermediate inputs for upstream and downstream enterprises, and providing impetus for the penetration of productive service industry into the manufacturing value chain. Secondly, the agglomeration of foreign productive service industries strengthens competition among local productive service providers, forcing them to explore new markets and businesses. This provides impetus for productive service providers to explore the market of small and medium-sized manufacturing enterprises that have not yet introduced productive services, develop personalized and customized services, and achieve a long tail effect of supply and demand matching between both parties. Manufacturing enterprises derive flexible manufacturing functions by introducing personalized and customized services, and continuously extend their production

processes to both ends of the value chain, promoting the penetration and restructuring of both value chains. Finally, the agglomeration of productive service industries will attract a large number of high-quality factors, cultivate intermediate product service markets, improve regional resource allocation efficiency, and regulate market order. Promote real-time trading of intermediate input services between manufacturing and productive service industries, reduce industry transaction costs and risks, and create a suitable environment for the integration of the value chain between manufacturing and productive service industries.

3.1.3 Innovation industry correlation model

The liberalization of service trade can also force manufacturing enterprises to innovate their own value activity correlation models, deepen their cooperation with productive service suppliers, and provide impetus for the integration of the M&P industries through knowledge spillovers and the emergence of new "product+service" demands. On the one hand, while liberalization of service trade brings advanced technology and management experience, it also forms a rich and mature service factor supply network and information transmission network through knowledge spillover, effectively reducing the cost of knowledge search for enterprises and accelerating the updating and iteration of new knowledge and products. This provides motivation for manufacturing enterprises to search for and apply new knowledge through cooperation with productive service providers. On the other hand, new products formed by the entry of high-end and refined productive services from outside and their association with the manufacturing industry will inevitably have an impact on traditional products, leading to new demands for "product+service". To meet market demand, manufacturing enterprises need to embed specialized productive services as intermediate inputs into their own value chains, and continuously extend their industrial chains outward, transforming their products into a "product+service" model. In this process, manufacturing enterprises upstream and downstream of the value chain need to search, negotiate, and connect with various productive service suppliers, promoting the restructuring and integration of the manufacturing and productive service value chains. Based on the above analysis, this article proposes the following assumptions:

Hypothesis 1: Liberalization of service trade has a positive promoting effect on the integration of the M&P industries.

3.2 The Regulatory Effect of the Digital Economy

The digital economy can promote the decomposition, aggregation, and restructuring of the value chain between manufacturing and productive service industries through ubiquitous connectivity and penetration, becoming a key force in coordinating resource allocation, reconstructing value creation, and promoting the integration of the M&P industries.

Firstly, the digital economy can promote innovation and upgrading of productive service industries, reduce transaction costs, continuously expand the relative cost gap between manufacturing and productive service industries in the same productive service links, and strengthen the division of labor effect brought about by service trade liberalization. On the one hand, the digital economy uses data information, digital technology, and digital ecology as input factors to drive industrial upgrading, replacing the input factors of productive services themselves, and promoting technological innovation and upgrading in the productive service industry. For example, with the support of data resources and digital ecology, the digital economy can further expand the scope and accessibility of financial services, and improve the inclusiveness of financial services. Information communication, warehousing and transportation, wholesale and retail and other services are constantly upgrading towards digitization and intelligence, giving rise to emerging service forms such as instant messaging, intelligent logistics, and e-commerce, forming an efficient and low-cost digital service system. On the other hand, while liberalization of service trade refines the division of labor between manufacturing and productive services, it also brings about an increase in transaction costs and hinders the division of labor between industries. However, the digital economy can create a digital ecosystem and reduce information costs, enabling businesses to complete transactions with low cost and high efficiency. The unique information technology and digital platforms of the digital economy enable production service providers and manufacturers to achieve instantaneous and precise matching of supply and demand in cooperation, reduce intermediate links in inter industry trade, improve the frequency and efficiency of interaction between production service industry and manufacturing enterprises, and thereby expand industry boundaries while reducing coordination and communication costs for enterprises, promoting the extension of production service industry to manufacturing industry, and creating conditions for the penetration and restructuring of the value chains of both parties.

Secondly, the digital economy can promote the transformation of productive service industries from geographical agglomeration to online agglomeration with wider coverage, strengthen the agglomeration effect of service trade liberalization, and promote the integration of the M&P industries. The digital economy can give play to its advantages of rapid online interaction and integrated information platform to form a large-scale online agglomeration of manufacturing enterprises in the Internet space. Transforming the two industrial clusters from unilateral online clustering to bilateral online clustering, making the interaction between the two industrial clusters more efficient and precise, and creating a suitable environment for the integration of the value chains of the M&P industries. Firstly, the rapid development of digital technologies represented by 5G, artificial intelligence, cloud computing, and the Internet of Things continues to reduce transaction costs between enterprises. Among them, the productive service industry is currently the most thoroughly transformed industry by digital technology. Under the influence of the digital economy, the transaction costs of many productive services are almost zero, causing productive service providers to shift from traditional geographical clustering to online clustering, forming industrial clusters with wider coverage, more participating entities, and stronger derivative effects. In addition, unlike productive service industries, manufacturing

enterprises are more sensitive to land costs, so more manufacturing industries tend to cluster in small and medium-sized cities with lower land costs. With the support of digital twin, intelligent supply chain management, industrial Internet and other digital technologies and digital ecology, the manufacturing industry is becoming more and more digital, intelligent and collaborative. Enterprises located in different geographical locations can digitize their manufacturing processes online, achieving online production and clustering throughout the entire manufacturing process. When both manufacturing and productive service industries have achieved online clustering, the expression of demands for products and services between manufacturing enterprises and productive service suppliers becomes more precise, gradually forming an industrial ecosystem of collaborative and integrated development between manufacturing and productive service enterprises, creating a suitable environment for the penetration of productive service industries into the manufacturing value chain.

Thirdly, the digital economy can also promote manufacturing enterprises to innovate their own value activity correlation models, deepen their cooperation with productive service providers, and promote the integration of the M&P industries by improving enterprise management efficiency, resource allocation efficiency, and nurturing new industrial organizational forms. On the one hand, the digital economy can improve enterprise management efficiency and resource allocation efficiency by reducing internal communication and information acquisition costs, driving organizational change, and improving the predictive ability of managers. The improvement of enterprise management efficiency can help enterprises adjust their development strategies according to market conditions and enhance the service orientation of enterprise decision-making. The improvement of resource allocation efficiency can effectively reduce the cost of factor flow required for the integration of the M&P industries, forming a market environment conducive to the deep integration of the M&P industries. On the other hand, the digital economy has penetrated into various industries, gradually weakening and eliminating industry attributes and barriers, allowing different types of enterprises to coexist in the same industry ecosystem, nurturing new forms of industrial organization: in the digital economy era, modern industrial organization forms are developing towards an industry ecosystem dominated by flat enterprises. Platform based enterprises leverage their advantages of integrating resources and gathering enterprises to promote precise and efficient connections between industries. As a module supplier, manufacturing enterprises are committed to being specialized, refined, unique, and innovative at a certain stage of the value chain, integrating into the platform with core capabilities. And continuously divest non core businesses, outsourcing production services in its own production process to specialized suppliers. In this form of industrial organization, the productive service industry penetrates into the manufacturing value chain from various links such as pre production, during production, and post production, providing comprehensive support for technical consultation, product approval, process optimization, and marketing services, promoting deep integration between manufacturing and productive service industries. Therefore, this article proposes the following assumptions:

Hypothesis 2: The digital economy can enhance the promoting effect of service trade liberalization on the integration of the M&P industries.

4 ECONOMETRIC MODELS

4.1 Model Settings

To study the impact of service trade liberalization on the integration of the M&P industries, this article sets the following econometric model:

$$Com_{ijt} = \beta_0 + \beta_1 lnser_{ijt} + \sum \beta Controls_{ijt} + \eta_i + \lambda_t + \mu_j + \varepsilon_{ijt} \quad (1)$$

Among them, Com_{ijt} represents the integration of "M&P industries"; $lnser_{ijt}$ represents the openness of the productive service industry at the industry level; $Controls_{ijt}$ represents a series of control variables; i represents the country or region, j represents the manufacturing industry, t represents the year, η_i represents the country's fixed effect, μ_j represents the industry's fixed effect, λ_t represents the time fixed effect, which are used to control the country differences, industry characteristics, and time trends of the country or region, respectively. ε_{ijt} represents the stochastic disturbance term. The detailed calculations for each variable can be found in the following text.

To study the regulatory role of the digital economy in promoting the integration of the M&P industries through service trade liberalization, the benchmark regression model is extended to:

$$Com_{ijt} = \beta_0 + \beta_1 lnser_{ijt} + \beta_2 dige_{it} + \beta_3 lnser_{ijt} * dige_{it} + \sum \beta Controls_{ijt} + \eta_i + \lambda_t + \mu_j + \varepsilon_{ijt} \quad (2)$$

Among them, $dige_{it}$ represents the overall level of digital economy development in a country, and the definitions of other variables are consistent with the benchmark regression model.

4.2 Variable Construction

4.2.1 Dependent variable

The dependent variable of this article is the integration of manufacturing and productive services. Using input-output data, the comprehensive integration degree is calculated based on the one-way integration degree of manufacturing and productive services in the sample country. The specific calculation method is as follows:

(1) Unidirectional Integration Degree: In the unidirectional integration degree, GX_{j1} and GX_{j2} represent the proportion of productive service industry and manufacturing industry as intermediate products invested in manufacturing and productive service industry, respectively. This reflects the degree of integration and infiltration between the two. The

specific formula for these two indicators is:

$$GX_{j1} = \frac{\sum_{s=1}^5 Y_{s*j}}{Y_j} \quad (j \in [1,18]; s \in [1,5]) \tag{3}$$

Among them, j represents the classification of the manufacturing industry, and i represents the classification of the productive service industry. This calculation result represents the proportion of productive service industry as intermediate input to the total input of manufacturing industry.

$$GX_{j2} = \frac{\sum_{s=1}^5 Y_{j*s}}{Y_s} \quad (s \in [1,5]; j \in [1,18]) \tag{4}$$

The meanings of i and j are consistent with equation (3), which represents the proportion of manufacturing as an intermediate input to the total input of productive services.

(2) Comprehensive fusion degree: The comprehensive fusion degree Com_{ijt} is calculated based on the unidirectional fusion degree, and the specific formula is as follows:

$$Com_{ijt} = \frac{GX_{itj1}}{GX_{itj2}} \tag{5}$$

The comprehensive integration degree reflects the degree of bi-directional integration of industries at the industry level in a country, specifically defined as the ratio of the contribution of productive service industries to the contribution of manufacturing industries. The larger the indicator, the higher the degree of mutual penetration between the value chains of manufacturing and productive service industries. To increase the robustness of empirical results, this article uses standardized one-way fusion degree as the dependent variable in benchmark regression, and standardized comprehensive fusion degree as a substitute variable for the dependent variable in robustness testing.

4.2.2 Core explanatory variable

This article measures the degree of impact of service trade liberalization on the manufacturing industry by measuring the penetration rate of service openness, that is, the penetration rate of service trade on the manufacturing industry's sub sectors:

$$lnser_{isjt} = \ln \left(\sum_s service_{isjt} \times imports_{ist} \right) \tag{6}$$

Among them, i represents the country, t represents time, j represents 24 manufacturing industries, and s represents five service sectors. Among them, the five service departments are wholesale and retail, warehousing and transportation, information and communication, finance and insurance, and patent technology services. $imports_{ist}$ represents the import volume of various service sectors in a country, and $service_{isjt}$ represents the input coefficient of productive services in various manufacturing industries in country i. The academic community generally uses the complete consumption coefficient to calculate, which represents the sum of direct and indirect consumption of productive services by manufacturing industry j. The specific calculation formula is as follows:

$$service_{sj} = \alpha_{sj} + \sum_{m=1}^n a_{sm} \alpha_{mj} + \sum_{m=1}^n \sum_{k=1}^n a_{sk} \alpha_{km} \alpha_{mj} + \dots \tag{7}$$

α_{sj} is the direct consumption of J manufacturing industry towards S service department, $\sum_{m=1}^n a_{sm} \alpha_{mj}$ is the second round of indirect consumption of J manufacturing industry towards S department through M department, $\sum_{m=1}^n \sum_{k=1}^n a_{sk} \alpha_{km} \alpha_{mj}$ is the third round of indirect consumption, and so on.

4.2.3 Moderating variable

The moderating variable in this article is the level of development of the digital economy. This article constructs a national level evaluation index system based on the "Statistical Classification of Digital Economy and Its Core Industries (2021)" released by the National Bureau of Statistics, from three aspects: digital industrialization, industrial digitization, and digital infrastructure. The principal component analysis method is used to reduce dimensions and obtain comprehensive indicators of the development level of digital economy in each country. The development level of digital economy in 68 countries, including sample countries, is evaluated. The specific indicator selection is shown in Table 1:

Table 1 Construction of Digital Economy Development Level Indicators

Primary indicators	Secondary indicators	data sources
Digital infrastructure	Fixed broadband penetration rate	WDI
	Fixed line telephone penetration rate	WDI
	Mobile network coverage	WDI
	Number of secure servers/million people	WDI
	The government promotes the level of domestic ICT application	WEF
Industrial digitization	Enterprise Internet application level	WEF
	The Impact of Digital Economy on Local Business Models	WEF
	The Impact of Digital Economy on Local Organizational Models	WEF
Digital industrialization	The Impact of Digital Economy on Local Basic Services	WEF
	The share of ICT information and communication service exports in total service exports	UNCTAD
	The share of ICT product exports in total product exports	UNCTAD

Among them, digital industrialization refers to the development level of the digital sector that produces digital

technology products or provides digital technology services. The products and services of these digital sectors are the foundation for the role of digital technology in economic and social operations. Therefore, this article selects the share of ICT information and communication service exports in the total service exports and the share of ICT product exports in the total product exports to measure a country's digital industrialization process. Industrial digitization refers to the degree of penetration of digital technology and digital ecology into various socio-economic activities such as production and consumption. Therefore, this paper selects the level of domestic ICT application promoted by a government, the level of enterprise Internet application, and the impact of digital economy on local business models, organizational models, and basic services to quantify the process of industrial digitalization in a country. Adding four indicators to measure the infrastructure of the digital economy, a total of 13 secondary indicators were selected for standardization. Three principal components with eigenvalues greater than 1 and reflecting 87% of the data information were calculated using Stata software. The comprehensive evaluation index for the development level of the digital economy was calculated using variance contribution rate as a weighted weight, denoted as $dige_{it}$.

4.2.4 Control variables

The control variables used in this article include national and industry levels. The national level control variables include: Gross Domestic Product (lnGDP), Population Size (lnpopulation), Per Capita Gross Domestic Product (lnperGDP), Industrial Value Added to GDP (invalue a), Medium and High tech Enterprise Value Added to Industrial Value Added (mahvalue), and R&D Investment to GDP (ri). Among them, the gross domestic product, population size, and per capita gross national product are logarithmically processed. Industry level control variables include industry added value (lnsva), represented by the added value of each industry in a country. Forward GVC Participation (GVC PF) is expressed as the share of added value from value chain activities in the final product produced by a certain industry in a country. Backward GVC Participation (GVC PD) is expressed as the share of added value created by a certain industry in a country for value chain activities. The Industry Explicit Comparative Advantage Index (RCA) is expressed as the ratio of the share of a certain industry in a country's exports to the share of that industry in the total world trade. Industry size (lnfpv), expressed as the total final product value of a certain industry in a country. The upstream degree of the value chain (lnup) is expressed as the distance from product production to final demand in a certain industry in a country, and is logarithmic. Downstream degree of the value chain, expressed as the average number of production stages included in a country's industry products.

4.3 Data Source and Sample Description

The fusion data of the M&P industries used in this article, the direct consumption coefficient and the complete consumption coefficient, are sourced from the 2016 World Input Output Database (WIOD). This database contains input-output data from countries around the world from 2000 to 2014. In addition, the service trade data used in this article to calculate the liberalization of service trade is sourced from the United Nations Trade and Development Database (UNCTAD Statistics). The country level control variables in the control variables are sourced from the World Development Indicators Database (WDI) of the World Bank, and the industry level control variables are sourced from the UIBE-GVC indicator system database of the University of International Business and Economics. The sources of secondary indicators used to measure the development level of the digital economy are detailed in Table 1.

Considering the statistical caliber and years of explanatory and moderating variables, this article selects input-output data from 29 countries, including China, from 2007 to 2014 as the econometric sample. In terms of industry statistics and classification, based on existing literature research, 18 industries including C5-C22 are considered as manufacturing industries, and C28-C35, C37-C43, and C45-C49 are used as productive service industries to calculate the degree of integration between a country's manufacturing and productive service industries.

5 REGRESSION RESULT ANALYSIS

5.1 Basic Regression Results

According to column (1) of Table 2, the coefficient before service trade liberalization is significantly positive at the 1% significance level, indicating that service trade liberalization has a significant positive promoting effect on the integration of the M&P industries. As can be seen from column (3), this conclusion still holds even after adding control variables. Once again, it has been verified that liberalization of trade in services is conducive to the integration of the M&P industries, and hypothesis 1 has been confirmed. To test hypothesis 2 in theoretical analysis, this article uses econometric model (2) for regression analysis. According to column (2) of Table 2, the coefficient before the interaction term between service trade liberalization and the level of digital economy development is significantly positive at the 1% significance level, indicating that the digital economy enhances the positive promotion effect of service trade liberalization on the integration of the M&P industries. Hypothesis 2 is confirmed.

Table 2 Basic regression results

Variables	(1)	(2)	(3)	(4)
lnser	5.090*** (13.99)	8.185*** (16.33)	4.546*** (13.54)	7.946*** (16.75)
dige		-7.118*** (-7.981)		-3.522*** (-4.231)

Inser*dige		0.500*** (7.868)		0.219*** (3.825)
controlling variables	NO	NO	YES	YES
Industry fixed effects	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
N	3132	3001	3132	3001
R2	0.725	0.791	0.728	0.791

5.2 Endogeneity Testing

There may be endogeneity issues of reverse causality in benchmark regression, and liberalization of service trade can promote the integration of the M&P industries. On the contrary, the higher the degree of integration between the M&P industries in a country, the more likely it is to increase its demand for high-quality productive foreign services, thereby promoting the liberalization of service trade. To eliminate endogeneity, this article uses the first-order and second-order lag values of service trade liberalization as instrumental variables to perform two-stage least squares estimation on the original model, and the results are listed in Table 3. The first and second columns represent the results of re estimation using the first-order lag value of service trade liberalization as instrumental variables, while the third and fourth columns represent the results of re estimation using the second-order lag value of service trade liberalization as instrumental variables. Based on all the results in Table 3, regardless of which instrumental variable is used, liberalization of service trade still has a significant positive promoting effect on the integration of the M&P industries, while the digital economy expands this promoting effect. Meanwhile, the endogeneity test results rejected the hypothesis of weak instrumental variables and identification of instrumental variables, indicating that the core conclusion of this article has not changed.

Table 3 Endogeneity test results

Variables	(1)	(2)	(3)	(4)
	Lagged first-order		Lagged second-order	
Inser	8.304*** (15.02)	8.042*** (15.47)	8.246*** (13.89)	7.897*** (14.03)
dige		-3.388*** (-4.185)		-3.522*** (-4.334)
Inser*dige		0.210*** (3.82)		0.219*** (4.027)
controlling variables	YES	YES	YES	YES
Kp rk Wald F	2513.999***	3819.652***	210.185***	178.693***
Kp rk Wald LM	12.995***	13.853***	13.020***	13.750***
Industry fixed effects	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
N	3001	3001	3001	3001

5.3 Robustness Test

To further test the robustness of the regression results, this article uses multiple robustness testing methods to test the core conclusions of this article. Firstly, considering that the liberalization of trade in services has a certain time lag in its impact on the integration of the M&P industries, the core explanatory variables were introduced into the benchmark model after lagging for one and two periods respectively, and re estimated. The regression results of the core explanatory variables lagging for one and two periods are shown in columns (1) - (4) of Table 4. Secondly, the replacement variables of the core variables were selected for robustness testing. The regression results of the integration calculation method for the replacement manufacturing and productive service industries are presented in columns (5) and (6) of Table 4. Thirdly, add an interaction term between the fixed effects of country x time and industry x time, and strengthen the constraint of fixed effects. To further examine the impact of other unmeasurable factors on the regression results and avoid endogeneity and heteroscedasticity caused by improper selection of control variables, the test results are listed in columns (7) and (8) of Table 4.

Table 4 Robustness Test Results

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Lagged first-order regression		Lagged second-order regression		Replace the dependent variable		Increase the constraint on fixed items	
Inser	7.891*** (17.17)	7.768*** (17.17)	4.821***(8.28)	4.395*** (7.84)	0.125*** (3.29)	0.104** (2.25)	8.221*** (16.58)	7.957*** (16.59)
dige		-1.750**		-5.826***(7.41)		-		-2.026** (2.54)

		(-2.37)				0.000457 (-0.0061)		
Inser*dige		0.104** (2.59)		0.465*** (9.63)		0.010* (1.817)		0.251*** (4.31)
controlling variables	YES	YES	YES	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
National fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Time #	NO	NO	NO	NO	NO	NO	YES	YES
Country	NO	NO	NO	NO	NO	NO	YES	YES
Time #	NO	NO	NO	NO	NO	NO	YES	YES
Industry	NO	NO	NO	NO	NO	NO	YES	YES
N	3001	3001	3001	3001	3002	3002	3001	3001
R ²	0.781	0.781	0.747	0.749	0.551	0.553	0.787	0.787

5.4 Heterogeneity Test

Considering the differential impact of trade liberalization in different service sectors on the integration of the M&P industries, this article divides the main service sectors into five categories: wholesale and retail services, warehousing and transportation services, information and communication services, financial and insurance services, and patent technology services. According to columns (1) - (5) of Table 5, it can be seen that trade liberalization in the five types of service sectors has a significant promoting effect on the integration of the M&P industries, and the digital economy can enhance the promoting effect of trade liberalization in these five types of services. From the perspective of core explanatory variable coefficients, the coefficients before the liberalization of trade in warehousing and transportation services and financial insurance services are relatively large, which has a stronger positive promoting effect on the integration of the M&P industries. This may be because manufacturing enterprises need to first utilize intelligent production lines and intelligent logistics systems to improve their supply chain efficiency during transformation and upgrading. Therefore, manufacturing enterprises have a stronger demand for warehousing and transportation services, and external specialized and intelligent warehousing and transportation services have a stronger positive promoting effect on the integration of the M&P industries. In addition, the introduction of foreign financial services through the liberalization of financial and insurance service trade can effectively reduce the financing costs and risk coefficients of manufacturing enterprises, provide impetus for manufacturing enterprises to innovate their own industry related models, transform to the "product+service" model, and promote the integration of the "M&P industries".

Table 5 Heterogeneity analysis and expansion analysis results

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Wholesale and retail services	warehousing and transportation services	information and communication services	financial insurance services	patent technology services	non-linear regulatory effects
Inser	0.262*** (13.78)	1.251*** (5.989)	0.952*** (11.88)	1.163*** (6.148)	0.876*** (8.255)	8.644*** (16.63)
dige	0.116 (1.71)	-0.408*** (-3.061)	-0.970*** (-5.152)	-0.123 (-1.574)	-0.509*** (-3.868)	9.225*** (6.43)
Inser*dige	0.0326*** (3.61)	0.0141** (2.37)	0.0778*** (3.946)	0.0397*** (5.017)	0.0284** (2.113)	0.665** (2.19)
digesq						-3.479*** (-9.21)
Inser*digesq						0.378*** (9.44)
controlling variables	YES	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES	YES
National fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
N	3001	3001	3001	3001	3001	3001

R2	0.738	0.766	0.635	0.628	0.735	0.788
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On the other hand, from the perspective of the interaction coefficient size, the digital economy has a stronger positive regulatory effect on the liberalization of wholesale and retail, information and communication, and financial and insurance service trade. The reason may be that the digital economy is more in line with the input factors, business models, and ecology of these service industries, making it easier to promote technological innovation and upgrading. With the support of digital technology and digital ecology, wholesale and retail services have shifted from traditional negotiation, payment, and delivery to e-commerce centered on digital platforms. Information and communication services have derived functions such as instant messaging and digital twins in the digital ecosystem, which have a stronger innovative effect on the production processes and associated models of manufacturing enterprises. With the support of big data, cloud computing and other technologies, financial and insurance services have further expanded their service scope and reach capabilities, enhancing the inclusiveness of their services. In the context of the digital economy, the productive service industry is increasingly developing towards digitization and intelligence, presenting characteristics of high efficiency, high quality, and high efficiency, adding impetus for manufacturing enterprises to replace their original value chains with specialized productive services.

5.5 Expansion Analysis: Nonlinear Regulatory Effects of Digital Economy

Considering the network externalities of the digital economy, that is, with the development of the digital economy, the marginal cost of collaboration among various departments in the digital ecosystem continues to decrease, showing a non-linear characteristic of increasing marginal benefits. We speculate that the regulatory effect of the digital economy on the integration of the M&P industries may also have non-linear characteristics. This article introduces the quadratic term $dige_sq_{it}$ of the development level of the digital economy and the cross term $lnser_{ijt} * dige_sq_{it}$ it with the openness of the productive service industry into model (2). Construct the following model (8) to test the nonlinear regulatory effect of the digital economy, and present the results in column (6) of Table 5.

$$Com_{ijt} = \beta_0 + \beta_1 lnser_{ijt} + \beta_2 dige_{it} + \beta_3 lnser_{ijt} * dige_{it} + \beta_4 dige_sq_{it} + \beta_5 lnser_{ijt} * dige_sq_{it} + \sum \beta Controls_{ijt} + \eta_i + \lambda_t + \mu_j + \varepsilon_{ijt} \tag{8}$$

The results showed that after introducing the quadratic term of the development level of the digital economy, the coefficients of its first and second terms and the cross terms $lnser_{ijt} * dige_{it}$, $\beta_5 lnser_{ijt} * dige_sq_{it}$ of service trade liberalization were significantly positive at the 1% significance level. This indicates that the development level of the digital economy positively and nonlinearly regulates the relationship between service trade liberalization and the integration of the M&P industries. The higher the level of development of the digital economy, the stronger the marginal benefits of its positive regulatory effect, which is significantly manifested as a positive non-linear regulatory effect. With the widespread application of the digital economy in various fields of the economy and society, the number of manufacturing enterprises and productive service providers participating in it continues to increase, forming economies of scale. The marginal cost of linkage between various participating entities continues to decrease, resulting in a significant decrease in the cost of acquiring knowledge, information, and technology for these participating entities, and a geometric increase in the benefits they receive, promoting the integration of manufacturing and productive service industries. When the digital economy develops to a certain level and the number of participating entities exceeds a certain critical point, a positive feedback mechanism will be triggered, and its regulatory effect will show explosive growth, exhibiting positive nonlinear regulatory characteristics.

6 CONCLUSION

This article uses panel data from multinational industries from 2007 to 2014 to study the impact of service trade liberalization on the integration of the M&P industries, and analyzes the role of the digital economy in it. The research results indicate that firstly, the liberalization of service trade has a significant positive promoting effect on the integration of the M&P industries. Among them, the liberalization of trade in warehousing and transportation services, as well as financial and insurance festival services, has a stronger positive promoting effect on the integration of the M&P industries; Secondly, the digital economy strengthens the promoting effect of service trade liberalization on the integration of the M&P industries through positive regulatory effects. The above conclusion still holds after a series of robustness tests, including endogeneity testing of instrumental variables, replacement of the method of calculating the dependent variable, lagged treatment of core explanatory variables, and strengthening the constraint of fixed effects; Thirdly, the non-linear moderation effect test shows that the regulatory role of the digital economy in promoting the integration of the M&P industries through service trade liberalization also has non-linear characteristics. The higher the level of development of the digital economy, the stronger the marginal benefits of its positive moderation effect.

Based on the above research conclusions, this article proposes the following suggestions: Firstly, make high-level opening up of the service industry a top priority in building a new open economy system, and use it as a lever to promote the integration of the M&P industries and build a strong manufacturing country. According to the Service Trade Restriction Index released by the Organization for Economic Cooperation (OECD), as of 2021, the degree of openness in some industries in China has exceeded that of developing countries, but there is still significant room for improvement compared to developed countries represented by Europe and America. Faced with the increasingly complex international political and economic environment, China should actively promote international economic and

trade cooperation, establish more stable trade relations with trading partners, and leverage regional trade agreements such as RCEP to integrate into the global productive service network. By implementing high-level opening up to the outside world, allocating international high-quality service elements, enhancing the interaction and integration between manufacturing and productive service industries, we will provide impetus for China's transformation and upgrading from a "manufacturing powerhouse" to a "manufacturing powerhouse". Secondly, optimize the industry structure of service trade liberalization and formulate differentiated opening policies for different service industries. According to the previous conclusion, in the process of promoting the integration of the M&P industries, we can take the lead in promoting the liberalization of trade in warehousing and transportation services and financial and insurance services. By introducing high-level service elements, we can help manufacturing enterprises optimize their supply chain management, expand financing channels, and promote the integration of the M&P industries. At the same time, attention should also be paid to policy strength, and in combination with actual development situations, orderly and gradient open policies should be formulated for different service industries. Thirdly, we should attach importance to the role of the digital economy in the high-level opening up of the service industry to the outside world, increase investment in the construction of digital economy infrastructure, and vigorously promote the process of digital industrialization and industrial digitization. Improve the policy system for supporting the management of the digital economy, and refine regulatory mechanisms such as data security and network security. Provide policy support for the development of new industrial forms such as digital service trade, and leverage the empowering role of the digital economy in the integration of the M&P industries. To form a policy synergy with the liberalization of service trade and promote the integrated development of the M&P industries. Fourthly, we should fully utilize the network externalities of the digital economy. With the development of the digital economy, the marginal cost of interaction between various participating entities continues to decrease, and the benefits obtained from it increase geometrically. In the process of promoting the integration of the M&P industries, it is necessary to continuously promote the participation of manufacturing and service industry enterprises in the construction of the digital economy. The government should introduce relevant preferential policies to guide enterprises to adapt to the trend of digital development and transform their business processes and management models towards digitalization. At the same time, we should pay attention to building industry benchmarks and leading enterprises, and play a demonstrative and leading role. In addition, it is necessary to enhance the ecological support capacity of enterprises in the process of digital upgrading. Accelerate the construction of information platforms and guide enterprise participation to create a favorable environment for the integrated development of the M&P industries.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCE

- [1] Guerrieri P, Meliciani V. Technology and international competitiveness: The interdependence between manufacturing and producer services. *Structural change and economic dynamics*, 2005, 16(4): 489-502.
- [2] Fai F, Von Tunzelmann N. Industry-specific competencies and converging technological systems: evidence from patents. *Structural change and economic dynamics*, 2001, 12(2): 141-170.
- [3] Bröring S, Martin Cloutier L, Leker J. The front end of innovation in an era of industry convergence: evidence from nutraceuticals and functional foods. *R&D Management*, 2006, 36(5): 487-498.
- [4] Lind J. The Convergence hype cycle: usage in management practice during an impending market re-definition, ITS Biannual Conference. Berlin, 2004: 4-7.
- [5] Katz M L. Remarks on the economic implications of convergence. *Industrial and Corporate Change*, 1996, 5(4): 1079-1095.
- [6] Yoffie D B. Competing in the age of digital convergence. *California Management Review*, 1996, 38(4): 31.
- [7] Arnold, Jens M., Beata S. Javorcik, and Aaditya Mattoo. Does services liberalization benefit manufacturing firms?: Evidence from the Czech Republic. *Journal of International Economics* 85.1 (2011): 136-146.
- [8] Biryukova O, Vorobjeva T. The Impact of Service Liberalization on the Participation of BRICS Countries in Global Value Chains. *International Organisations Research Journal*, 2017, 12: 94-113.
- [9] Markusen J, Rutherford T F, Tarr D. Trade and direct investment in producer services and the domestic market for expertise. *Trade Policies for Development and Transition*. 2017.
- [10] Tapscott and Don, 1996, "The Digital Economy: Promise and Peril in the Age of Networked Intelligence", *Educom Review*, 33 (9): 33-5199.
- [11] Fudenberg D, Villas-Boas J M. In the digital economy. *The Oxford handbook of the digital economy*, 2012: 254.
- [12] Bukht R, Heeks R. Defining, conceptualising and measuring the digital economyV. *Development Informatics working paper*, 2017 (68).
- [13] Wirtz B W. Reconfiguration of value chains in converging media and communications markets. *Long range planning*, 2001, 34(4): 489-506.

THE DYNAMIC INTEGRATION OF TECHNOLOGICAL INNOVATION AND ENTREPRENEURSHIP: A SYSTEMATIC LITERATURE REVIEW

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Abstract: This systematic literature review meticulously explores the complexities of technological innovation and entrepreneurship, with a particular focus on the strategies and management practices involved in new product development from an interdisciplinary standpoint. By conducting an extensive analysis of 323 key articles from 11 top-tier journals published between 2020 and 2023, the review delineates the current research trajectories within these fields, underscoring significant scholarly interest and development. The study particularly emphasizes the emergence of artificial intelligence-generated content technology since 2022 and critically assesses its influence on innovation processes and product development practices among both nascent entrepreneurs and well-established corporations. This emergent technology's role in shaping the competitive landscape and its potential to drive significant shifts in market dynamics are thoroughly examined.

Keywords: Technological innovation; Entrepreneurial transformation; Entrepreneurship; New product development; Innovation management; Systematic literature review.

1 INTRODUCTION

1.1 Research Background

Technological industries have rapidly advanced in the modern era. The significance of research on technological entrepreneurship and new product development is growing, especially in the context of innovation management for small to medium-sized enterprises (SMEs), emphasizing sustainable development processes. Emphasis has been placed on the role of homogeneity in work behavior focused on innovation, indicating its significant influence on employee conduct in innovative activities. This serves as empirical evidence reinforcing the domain of innovation management [1].

The intricate structure of the innovative entrepreneurial ecosystem encapsulates a web of relationships among diverse stakeholders such as academic institutions, universities, state-owned enterprises, incubation centres, and non-profit organizations. Significant differences have been discerned between university-incubated enterprises and innovative startups through rigorous scholarly examinations. Empirical research undertaken in Italy scrutinized the performance metrics of various types of enterprises within the innovation ecosystem, providing valuable insights into its evolution [2].

Wróbel et al. [3] focused intently on fostering creativity within entrepreneurial teams. They endeavoured to understand strategies that amplify creativity by cultivating the dynamics of the entire team. They proposed strategies and approaches aimed at guiding smaller groups to enhance creativity and, consequently refine innovation management practices.

The emergence of Artificial Intelligence Generated Content (AIGC) has exerted a profound influence on traditional industries in recent years, with its impact expected to persist through 2023. This technological innovation has opened new avenues for traditional sectors and fortified the innovative capacities of SMEs [4]. With the escalating allure of artificial intelligence (AI), an expanding cohort of entrepreneurial groups is directing their efforts toward this domain, thereby magnifying opportunities and optimizing resource allocation for SMEs. With the escalating allure of artificial intelligence (AI), an expanding cohort of entrepreneurial groups is directing their efforts toward this domain, thereby magnifying opportunities and optimizing resource allocation for SMEs. These progressive shifts are crucial for ensuring the sustainability of traditional sectors and facilitating the expansion of SMEs. By collaborating with these avant-garde teams, SMEs can foster innovation and secure enhanced technical assistance and collaborative ventures.

Finally, an array of comprehensive studies by Sordi et al. [5] elucidated the creative methodologies employed by entrepreneurs during the development phase of new products and services. Their research aimed to reveal the modifications and resulting impacts of creative methods employed by entrepreneurs across diverse stages, offering practical guidance and decision support for managing organizational innovation.

1.2 Research Motivation

By thoroughly immersing ourselves in these studies, a comprehensive understanding of the impact of technological entrepreneurial endeavors on innovative work behaviors, distinct performances among various enterprises within the

innovation ecosystem, effective strategies to foster creativity during team formation, and the inventive approaches employed by entrepreneurs in ideating and executing new products and services can be achieved. These scholarly articles provide invaluable research contexts, establishing a robust theoretical and empirical basis for our investigation. Considering the aforementioned research background, this study delves into the realm of innovation management and strategy concerning technological entrepreneurship and the development of new products. Employing an interdisciplinary perspective and amalgamating findings from a range of scholarly articles alongside insights from esteemed academics, our goal is to offer a comprehensive understanding of the challenges encountered in innovation management during technology entrepreneurship. Moreover, we aim to examine the impact of innovation strategies on the development and market introduction of new products. This study aims to provide enlightening perspectives on innovation management and strategies pertinent to technology entrepreneurs, business managers, and academia, thereby contributing to the sustainable advancement of the fields of technology entrepreneurship and new product development.

1.3 Research Gap

In 2022, the introduction of AIGC technology triggered a notable upswing in technological innovation. Tech entrepreneurs and major global corporations swiftly recognized the value and potential of this technology, actively engaging in AIGC-related businesses and new product development. Illustrative instances encompass the OpenAI team, led by its distinguished founder, responsible for the development of ChatGPT4.0, and the serial entrepreneur associated with the Midjourney product. This trend signifies the emergence of a new research focal point that concurrently presents challenges in technological and business model innovations for entrepreneurs. AIGC technology represents a significant advancement over previous AI technologies. This study stands as one of the pioneering efforts to systematically review the literature, revealing the latest research trends in the interconnected domains of technological innovation and entrepreneurship.

1.4 Purpose of the Study

The objective of this study is to conduct a literature review using inductive and observational methods from qualitative research approaches. By comparing recent noteworthy literature from the preceding three years—which represent an era of continuous technological innovation—we can identify innovative strategies that startups and SMEs should adopt, instead of persistently relying on existing products to maintain market share.

To this end, we review and analyse the relevant literature to answer the following research questions:

- a) Where do the opportunities for technology entrepreneurship and innovation management lie?
- b) What is the relationship between technological innovation and entrepreneurship and new product development in 2020-2023?

2 LITERATURE REVIEW

2.1 Relationship Between Entrepreneurship and New Product Development

2.1.1 Impact of new product development on entrepreneurship

Entrepreneurial endeavors exhibit diversification across various formats. The pivotal role of new product development in entrepreneurial pursuits significantly influences entrepreneurs and startup ventures. New product development encompasses diverse formats, including the creation of online applications catering to daily telecommuting or online entertainment, offline iterations, research and development (R&D), and enhancements of physical products like furniture, home appliances, and electronic devices to fulfill public demands.

Proactive new product development provides entrepreneurs with numerous advantages. Cenamor and Frishammar [6] highlighted the importance of platform openness regarding open platform ecosystems such as the Google App Store and Apple Store. They also emphasize that entrepreneurs can secure innovation and competitive advantages by engaging in platform ecosystems and collaborating with other participants to develop complementary products. This underscores that entrepreneurs should emphasize cooperation with third-party participants within relevant platform ecosystems during new product development and adopt different innovation strategies at different stages.

Many fledgling entrepreneurs concentrate their entrepreneurial activities on emerging technology industries due to the perceived substantial business opportunities in the future. Additionally, a robust association is evident between high-tech entrepreneurship and innovation effectiveness. Previous studies identified a positive correlation between high-tech entrepreneurial activities and innovation effectiveness, with absorptive capacity serving as a moderator [7]. Consequently, entrepreneurs are advised to augment the absorption of important external knowledge to enhance the innovation effectiveness of their subsequent entrepreneurial activities.

As entrepreneurs typically start with small- to medium-sized businesses, previous studies on entrepreneurship have mostly focused on SMEs. In this context, entrepreneurial orientation and business model innovation play a significant mediating role in the performance of new product development. Entrepreneurial orientation inspires innovative thinking and creativity, whereas business model innovation translates innovations into business success [8]. Therefore, entrepreneurs must attach significant importance to innovative thinking and skills in incorporating business models during the process of new product development.

An escalating number of entrepreneurs are now of a younger demographic, comprising many who initiate new ventures during their collegiate or high school years. These youthful entrepreneurs exhibit a proclivity for greater daring and innovation, leveraging their business acumen to discern business prospects and market demands [9]. Consequently, entrepreneurs should harness the characteristics associated with youthfulness in new product development, adeptly discerning market and consumer needs.

Entrepreneurs ought to recognize the substantial impact of new product development on entrepreneurship. Thus, active engagement in new product development is vital for accruing innovative and competitive advantages. This involves collaborating with platform participants, enhancing external knowledge absorption, fostering innovative thinking, innovating business models, and capitalizing on their youthful vigor and business foresight.

Within entrepreneurship, leaders must possess a firm grasp of innovation management. The failure rate of ventures surges when entrepreneurs detach from the external environment and eschew innovative pursuits. According to Amaya et al. [10], innovation management encompasses processes, resource allocation, and collaborative teamwork essential for developing new products within an organization. Hence, formulating robust innovation strategies becomes pivotal. Entrepreneurs must engage with the external milieu to access market opportunities and craft pertinent innovation strategies, thereby preserving their competitive edge.

In new product development, team characteristics and dynamics also play a major role. Researchers have also addressed the relationship between entrepreneurial imagination and startup teams. Entrepreneurs' imagination is closely related to the conceptualisation process of startup teams and can inspire innovative thinking and the generation of ideas [11]. This study highlights the importance of entrepreneurial creativity and imagination in developing new products.

Presutti et al. [12] conducted an analysis on the mediating effects within the relationship evolution of social capital and product innovation, utilizing a Born-Global firm as a case study. They underscored the paramount importance of knowledge acquisition. The findings indicate that startups can enhance innovation in both new and existing products through the establishment of robust social capital networks and active involvement in knowledge acquisition processes. In summary, this study highlights the pivotal roles played by boundary spanning, team size, and functional diversity in the context of new product development teams. These factors, deemed essential for reinforcing team confidence [13], collectively contribute to fostering knowledge sharing, collaboration, and innovation. This, in turn, augments the confidence and performance levels of teams involved in the development of new products.

The process of new product development is intricately connected to entrepreneurship. As a result, entrepreneurs are urged to prioritize innovation management and strategy development. They should actively engage with the external environment to consistently assimilate innovative knowledge. Furthermore, entrepreneurs should focus on constructing robust social capital networks, leveraging their creativity and imagination to establish appropriately sized, boundary-spanning teams imbued with functional diversity. These measures are integral to enhancing performance and confidence in the realm of new product development.

2.2 Function of Innovation Management and Technology Management in Entrepreneurship and New Product Development

2.2.1 Open innovation and business model innovation

Open innovation is an innovation management approach that emphasizes collaboration and knowledge sharing between an organization and its external environment. However, excessive open innovation also poses certain risks. Entrepreneurs' achievements and knowledge can easily be plagiarized or imitated by their competitors. In the process of entrepreneurship and new product development, open innovation has a significant impact on firms' business model innovation.

Barrett et al. [14] conducted a focused investigation into the influence of entrepreneurial founders on open innovation practices within high-tech SMEs. They discerned that entrepreneurial founders play a pivotal role in guiding and shaping decisions throughout the open innovation process. These founders are compelled to disseminate knowledge and resources by actively networking with external partners, thus leading the organization in embracing open innovation practices. This underscores the crucial role of entrepreneurial founders in facilitating the innovation of business models. In an open innovation milieu, coherence and interconnectivity among diverse product categories can augment the viability of business model innovation [15]. This implies that, through collaborative exchanges of open innovation among entrepreneurs, firms have the opportunity to glean inspiration and insights from disparate product categories, thereby propelling business model innovation.

Aagaard [16] systematically explored avenues for cultivating innovative business models through open innovation competitions and engagement with student teams. The study unveiled that, through collaboration with external participants and student teams, organizations can harvest novel business model innovations stemming from varied perspectives and ideas. Open innovation competitions serve as an expansive platform, enabling firms to attract and amalgamate innovative thinking and ideas from diverse communities, thereby steering innovation and the evolution of business models.

In summary, open innovation significantly contributes to the innovation of business models. The leadership and decision-making skills of entrepreneurial founders emerge as pivotal factors in steering open innovation within an organization. Simultaneously, collaborative exchanges in an open innovation environment empower firms to glean inspiration and innovative insights spanning various categories of recently developed products, thereby expediting

innovation in business models. Additionally, open innovation competitions and student team engagements establish an open platform, enabling firms to cultivate the development of innovative business models.

2.2.2 Entrepreneur cognition, leadership, and organisational structure

Entrepreneurs' cognition, leadership, and the organizational structure of innovative and entrepreneurial activities are equally important factors that influence the course of entrepreneurship and new product development. In the following section, the links between these factors are examined by analysing the relevant literature.

The knowledge spillover theory of entrepreneurship suggests that entrepreneurs foster economic growth by commercialising new knowledge created by existing organizations, such as firms, research laboratories, and universities [17]. In particular, advanced technologies developed through intense R&D activities express advanced knowledge and are considered core resources for strengthening innovation. Consequently, researchers have focused on the effects of entrepreneurial cognition and leadership on knowledge spillover. They have found that the board of directors plays a key role in startups by providing knowledge and resources to facilitate innovation and knowledge spillover [18]. Entrepreneurs' cognitive characteristics and leadership skills are instrumental in board decisions and have significant implications for driving innovation and knowledge transfer.

Bunduchi et al. [19] examined the effect of the entrepreneur cognition framework in digital product innovation. The results revealed that the cognitive framework of entrepreneurs plays a key role in decision-making and actions during the innovation process of digital products. Entrepreneurs' cognitive frameworks comprise an awareness of technology, markets, and business models instrumental for startups to innovate in the digital environment.

Previous studies have emphasised that the consistency of entrepreneurial and alliance orientations have synergistic effects on new product development. Entrepreneurial orientation emphasizes innovation and risk-taking, whereas alliance orientation values collaboration and resource integration. The synergy between entrepreneurial and alliance orientations can contribute significantly to the success of new product development [10].

Moreover, several scholars have investigated the origins of capabilities and assessed the implications of resource allocation strategies and capability development for startup performance. The research findings underscore that the strategies for resource allocation and the development of capabilities exert a notable influence on a startup's performance trajectory. Specifically, adept resource allocation and robust capability development bolster a new firm's competitiveness and capacity for innovation, thereby fostering entrepreneurial endeavors and facilitating advancements in product development [20].

Finally, Agostini et al. [21] investigated the challenges and opportunities for management arising from the digitalisation of the innovation process. They found that the widespread use of digital technologies has transformed management needs and the manner in which innovation processes are conducted. Entrepreneurial managers must address the challenges posed by digitalisation and take advantage of the opportunities offered by digital technologies to contribute to the success of innovation activities and new product development.

In summary, the cognitive attributes, leadership styles, and organizational structures of entrepreneurs assume pivotal roles in both entrepreneurial activities and the development of new products. The cognitive characteristics and leadership skills of entrepreneurs wield influence over knowledge spillover and decision-making behaviors. Simultaneously, the configuration of organizational structures and the strategies employed for resource allocation impact the capacity for innovation and overall performance. Consequently, there is a compelling need for researchers to delve deeper into how entrepreneurs' cognition, leadership, and organizational structures can be optimized, thereby fostering the success of entrepreneurship and the advancement of new product development.

2.2.3 Innovation performance assessment and KPIs

In innovation management and new product development, it is critical to assess innovation performance and identify key performance indicators (KPIs). This section addresses the significance of innovation performance assessments and the related KPIs.

Innovation and entrepreneurship are not identical concepts. Innovation refers to the introduction of a new idea, method, or product into an organization, whereas entrepreneurship emphasizes putting these innovations into practice and generating business value. When assessing innovation performance, firms must clarify the difference between innovation and entrepreneurship and establish corresponding assessment indicators [22].

The assessment of innovation performance is essential during the entrepreneurial phase. Innovation is the process of transforming passion into practice, where the key is translating innovative ideas into actual business practices and achieving business targets. Assessing innovation performance requires a focus on the implementation of innovation projects, market performance, and creation of business value [23].

Nappi and Kelly [24] conducted a comprehensive review of Key Performance Indicators (KPIs) for evaluating innovation process performance. The scholars highlighted that pivotal indicators gauging the effectiveness of the innovation process encompass inputs, outputs, speed, quality, and impact. These metrics empower organizations to evaluate their innovation performance thoroughly, discern areas requiring enhancement, and devise judicious management strategies.

In summary, innovation performance assessment and the identification of KPIs are critically important for innovation management and new product development. Firms should clarify the differences between innovation and entrepreneurship, monitor the implementation of innovation projects and business practices, and assess them using appropriate KPIs. This helps the organization identify the effectiveness and value of innovation activities and make management decisions accordingly.

2.2.4 Employee-driven innovation in entrepreneurial teams

A burgeoning body of research within innovation management focuses on the strategies adopted by entrepreneurial founders in conjunction with the role and impact of employees in the innovation trajectory. This section expounds upon the concept of employee-driven innovation (EDI), its associated measurement tools, and preliminary validation outcomes.

Echebiri et al. [25] endeavored to clarify the EDI construct and formulate an assessment tool for its quantification. They adopted an integrative methodology by assimilating existing measurement tools pertaining to EDI-related concepts into their study. Employing exploratory and confirmatory factor analysis techniques, the researchers identified three dimensions of EDI: emergence and ideation exploration, idea generation, and idea development coupled with implementation. The instrument exhibited satisfactory reliability and validity.

The current study provides an essential tool for understanding EDI, which implies that employees are actively involved in the innovation process and offer new perspectives and ideas to facilitate development and implementation. The use of EDI as a measurement tool allows organizations to assess the level of EDI and take appropriate managerial actions to facilitate innovation.

2.3 Technological Entrepreneurship and Digitalisation

2.3.1 AI and big data in innovation research

The use of AI and big data in innovation research has received increasing attention from business organisations and the academic community. Many scholars have explored the impact of AI and big data on the innovation process from the perspectives of a systematic literature review and theoretical construction and proposed a vision for future research.

A recent systematic literature review conducted by Mariani et al. [26] analysed the intersection of AI and innovation research. By conducting a bibliometric analysis using 1,448 articles retrieved from literature databases, they revealed the main topics of AI and innovation research and their evolution over time. Through keyword co-occurrence and literature coupling techniques, they provided insights into AI and innovation research. Based on their review, they proposed an explanatory framework that elucidates the drivers and outcomes of AI adoption in innovation. They found that firms' adoption of AI in innovation is influenced by economic, technological, and social factors and that AI adoption significantly impacts firms' outcomes in terms of economic, competitive, and organisational innovation.

Scholars also closely follow innovation and entrepreneurship activities in China. Among the companies listed on the Science and Technology Innovation Board in China, the strategic choices of technical founders in the digital context affect their innovation performance. Scholars have scrutinized the annual reports of 124 corporations listed on China's Science and Technology Innovation Board. Using machine learning techniques, they quantified the digital transformation of these firms and established a moderated mediation model to probe the correlation between technical founders and innovation performance. The findings suggest that corporations with technical founders are more inclined to embrace digital transformation and demonstrate superior innovation performance. Regarding heterogeneity, the results revealed that corporations with technical founders outperform those with commercial or academic founders in digital transformation. Simultaneously, venture capital or private equity support positively moderates the relationship between firms' digital transformation and innovation performance [27]. These findings reveal the micro-level mechanisms of technical founders on firm innovation performance, which have practical implications for promoting firms' digital transformation and enhancing their technological innovation.

Sun and Liu [28] examined the relationship between business model design, big data analysis capability, and new product development performance. Although business models have become an essential area of research in management studies, confusion and limitations remain in the existing literature regarding how business models are designed to drive new product development. Furthermore, few empirical studies have examined the moderating effects of various aspects of a firm's learning capabilities on this relationship. The current study demonstrates the impact of investigating the novel and efficient design of business models on the performance of new product development and the moderating role of the analytic capabilities of big data.

The above literature reveals the potential effects of AI and big data on innovation research. Through systematic review and theoretical construction, researchers have revealed the significant effects of AI on the drivers and outcomes of the innovation process. Notably, the strategic choices of technical founders and the digital transformations of firms play crucial roles in driving innovation performances.

2.4 Challenges and Opportunities in the Digital Transformation and Innovation Process

Digital transformation faces several challenges and opportunities in its innovation process. In the existing research, scholars have discussed this issue in depth and provided many valuable insights.

Digital innovation is complex. Agostini et al. [21] addressed challenges and opportunities from a management perspective. They pointed out that the rapid development of digital technologies has significantly improved many business processes and played an important role in the field of innovation. To understand this field better, researchers have divided it into three key topics: innovation inputs, processes, and outcomes.

Silva et al. [29] examined the application of the lean startup methodology to opportunity development. Lean startup refers to an entrepreneurial methodology designed to help entrepreneurs build and manage startups more effectively. It emphasizes rapid iteration, continuous learning, and flexible adaptation to validate the entrepreneurial hypotheses and facilitate product development. Silva et al. [29] paid special attention to startups in different technological communities

in Brazil. They investigated nine Brazilian startups in biotechnology, engineering, and software using qualitative data collection method and analysis. The results showed that the startups adopted the tools and practices of the lean startup methodology to conduct opportunity development activities such as business model validation. They also found that these startups responded to the limitations of contextual factors through the systematic adoption of the lean startup methodology by integrating them with other innovative strategies and practices in the early stages.

Upadhyay et al. [30] explored the impact of digital entrepreneurship and entrepreneurial orientation on family firms' intention to adopt AI. They used structural equation modelling and validated the model based on data from 631 respondents. The results showed that culture, flexible design, and entrepreneurial and technology orientations had significant effects on the intention to adopt AI and that firm creativity played a partially mediating role in the process. Their study has important implications for entrepreneurship, family business research, and theoretical developments in AI.

Collectively, the above studies show that digital transformation poses significant challenges and opportunities in the innovation process. Researchers have emphasised the value of digital technology in innovation and explored the application of the lean startup methodology and AI in different contexts. These studies provide valuable insights for researchers on how to address challenges and exploit opportunities for digital transformation.

2.5 Innovation Ecosystem and Cooperation Network

2.5.1 Collaborative innovation between academic and industrial communities

University-industry collaboration has served as a foundational pillar for supporting entrepreneurial endeavors. However, the intricacy and significance of collaborative innovation between academic and industrial communities are profound.

Gimenez-Fernandez et al. [31] compared the innovation performance of emerging innovative startups with that of traditional small firms. They found that emerging firms have barriers related to their novelty and size, while traditional small firms perform better in innovation because of their experience and accumulated resources. This suggests that, in collaborative innovation, academic and industrial communities can learn from the experiences of traditional small firms and provide support and guidance to emerging innovative startups.

Gimenez-Fernandez et al. [31] conducted a comparative analysis of the innovation performance between emerging innovative startups and traditional small firms. Their findings indicate that emerging firms encounter barriers associated with their novelty and size, whereas traditional small firms excel in innovation due to their accrued experience and available resources. Consequently, in the realm of collaborative innovation, there exists an opportunity for academic and industrial communities to glean insights from the experiences of traditional small firms and extend support and guidance to nascent innovative startups.

Auerswald and Dani [32] delved into the intricate relationship between entrepreneurial opportunities and specialization within economic ecosystems. Their research underscores that entrepreneurs play a pivotal role in fostering collaborative innovations by identifying and capitalizing on opportunities within a given economic ecosystem, coupled with a strategic specialization in related domains. This underscores the critical significance of fostering interaction between academic and industrial communities to not only bolster and nurture entrepreneurial opportunities but also to facilitate specialization in interconnected fields.

Additionally, there is a strong link between innovation management and organisational behaviour. Research has emphasised the importance of human factors in innovation management and proposed an approach that combines innovation management and organisational behaviour [33]. This implies that academic and industrial communities can draw on the theory and practice of organisational behaviour and apply them to innovation management to facilitate collaborative innovation.

Giasolli et al. [34] identified management technology and innovation and technology entrepreneurship centres of excellence that guide and support innovation. They highlighted the importance of collaboration between academic and industrial communities to jointly drive the development of management technologies and innovation. Furthermore, such collaboration can foster centres of excellence to contribute to the growth of innovation ecosystems.

Subsequently, researchers have revealed the impact of information availability on technology entrepreneurship through long-term analyses. The findings show how information availability affects the process and performance of technology entrepreneurship [35]. This warns academic and industrial communities that they should prioritise information access and sharing to improve innovation effectiveness and collaborative innovation outcomes.

Lu and Dimov [36] explored the relationship between entrepreneurship and intra-firm growth using a system dynamics model. Their study revealed the effect of entrepreneurship on the intra-firm growth process and highlighted that academic and industrial communities can work together to promote an organisational environment with an entrepreneurial culture and growth orientation.

Fan et al. [37] directed their attention towards habitual entrepreneurial behavior within digital platform ecosystems. They constructed a time-centric learning model to elucidate the learning processes of entrepreneurs, drawing insights from their experiences in past software projects. The study delved into the nexus between these experiences and the consequential impact of habitual entrepreneurial behaviors on collaborative innovation. Special emphasis was placed on fostering collaboration between academic and industrial communities within the digital platform ecosystem, with a view to endorsing innovative practices and cultivating habitual entrepreneurial behaviors.

In the innovation and entrepreneurship processes, accelerating innovation through minimal and adaptive coordination without compromising the innovation process poses a significant challenge. Scholars have examined hackathons, and

their findings reveal how this coordination approach can play a positive role in the innovation process. Thus, academic and industrial communities should value collaborative approaches and strategies to facilitate the rapid development of innovation [38].

The preceding literature highlights the pivotal roles played by academic and industrial communities in collaborative innovation. Academic research provides both theoretical guidance and practical experience to the industry. Furthermore, it facilitates synergy and innovation in innovation management, the identification of entrepreneurial opportunities and specialisation, the application of organisational behaviour, access to technological information, habitual entrepreneurial behaviour in the digital platform ecosystem, and optimisation of the coordination approach. Industrial requirements and practices have contributed to the advancement of research and theories in the academic community. Consequently, collaborative innovation between academic and industrial communities mutually reinforces, laying a solid foundation for the prosperous and sustainable development of innovation ecosystems.

2.5.2 Entrepreneurial teams, alliances, and resource allocation

In new product development, consistent positioning of entrepreneurial teams and alliances is critical to success (Rivas et al., 2020). Rivas et al. (2020) found that differences between the orientation of the entrepreneurial teams and that of the alliances may lead to conflicts in resource allocation and breakdowns in partnerships. Therefore, firms should strive to achieve alignment between the entrepreneurial team and the alliance to contribute to the success of new product development. Effective resource-allocation strategies are essential for the capability development and performance of new ventures [20]. Different types of resourcing strategies, such as diversified and focused resource allocation, may affect firm performance to varying degrees. Consequently, startups should carefully select and manage resources to support the development of capabilities and achieve favourable performance.

Simultaneously, entrepreneurship can boost the development of local areas in various ways [39]. One such way is to achieve rapid growth through rapid expansion and sprawling, and another is to achieve sustainable growth through steady development and deep cultivation. This depends on the specific local contexts and resource conditions. Entrepreneurship can create jobs, promote economic growth, and achieve sustainable development in local communities. The 'Innovation Systems Roadmap' constitutes a foundational innovation concept, providing a crucial framework for organizations to incorporate future-oriented thinking into their decision-making processes. This roadmap empowers organizations to identify and assess potential future scenarios, comprehend the impact of these scenarios on their strategic goals, and devise pertinent strategies and actions to leverage emerging opportunities. It has been argued that traditional approaches to strategic decision-making tend to concentrate on the past and present, neglecting the importance of anticipating and preparing for future change [40].

Enhancing the confidence of new product development teams is crucial [13]. Team boundary spanning, size, and functional diversity significantly contribute to enhancing team confidence. Team boundary spanning facilitates information flow and knowledge sharing; moderate team size provides resources and support, while functional diversity fosters innovation and diverse perspectives.

Innovation ecosystems and collaborative networks address crucial aspects: maintaining consistency in the positioning of entrepreneurial teams and alliances, implementing effective resource allocation strategies, ensuring local sustainability, and bolstering confidence within new product development teams. These interrelated factors are crucial for firms' innovation and development.

3 METHODOLOGY

3.1 Research Process

Employing a qualitative research approach, this study explores the management and strategic aspects of innovation within the context of technological entrepreneurship and new product development. Initially, the Scimago journal ranking database was used to retrieve relevant journals, focusing on the primary categories of business, management, and accounting and the subcategory of technological innovation and management without any geographical limitations. This ensured comprehensive coverage of the pertinent global literature.

Subsequently, we identified authoritative and professional journals from the Social Sciences Citation Index zones one and two, which align closely with the research fields of innovation entrepreneurship management and new product development. During this selection process, we meticulously assessed each journal's metrics, including the impact factor, CiteScore, Source-Normalized Impact per Paper, Field-Weighted Citation Impact, and h-index, to ensure that the literature review was grounded in the most authoritative and professional sources.

Finally, eleven journals were chosen for the systematic literature review. This approach guaranteed a thorough examination of each piece of literature within the selected journals, facilitating the extraction of key insights related to technological entrepreneurship, new product development, innovation management, and strategies. The focus was on the theoretical frameworks, research methodologies, primary findings, and conclusions within these sources, facilitating a comprehensive understanding of the respective research fields.

3.2 Literature Research Collection

In this literature review, a comprehensive literature collection strategy focusing on 11 authoritative and professional journals was employed. The focus was on articles published between 2020 and 2023, facilitating comprehensive insight into the latest research trends and future trajectories in the realm of innovation entrepreneurship management

and new product development. The searches in these 11 journals were guided by the following keywords: 'entrepreneurship and new product development', 'innovation management', and 'technology management'. These keywords were selected to maximize the relevance of the search results to the study's research topic.

Literature collection and screening occurred in two stages. Initially, 324 studies pertinent to the research topic were identified (Figure 1). This broadened the scope of the research to the greatest extent possible, facilitating a comprehensive understanding of the current research landscape and developmental trends in this field. In the second stage, the selection was refined to 40 pieces of literature with the greatest relevance and significance to the research topic. This step was intended to deepen the research, allowing for an in-depth analysis and discussion of the selected literature. We undertook a systematic review of these sources, focusing on aspects including, but not limited to, the theoretical framework, research methods, main findings, and conclusions.

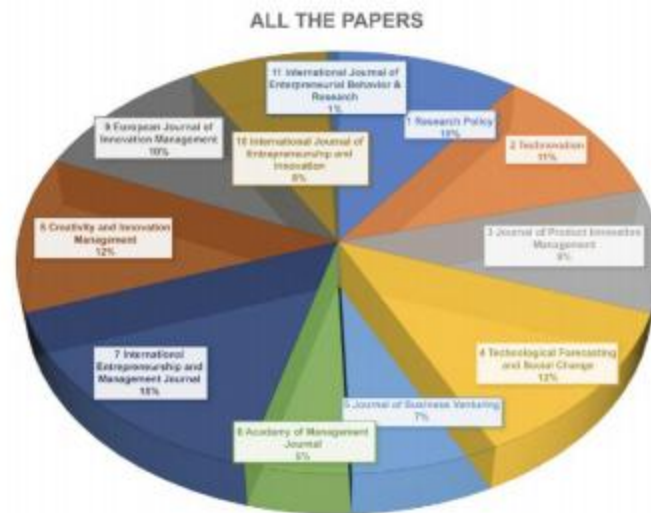


Figure 1 Eleven Authoritative Journals were Searched for Studies Pertinent to the Research Topic (Total: 324 Papers)

4 DISCUSSION AND CONCLUSION

This study undertook an in-depth exploration and rigorous analysis of the findings and results of an extensive collection of 40 studies, each from diverse sub-fields of innovation and entrepreneurship.

Discussions on technology entrepreneurship and new product development uncovered a compelling argument that academia and industry have a decisive impact on the process of collaborative innovation. Academic research contributes to theoretical frameworks and tangible experiences by acting as a catalyst in advancing innovation management, unearthing entrepreneurial opportunities, specialisation, and harnessing organisational behaviours. This nexus further facilitates the procurement of technological information and optimizes entrepreneurial activities and modes of coordination within the digital platform ecosystem, fostering an environment conducive to collaboration and innovation. Consequently, the industry's inherent requirements and applied practices continually propel the evolution of academic research and its underlying theories. Academia and industry exist in a state of mutual enhancement and interdependence, forming a robust foundation that underpins the dynamic and sustainable proliferation of the innovation ecosystem.

In the ambit of new product development, the alignment between the entrepreneurial team's orientation and that of the alliance proves to be a decisive factor in dictating success or failure. This discourse further posits that heightened self-assuredness stemming from entrepreneurial success profoundly affects the trajectory and outcomes of technological entrepreneurship. This underscores the paramount importance of entrepreneurs focusing on the procurement and dissemination of information, which, in turn, augments the efficiency of innovation and the fruition of collaborative innovation.

Meticulous examination of the relevant literature highlighted the pivotal role of entrepreneurship in the internal growth process of enterprises. This accentuates the potential for academia and industry to jointly foster an entrepreneurial culture and an organisational environment oriented towards growth. The significance of habitual entrepreneurial behaviour within the digital platform ecosystem, along with its contribution to the process of collaborative innovation, warrants attention. This highlights the imperative for academia and industry to engage in collaborative efforts to scrutinise the digital platform ecosystem, bolstering innovation and habitual entrepreneurial behaviour.

Amid the advancing tides of globalisation and technological progress, innovation and entrepreneurship emerge as pivotal contributors to economic growth. In this context, the nexus between the academic and industry sectors has drawn considerable attention. This study embarked on an extensive literature review, combined with analytical and empirical examinations, to delineate the synergies and roles of academia and industry in bolstering innovation and entrepreneurship trajectories.

Our research emphasizes the pivotal roles of academia and industry within the innovation and entrepreneurship landscape. Particularly in the context of new product development, academia provides theoretical guidance, technological research, and talent development, while industry offers market insights, avenues for application, and financial support. This reciprocal relationship not only facilitates the transition from conceptualizing technology to implementing practical applications but also expedites the introduction and market acceptance of new products.

Furthermore, we emphasize the importance of university incubators. In today's highly competitive environment, reliance solely on academic research is inadequate. It is essential for university incubators to establish collaborations with leading industry enterprises, thereby aiding in the realization and integration of technological innovations into the market. Such an approach not only broadens the practical scope for scholars and professionals but also strengthens the alignment of educational institutions and incubators with evolving market dynamics, mitigating potential obsolescence. In conclusion, the synergistic interaction between academia and industry significantly contributes to the perpetuation of socio-economic progress. Their collaborative efforts can enhance the effectiveness of innovations while establishing a resilient groundwork for both innovation and entrepreneurial endeavors.

5 LIMITATIONS AND FUTURE DIRECTIONS

This study has specific limitations, notably the lack of geographical constraints in the search for journals and literature, which might have impacted the comprehensiveness and depth of the research findings. Additionally, this study did not analyze the distinct psychological states of first-time and serial entrepreneurs, an area warranting further investigation. Moreover, entrepreneurial risk assessment, another important research avenue, was not extensively examined in this study. Therefore, future research should comprehensively address these aspects to mitigate the limitations of this study.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Yousaf Z, Palazzo M. Influential role of homophily on innovative work behavior: Evidence from innovation management of SMEs. *International Entrepreneurship and Management Journal*, 2023, 19: 1239-1256.
- [2] Modina M, Capalbo F, Sorrentino M, et al. Innovation ecosystems: A comparison between university spin-off firms and innovative start-ups. Evidence from Italy. *International Entrepreneurship and Management Journal*, 2023, 19: 1-31.
- [3] Wróbel AE, Johansen MK, Jørgensen MS, et al. Facilitating creativity: Shaping team processes. *Creativity and Innovation Management*, 2021, 30: 742-762.
- [4] Zhang Z, Zeng J, Xia C, et al. Information resource management researchers' thinking about the opportunities and challenges of AIGC. *Journal of Library and Information Sciences in Agriculture*, 2023, 35: 4-28.
- [5] Sordi JOD, Nelson RE, Meireles M, et al. A longitudinal study of the creation methods used by entrepreneurs to develop new products and services. *International Journal of Entrepreneurship and Innovation Management*, 2020, 24: 482-502.
- [6] Cenamor J, Frishammar J. Openness in platform ecosystems: Innovation strategies for complementary products. *Research Policy*, 2021, 50: 104148.
- [7] Chung D, Jung H, Lee Y. Investigating the relationship of high-tech entrepreneurship and innovation efficacy: The moderating role of absorptive capacity. *Technovation*, 2022, 111: 102393.
- [8] Ferreras-Méndez JL, Olmos-Peñuela J, Salas-Vallina A, et al. Entrepreneurial orientation and new product development performance in SMEs: The mediating role of business model innovation. *Technovation*, 2021, 108: 102325.
- [9] Grilli L. Entrepreneurship and new product development: Exploring the "advantage of youth" and "business acumen" views. *Journal of Product Innovation Management*, 2022, 39: 662-685.
- [10] Amaya Rivas A, Chen Y-C, Yang T-K. Entrepreneurial and alliance orientation alignment in new product development. *Technological Forecasting and Social Change*, 2020, 153: 119916.
- [11] Kier AS, McMullen JS. Entrepreneurial imaginativeness and new venture ideation in newly forming teams. *Journal of Business Venturing*, 2020, 35: 106048.
- [12] Presutti M, Cappiello G, Johanson M. Analysing social capital and product innovativeness in the relationship evolution of born-global companies the mediating role of knowledge acquisition. *International Entrepreneurship and Management Journal*, 2022, 18: 1347-1371.
- [13] Carbonell P, Escudero A. Boosting the confidence of new product development teams: The role of team boundary spanning, team size and functional diversity. *Creativity and Innovation Management*, 2022, 32: 100-116.
- [14] Barrett G, Dooley L, Bogue J. Open innovation within high-tech SMEs: A study of the entrepreneurial founder's influence on open innovation practices. *Technovation*, 2021, 103: 102232.
- [15] Soublière J-F, Lo JY, Rhee EY. Coherence within and across categories: The dynamic viability of product categories on Kickstarter. *Academy of Management Journal*, 2023, 2022: 13564.
- [16] Aagaard A. Ready, set, innovate! Developing business model innovation through open innovation contests and student teams. *International Journal of Entrepreneurship and Innovation Management*, 2022, 26: 318-339.

- [17] Li C, Isidor R, Dau LA, et al. The more the merrier? Immigrant share and entrepreneurial activities. *Entrepreneurship Theory and Practice*, 2018, 42: 698-733.
- [18] Baum CF, Löffel, Stephan A, et al. Innovation by start-up firms: The role of the board of directors for knowledge spillovers. *Research Policy*, 2022, 51: 104375.
- [19] Bunduchi R, Crişan-Mitra C, Salanță I-I, et al. Digital product innovation approaches in entrepreneurial firms: The role of entrepreneurs' cognitive frames. *Technological Forecasting and Social Change*, 2022, 175: 121343.
- [20] Symeonidou N, Leiponen A, Autio E, et al. The origins of capabilities: Resource allocation strategies, capability development, and the performance of new firms. *Journal of Business Venturing*, 2022, 37: 106208.
- [21] Agostini L, Galati F, Gastaldi L. The digitalization of the innovation process: Challenges and opportunities from a management perspective. *European Journal of Innovation Management*, 2019, 23: 1-12.
- [22] Kahn K. Innovation is not entrepreneurship, nor vice versa. *Journal of Product Innovation Management*, 2022, 39: 467-473.
- [23] Hölzle K. No innovation without entrepreneurship: From passion to practice. *Journal of Product Innovation Management*, 2022, 39: 474-477. DOI: 10.1111/jpim.12635
- [24] Nappi V, Kelly K. Review of key performance indicators for measuring innovation process performance. *International Journal of Entrepreneurship and Innovation Management*, 2022, 26: 85-109.
- [25] Echebiri C, Engen M, Amundsen S. Employee-driven innovation: Conceptualisation, scale development and preliminary validation. *International Journal of Entrepreneurship and Innovation Management*, 2021, 25: 233-255.
- [26] Mariani MM, Machado I, Magrelli V, et al. Artificial intelligence in innovation research: A systematic review, conceptual framework, and future research directions. *Technovation*, 2023, 122: 102623.
- [27] Li ZG, Wu Y, Li YK. Technical founders, digital transformation and corporate technological innovation: Empirical evidence from listed companies in China's STAR market. *International Entrepreneurship and Management Journal*, 2023, 19: 1-26.
- [28] Sun B, Liu Y. Business model designs, big data analytics capabilities and new product development performance: Evidence from China. *European Journal of Innovation Management*, 2021, 24: 1162-1183.
- [29] Silva D, Ghezzi A, Barbosa De Aguiar R, et al. Lean startup for opportunity exploitation: Adoption constraints and strategies in technology new ventures. *International Journal of Entrepreneurial Behaviour & Research*, 2021, 27: 944-969.
- [30] Upadhyay N, Upadhyay S, Al-Debei M, et al. The influence of digital entrepreneurship and entrepreneurial orientation on intention of family businesses to adopt artificial intelligence: Examining the mediating role of business innovativeness. *International Journal of Entrepreneurial Behavior & Research*, 2022, 29: 80-115.
- [31] Gimenez-Fernandez EM, Sandulli FD, Bogers M. Unpacking liabilities of newness and smallness in innovative start-ups: Investigating the differences in innovation performance between new and older small firms. *Research Policy*, 2020, 49: 104049.
- [32] Auerswald P, Dani L. Entrepreneurial opportunity and related specialization in economic ecosystems. *Research Policy*, 2022, 51: 104445.
- [33] Weiss M, Baer M, Hoegl M. The human side of innovation management: Bridging the divide between the fields of innovation management and organizational behavior. *Journal of Product Innovation Management*, 2022, 39: 283-291.
- [34] Giasolli R, Groen DA, Haak R, et al. Identifying management of technology and innovation (MOT) and technology entrepreneurship (TE) centers of excellence. *Technological Forecasting and Social Change*, 2021, 173:121075.
- [35] Yeganegi S, Laplume AO, Dass P. The role of information availability: A longitudinal analysis of technology entrepreneurship. *Technological Forecasting and Social Change*, 2021, 170: 120910.
- [36] Lu J, Dimov D. A system dynamics modelling of entrepreneurship and growth within firms. *Journal of Business Venturing*, 2023, 38: 106285.
- [37] Fan T, Schwab A, Geng X. Habitual entrepreneurship in digital platform ecosystems: A time-contingent model of learning from prior software project experiences. *Journal of Business Venturing*, 2021, 36: 106140.
- [38] Lifshitz-Assaf H, Lebovitz S, Zalmanson L. Minimal and adaptive coordination: How Hackathons' projects accelerate innovation without killing it. *Academy of Management Journal*, 2020, 64: 684-715.
- [39] Karp R. Gaining organizational adoption: Strategically pacing the position of digital innovations. *Academy of Management Journal*, 2023, 66: 773-796.
- [40] Vettorello M, Eisenbart B, Ranscombe C. The innovation system roadmap: A novel approach to instil futures - oriented reasoning in strategic decision making. *Creativity and Innovation Management*, 2021, 31: 5-18.

STOCK MARKET PREDICTION STRATEGY BASED ON REGULARIZED MULTIPLE ENSEMBLE LEARNING

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Abstract: The capital market has always aimed to use human intelligence algorithms to predict stock trends. However, due to the stock market's complexity and variability, accurately predicting the stock market and enhancing profits remains challenging and crucial. Internal and external factors affect the stock market, making it difficult to forecast its movements with precision. To improve the prediction accuracy, this paper proposes a Boosting ensemble learning method with regularized weights, which combines support vector Machine (SVM), decision tree and ridge regression in a gradient boosting framework. The algorithm has been recognized for improving prediction performance by exploiting the strengths of a single model and mitigating its weaknesses. A new method of model weight adjustment has been proposed to speed up the training speed of Meta-learning. This study uses ensemble learning to capture complex patterns and trends in stock market data, aiming to build a robust prediction model and improve generalization ability. We evaluate our model by back-testing different stocks in the US. Our model achieves significant prediction accuracy improvement. Compared with the single model method, the MSE and MAE of the back-test data and the actual trend are significantly reduced, and the volatility is also significantly improved.

Keywords: Ensemble learning; Boosting; Regularized weights; SVM; Meta-learner; Ridge regression

1 INTRODUCTION

The unpredictability of financial markets and the large risks involved in investment decisions highlight the importance of accurately predicting the stock market. Traditional statistical methods such as time series forecasting methods and regression forecasting methods, including ARIMA [1], prophet [2] and Exponential Smoothing (ETS) [3], capture the trend change from the perspective of statistics. While linear regression, ridge regression [4] and lasso regression [5] assume the stock trend as a regression problem to predict, machine learning algorithms ensure higher accuracy by capturing complex patterns in historical data. In the latest results, deep learning proposes deep learning prediction methods based on LSTM [6] and CNN [7] to predict stock trends by capturing long-term dependencies in time series data [8].

However, a single classifier system is often inadequate when dealing with the multifaceted nature of the stock market. Ensemble learning addresses this gap by combining multiple classifiers to form more effective predictive entities. Specifically, ensemble methods like bagging, boosting, and stacking have been shown to outperform individual classifiers in various domains, including stock market prediction. Boosting, a sequential ensemble method that focuses on successively correcting the previous error, has been particularly successful. Gradient boosting is a boosting algorithm that iteratively improves the model by highlighting instances that were misclassified by previous iterations. By integrating support vector machine, decision tree and ridge Regression into Gradient Boosting Regression (GBR) [9], the complementary advantages of these algorithms are used to improve the prediction accuracy and reliability.

The study uses ensemble learning to overcome the limitations of a single algorithm and aims to provide a comprehensive solution for stock market forecasting. This paper proposes an ensemble learning prediction model based on Boosting method to regularize model weights. The model includes decision tree model, Ridge Regression model and Support Vector Regression model [10]. At the same time, we propose a model training method that can speed up the Meta-learner by regularizing the model weight parameters and integrate it into our ensemble learning Meta-Learner [11]. The experimental results show that our regularized Weighted Ensemble Learner achieves good results in stock prediction tasks. The MSE and MAE of the backtest data and the actual trend are significantly reduced, and the maximum retrace, and volatility perform well. Our method further makes progress on the stock market prediction problem.

Our contributions as follows,

- We designed an ensemble meta-learner based on decision tree model, ridge Regression model and Support Vector Regression model for stock prediction problem.
- We propose a method to regularize the parameter adjustment between Meta-learner baseline models, which effectively improves the iterative training time of ensemble learning.

2 RELATED WORK

2.1 Traditional Stock Forecasting Methods

Stock market prediction has long been a significant area of interest for researchers and practitioners due to its potential for substantial financial gains and the inherent challenges it presents. Traditional methods for stock market prediction, including technical analysis, fundamental analysis, time series analysis, and the random walk theory, have laid the foundation for understanding and forecasting stock price movements.

Technical analysis involves studying past market data, primarily price and volume, to identify patterns and make predictions about future price movements. The underlying assumption of technical analysis is that historical price movements tend to repeat themselves due to market psychology. Key tools and techniques in technical analysis include candlestick charts, moving averages, and the relative strength index (RSI) [12]. Candlestick charts display the open, close, high, and low prices for a given period, helping traders identify patterns and potential reversals. Moving averages, such as the simple moving average (SMA) and exponential moving average (EMA), help smooth out price data to identify trends and reversals by averaging a stock's price over a specific period. The RSI measures the speed and change of price movements to identify overbought or oversold conditions [13].

Fundamental analysis assesses a stock's intrinsic value by examining related economic, financial, and other qualitative and quantitative factors. The goal is to determine a company's actual worth and predict future stock price movements based on this assessment. Key components of fundamental analysis include financial statements, industry conditions, and macroeconomic indicators. Analysis of the balance sheet, income statement, and cash flow statement helps evaluate a company's financial health and profitability. Industry conditions involve studying market trends, competition, and the regulatory environment to understand a company's market position and potential. Macroeconomic indicators, such as GDP growth rates, inflation, and unemployment rates, provide insights into the broader economic environment that can impact a company's performance [14].

Time series analysis is a statistical method used to analyze time-ordered data points to identify patterns and predict future values. Common time series models include autoregressive (AR) models, moving average (MA) models, and autoregressive integrated moving average (ARIMA) models [1]. AR models predict future values based on past values, assuming that current values are a linear combination of past values. MA models predict future values based on past error terms, assuming that current values are a linear combination of past errors. ARIMA models combine AR and MA models and are suitable for non-stationary time series data, transforming non-stationary data into stationary data through differencing [15].

2.2 Machine Learning Methods in Stock Forecasting

Machine learning has revolutionized the field of stock forecasting by providing sophisticated tools to model and predict complex market behaviors. This section reviews some of the most widely used machine learning methods in stock forecasting, including traditional algorithms, deep learning techniques, and ensemble methods.

2.2.1 Linear regression

Linear regression is one of the simplest and most interpretable models for predicting stock prices. It models the relationship between a dependent variable (stock price) and one or more independent variables (predictors) by fitting a linear equation to the observed data. However, its assumption of linearity often limits its performance in capturing the complex, nonlinear patterns in stock data [16].

2.2.2 Support Vector Machines (SVM)

SVMs are powerful for classification and regression tasks. They work by finding the hyperplane that best separates different classes in the feature space [17]. In stock forecasting, SVMs are used to predict stock price trends or classify stock movements (upward or downward). Their ability to handle high-dimensional data and prevent overfitting makes them popular in this domain.

2.2.3 Decision Trees and Random Forests

Decision trees split the data into branches to make predictions based on the values of the input features [18]. Random forests, an ensemble of decision trees, improve the prediction accuracy by averaging the predictions of multiple trees [19]. They are robust to overfitting and can handle large datasets with many features, making them suitable for stock forecasting.

2.2.4 Recurrent Neural Networks (RNN)

RNNs are specifically designed for sequential data, making them ideal for time series forecasting such as stock prices. They maintain a hidden state that captures information from previous time steps, enabling them to model temporal dependencies. Long Short-Term Memory (LSTM) networks, a type of RNN, are particularly effective in handling long-term dependencies and mitigating the vanishing gradient problem [20].

2.3 Ensemble Learning Method

In the field of machine learning, ensemble learning methods are widely used due to their ability to improve model performance and stability. Traditional time series analysis methods (e.g., ARIMA and GARCH) and statistical models (e.g., multiple regression analysis and support vector machines) often struggle with capturing complex market dynamics and nonlinear relationships [21] [22]. With advancements in machine learning, particularly deep learning models such

as LSTM and CNN, researchers have achieved significant results in stock prediction [6] [23]. However, these methods still face challenges such as overfitting and poor adaptability to market fluctuations.

Ensemble learning methods can effectively overcome the limitations of a single model by building multiple models and combining their prediction results. Common ensemble learning methods include Bagging and Boosting. Bagging, such as random forests, improves the accuracy and stability of models by building multiple decision trees and combining their predictions. Boosting methods such as AdaBoost [24], GBM [25], XGBoost [26], LightGBM [27], and CatBoost [28] optimize the overall model performance by gradually adding weak classifiers, especially when dealing with large-scale data and classification features.

In addition, stacking generalization and Voting are also commonly used ensemble methods. Stacked generalization improves prediction accuracy by training multiple base models and using a meta-model to combine the predictions of these base models [11]. The voting method uses hard voting or soft voting to carry out majority voting or weighted average of the prediction results of multiple models [29]. Blending is similar to Stacking, but typically only one validation set is used to train the meta-model without cross-validation [30]. Bagged Boosting combines the advantages of Bagging and Boosting and improves the robustness of the model by resampling the data and training with Boosting [31]. Bayesian Model Averaging (BMA) uses Bayesian method to weighted average multiple models, which makes the prediction results of the model more reliable [32].

3 METHODOLOGY

In this section, we will first introduce three baseline models: Decision Tree Regressor, Ridge Regressor, and Support Vector Regressor. Then we will introduce the Regularization Weighted Meta Learner used to train the Meta-learner.

3.1 Decision Tree Regressor

Decision Tree Regressors (DTR) are non-parametric, supervised learning algorithms used for regression tasks that partition the data into subsets based on feature value conditions, forming a tree-like structure. The methodology for training a Decision Tree Regressor involves several key steps:

3.1.1 Tree construction

Decision Tree Regressors (DTR) are non-parametric, supervised learning algorithms used for regression tasks that partition the data into subsets based on feature value conditions, forming a tree-like structure. The methodology for training a Decision Tree Regressor involves several key steps:

$$MSE_m = \frac{1}{N_m} \sum_{i \in N_m} (y_i - \hat{y}_m)^2$$

where N_m is the number of observations in node N_m , y_i is the actual value of the i -th observation, and \hat{y}_m is the predicted value for the observations in node m , typically taken as the mean of the target values within the node.

3.1.2 Splitting criterion

The decision on how to split the data at each node is based on the Reduction in Impurity (RI), which is calculated as the difference in the impurity measure before and after the split. For a potential split s that partitions the data into left and right nodes, L and R , the Reduction in Impurity is given by:

$$RI(s) = I_{\text{parent}} - \left(\frac{N_L}{N} \times I_L + \frac{N_R}{N} \times I_R \right)$$

where I is denoted the impurity, N is the total number of observations at the parent node, N_L and N_R are the number of observations in the left and right nodes respectively, and Impurity I_L and Impurity I_R are the impurity measures of the left and right nodes, calculated similar to MSE_m for each node.

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3.1.2 Pruning:

To prevent overfitting, the tree may be pruned by removing branches that have little power to classify instances. This can be done using cost-complexity pruning, which introduces a complexity parameter, α , that penalizes the tree size. The goal is to find the subtree that minimizes the following cost-complexity function:

$$R_\alpha(T) = R(T) + \alpha \times |Leaves|$$

where $R(T)$ is the total misclassification rate of the tree T , $|Leaves|$ is the number of terminal nodes in the tree, and $\alpha \geq 0$ is the complexity parameter.

3.2 Ridge Regressor

Ridge Regression is a supervised learning algorithm specifically for regression that aims to solve multicollinearity problems and reduce the risk of model overfitting by introducing a regularization term. The methodology of ridge regression is described in detail in this section.

Ridge regression improves the fit of the model to the data by adding an L2 regularization term to the ordinary least squares method. This regularization term penalizes the size of the model coefficients, preventing them from becoming too large during fitting. The objective function for ridge regression can be expressed as follows.

$$RSS_{\text{ridge}}(w) = \sum_{i=1}^N (y_i - w^T x_i)^2 + \lambda \sum_{j=1}^p w_j^2$$

Where N is the number of samples, y_i is the target variable for the i -th observation, x is the feature vector for the i -th observation, w is the vector of model coefficients, p is the number of features, and n is the number of features. λ is the regularization strength parameter.

The regularization parameter λ controls the influence of the regularization term. When $\lambda = 0$, ridge regression is equivalent to ordinary least squares regression. As the value of λ increases, the penalty on the coefficients becomes stronger and the complexity of the model decreases, reducing the possibility of overfitting.

The training process of ridge regression models involves minimizing a loss function with a regularization term. This can be done by solving the following optimization problem: $\min_w \{RSS_{\text{ridge}}(w)\}$ By differentiating the loss function and setting it equal to zero, we can find an optimal set of coefficients w to achieve the best fit on the training data.

The closed-form solution of ridge regression can be obtained directly by matrix operations with the following formula.

$$w = (X^T X + \lambda I)^{-1} X^T y$$

X is the design matrix, I is the identity matrix, and y is the target variable vector.

3.3 Support Vector Regressor

Support Vector Regressor (SVR) is a regression analysis method based on Support Vector Machine (SVM). SVR looks for a hyperplane in a high dimensional space to maximize the edges of this hyperplane while keeping the error of all data points within a certain threshold. The methodology of SVR is detailed in this section. The basic idea of SVR is to find a linear function in the feature space such that the gap between the predicted value and the actual value is as small as possible, while ensuring that the complexity of the model is under control. Specifically, this optimization problem can be formulated as follows,

$$\begin{aligned} & \min_{w, b, \xi, \xi^*} \frac{1}{2} \|w\|^2 + C \sum_{i=1}^N (\xi_i + \xi_i^*) \\ & \text{subject to } \begin{cases} y_i - (w^T \phi(x_i) + b) \leq \epsilon + \xi_i, \\ (w^T \phi(x_i) + b) - y_i \leq \epsilon + \xi_i^*, \\ \xi_i, \xi_i^* \geq 0, i = 1, 2, \dots, N \end{cases} \end{aligned}$$

Where w is the normal vector of the hyperplane, b is the bias term, C is the regularization parameter, and ϵ is the threshold of the insensitive loss function. ξ and ξ^* are loose variables, and ϕ is a function that maps to a higher dimensional space.

In SVR, kernel functions are usually used to deal with nonlinear problems, and kernel functions can map the input data into a high-dimensional feature space. Commonly used kernel functions include linear kernels, polynomial kernels, and Radial Basis Function (RBF) kernels. RBF kernel is a common kernel function, which is defined as follows.

$$K(x_i, x_j) = \exp(-\gamma |x_i - x_j|^2)$$

Where γ is the parameter of the kernel function, and x_i and x_j are the feature vectors.

3.4 Regularization Weighted Meta Learner

In this part, we want to propose the Regularization Weighted Meta Learner based on the ensemble learning Boosting method. We will propose Gradient Boosting based on weight regularization as our enhanced parameter update method.

$$\hat{y}^{(0)}(x) = \arg \min_{\gamma} \sum_{i=1}^N L(y_i, \gamma)$$

Among them, $\hat{y}^{(0)}(x)$ is the prediction of the initial model, $L(y_i, \gamma)$ is the loss function, commonly used is the mean squared error (MSE), y_i is the true value of the i -th sample in the training data, N is the number of training samples, γ is the parameter of the initial model, such as the mean. For each step of Boosting $t = 1, 2, \dots, T$, we compute the residual of the model on the currently learned training data:

$$r_{it} = - \left[\frac{\partial L(y_i, \hat{y}(x_i))}{\partial \hat{y}(x_i)} \right]_{\hat{y}(x_i) = \hat{y}^{(t-1)}(x_i)}$$

r_{it} is the residual at step t for the i sample, $\hat{y}(x_i)$ is the model prediction at the i sample, and $\frac{\partial L(y_i, \hat{y}(x_i))}{\partial \hat{y}(x_i)}$ is the partial derivative of the loss function with respect to the prediction. Next, we use these residuals to train the next regressor $h_t(x)$:

$$h_t(x) = \arg \min_{h \in \mathcal{H}} \sum_{i=1}^N L(r_{it}, h(x_i))$$

The contribution of each regressor is adjusted by the learning rate ν , and the model complexity is controlled by a regularization term $\Omega(h)$:

$$\hat{y}^{(t)}(x) = \hat{y}^{(t-1)}(x) + \nu \cdot h_t(x) - \lambda \cdot \Omega(h_t)$$

$\hat{y}^{(t)}(x)$ is the predicted value of the ensemble model at step t , ν is the learning rate, which controls the update rate at each step, λ is the regularization parameter, which is used to balance model complexity and fit. $\Omega(h_t)$ is the regularization term for the t -th regressors.

The regularization term $\Omega(h)$ can be L1 or L2 regularized, depending on the regularization strategy we want to use. For ridge regression, for example, regularization item usually L2 regularization: $\Omega(h_t) = |w_t|^2$, for the support vector regression machine, regularization item may be more complex, depending on the kernel function and other parameters. In this way, we prevent the model from becoming too complex during augmentation and help improve the generalization ability of the final model.

After T rounds, we get the final ensemble model:

$$\hat{y}^{(T)}(x) = \hat{y}^{(0)}(x) + \sum_{t=1}^T (\nu \cdot h_t(x) - \lambda \cdot \Omega(h_t))$$

$\hat{y}^{(T)}(x)$ is the final model prediction after T rounds of Boosting, where T is the total number of Boosting iterations. In this process, we will choose the λ and ν that make the whole model perform best on the validation set.

4 EXPERIMENTS



Figure 1 Single Model Prediction Results

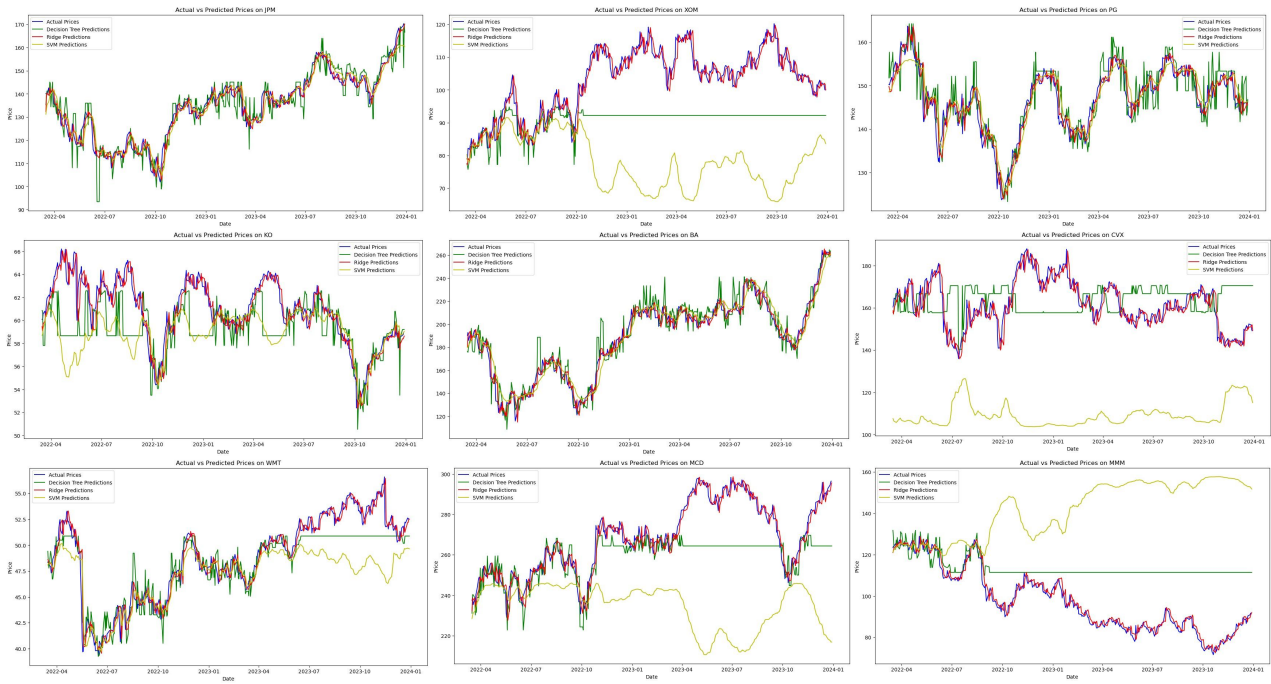


Figure 2 Ensemble Models Prediction Results

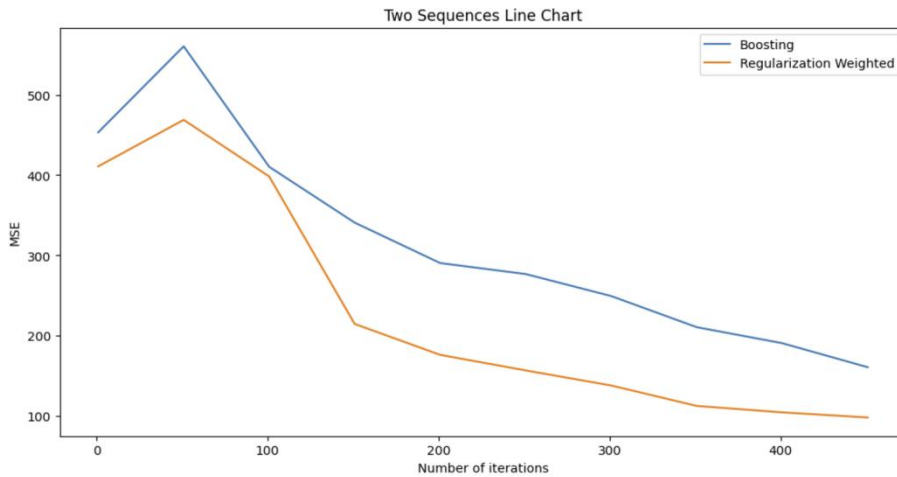


Figure 3 Performance comparison of the number of iterations between strategies

4.1 Prediction Comparison

In this part, we selected the representative blue-chip stocks of the US stock market to carry out a ten-year stock trend backtest. Here, we selected the trading data of several big blue-chip stocks from 2014-01-01 to 2024-01-01, including 'APPL', 'GOOGL', 'DOW', 'AMZN', 'MSFT', 'META', 'NKE', 'GS'. We set back the step length measurement is 10, the random number seed to 42, and GradientBoostingRegressor as a integrated study of the learner, the number of the estimators is set to 100, the vector is set to 0.1, Max_depth set to 3. The result is shown in the figure 1,2 below, and in the table 1 below.

Table 1 The Stock Market Predictions

Stock	Model	MSE	MAE	DrawDown	Volatility
JPM	Decision Tree	26.18	3.88	-0.36	0.04
	Ridge	8.10	2.18	-0.28	0.02
	SVM	13.99	2.92	0.26	0.01
	Ensemble	9.87	2.65	-0.11	0.02
XOM	Decision Tree	204.55	12.20	-0.19	0.02
	Ridge	7.21	2.13	-0.20	0.02
	SVM	876.07	29.60	-0.28	0.01

	Ensemble	229.44	12.86	-0.15	0.01
PG	Decision Tree	12.97	2.82	-0.25	0.03
	Ridge	5.77	1.80	-0.24	0.01
	SVM	10.40	2.42	-0.19	0.00
KO	Ensemble	7.08	2.08	0.26	0.01
	Decision Tree	8.32	2.16	-0.20	0.02
	Ridge	0.81	0.66	-0.21	0.01
BA	SVM	11.10	2.33	-0.14	0.00
	Ensemble	6.15	2.48	0.16	0.01
	Decision Tree	94.35	7.26	-0.45	0.06
CVX	Ridge	31.66	4.42	-0.41	0.03
	SVM	70.55	6.49	-0.31	0.01
	Ensemble	35.95	4.68	0.31	0.02
WMT	Decision Tree	225.49	12.70	-0.18	0.02
	Ridge	16.69	3.12	-0.25	0.02
	SVM	307.64	52.77	-0.18	0.01
MCD	Ensemble	115.46	8.76	0.16	0.01
	Decision Tree	3.18	1.38	-0.23	0.02
	Ridge	0.94	0.64	-0.26	0.01
MMM	SVM	8.17	2.02	-0.21	0.01
	Ensemble	4.17	1.46	0.23	0.02
	Decision Tree	228.25	11.15	-0.17	0.02
MCD	Ridge	15.21	3.04	-0.16	0.01
	SVM	181.90	33.45	-0.14	0.00
	Ensemble	223.77	10.85	0.14	0.01
MMM	Decision Tree	410.62	16.97	-0.22	0.02
	Ridge	6.13	1.84	-0.24	0.02
	SVM	277.19	44.59	-0.14	0.00
	Ensemble	436.31	17.09	0.17	0.00

4.2 Ablation Study

In this part of ablation experiment, we will conduct ablation experiments on our Meta-learner and Regularization Weighted Method, and the effectiveness of these two strategies has been determined.

4.2.1 Effectiveness Experiments on Meta-learner

We designed a set of experiments on the number of iterations and the prediction effect of Gradient Boosting Regression in estimation. Here, the contrast of Boosting method and Regularization Weighted Ensemble learning method are shown in Figure 3, respectively.

From the experimental results shown in Figure 3, our regularized Weighted Ensemble Learning indeed Narrows the number of iterations required by our Gradient Boosting Regression to some extent. Thus, the effectiveness of our regularized weight adjustment strategy is verified. Bagging, Boosting and Reg_Weighted Results can be seen in table 2.

Table 2 Bagging, Boosting and Reg_Weighted Results

Model Type	Stock	MSE	MAE	DrawDown	Volatility
Bagging	DOW	1.305	0.901	-0.33	0.016
	GOOGL	15.561	3.121	-0.41	0.018
	AMZN	30.702	4.162	-0.52	0.023
	MSFT	361.975	13.218	-0.35	0.015
Boosting	DOW	1.352	0.923	-0.27	0.015
	GOOGL	19.989	3.534	-0.41	0.020
	AMZN	48.763	5.089	-0.48	0.025
	MSFT	214.401	9.798	-0.35	0.017
Reg-Weighted	DOW	1.01	0.92	0.22	0.01
	GOOGL	9.89	1.53	0.45	0.01
Boosting	AMZN	9.07	1.29	0.60	0.01
	MSFT	38.14	3.80	0.35	0.01

4.2.2 Effectiveness experiments on Regularization Weighted Method

We designed a set of experiments on the number of iterations and the prediction effect of Gradient Boosting Regression in estimation. Here, the contrast of Boosting method and Regularization Weighted Ensemble learning method are shown in Figure 3, respectively.

From the experimental results shown in Figure 3, our regularized Weighted Ensemble Learning indeed Narrows the number of iterations required by our Gradient Boosting Regression to some extent. Thus, the effectiveness of our regularized weight adjustment strategy is verified.

5 CONCLUSIONS

By combining Support Vector Machine (SVM), decision tree and ridge regression models, this study proposes a regularized weighted Boosting ensemble learning method aimed at improving the accuracy of stock market forecasting. Our empirical study shows that the method significantly reduces the mean square error (MSE) and mean absolute error (MAE) for both backtest data and actual trends, and significantly improves volatility. Our model provides a comprehensive solution to solve the stock market prediction problem, provides new ideas and methods for future stock market prediction research, and is expected to have a positive impact in practice.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Box GE, Jenkins GM, Reinsel GC, Ljung GM. Time series analysis: Forecasting and control. John Wiley & Sons , 2015.
- [2] Taylor SJ, Letham B. Forecasting at scale. *The American Statistician*, 2018,72 (1): 37–45.
- [3] Hyndman RJ, Khandakar Y. State space models for time series forecasting in r. *Journal of Statistical Software*, 2002, 18 (1): 1–16.
- [4] Hoerl AE, Kennard RW. Ridge regression: Biased estimation for nonorthogonal problems. *Technometrics*, 1970, 12 (1): 55–67.
- [5] Tibshirani R. Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society: Series B (Methodological)*, 1996, 58 (1): 267–288.
- [6] Hochreiter S, Schmidhuber J. Long short-term memory. *Neural computation*, 1997, 9 (8): 1735–1780.
- [7] Lawrence S, Giles CL, Tsoi AC, Back A. Face recognition: A convolutional neural-network approach. *IEEE transactions on neuralnetworks*, 1997: 8 (1): 98–113.
- [8] Nti IK, Adekoya AF, Weyori BA. A comprehensive evaluation of ensemble learning for stock-market prediction. *Journal of Big Data*, 2020, 7 (1): 20.
- [9] Friedman JH. Greedy function approximation: A gradient boosting machine, *Annals of statistics*, 2001, 1189–1232.
- [10] Drucker H, Burges CJ, Kaufman L, Smola A, Vapnik V, Support vector regression machines. *Advances in neural information processing systems*, 1997, 9: 155–161.
- [11] Wolpert DH. Stacked generalization. *Neural networks*, 1992, 5 (2): 241–259.
- [12] Murphy J. Technical analysis on the financial markets. new york institute of finance. New York institute of finance, 1999.
- [13] Edwards RD, Magee J, Bassetti WC. Technical analysis of stock trends. CRC press, 2018.
- [14] Penman SH. Financial statement analysis and security valuation. McGraw-hill, 2013.
- [15] Granger CWJ, Hatanaka M, Spectral analysis of economic time series. Princeton university press, 2015.
- [16] Miller CN, Rol RI, Taylor W, et al.. Efficient capital markets: A review of theory and empirical work. *The journal of Finance*, 1970, 25 (2): 383–417.
- [17] Kim K-j, Financial time series forecasting using support vector machines. *Neurocomputing*, 2003, 55 (1-2): 307–319.
- [18] Breiman L. Bagging predictors machine learning, 1996, 24 (2): 123-140.
- [19] Breiman L. Random forests machine learning, 2001, 45 (1): 5-32.
- [20] Sherstinsky A. Fundamentals of recurrent neural network (rnn) and long short-term memory (lstm) network. *Physica D: Nonlinear Phenomena*, 2020, 404.
- [21] Nerlove M. Time series analysis, forecasting, and control, 1971.
- [22] Bollerslev T. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, 1986, 31 (3): 307–327.
- [23] LeCun Y, Bengio Y, Hinton G. Deep learning. *Nature*, 2015,521 (7553): 436–444.
- [24] Freund Y, Schapire RE. A decision-theoretic generalization of online learning and an application to boosting. *Journal of Computer and System Sciences*, 1997, 55 (1): 119–139.
- [25] Friedman JH. Greedy function approximation: A gradient boosting machine0 *Annals of Statistics*, 2001, 29 (5): 1189–1232.
- [26] Chen T, Guestrin C. Xgboost: A scalable tree boosting system, in: *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. ACM, 2016, 785–794.

- [27] Ke G, Meng Q, Finley T, Wang T, Chen W, Ma W, Ye Q, Liu TY. Lightgbm: A highly efficient gradient boosting decision tree. in: *Advances in Neural Information Processing Systems*, 2017, 30: 3146–3154.
- [28] Prokhorenkova L, Gusev G, Vorobev A, Dorogush AV, Gulin A. Catboost: Unbiased boosting with categorical features. in: *Advances in Neural Information Processing Systems*, 2018, 31: 6638–6648.
- [29] Polikar R. Ensemble based systems in decision making, *IEEE Circuits and Systems Magazine*, 2006,6 (3): 21–45.
- [30] Sill J, Takacs G, Mackey LW, Lin D. Feature-weighted linear stacking. *arXiv preprint arXiv*, 2009, 0911.0460.
- [31] Dietterich TG. Ensemble methods in machine learning, in: *International workshop on multiple classifier systems*. Springer, 2000: 1–15.
- [32] Hoeting JA, Madigan D, Raftery AE, Volinsky CT. Bayesian model averaging: A tutorial. *Statistical science*, 1999, 14 (4): 382–401.

THE ROAD OF DIGITAL TRANSFORMATION OF JINGDONG GROUP: EFFECTIVENESS AND IMPLICATIONS

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Abstract: Finance is the entry point and linkage point of enterprise digital transformation, the essence of which is to use digital technology as the support, use data to drive financial value creation, and empower enterprise management innovation. This paper takes JD as an example, based on the digital transformation data of its financial statements and annual reports, through the method of case study, discusses the logical framework of its financial digital transformation and its impact on enterprise financial performance. It is found that JD has realized the big data of financial analysis and the intelligence of financial accounting, which effectively reduces costs, improves human capital efficiency and promotes innovation. Its success comes from the application of digital technology and the transformation of business models, which brings significant improvement to the financial performance of enterprises. The paper not only enriches the relevant research on financial digital transformation, but also provides practical guidance for enterprises to cope with digital challenges and achieve sustainable growth.

Keywords: Digital transformation; Financial performance; Financial analysis; Value creation

1 INTRODUCTION

The development direction of financial digitalization is still a topic of great concern. General Secretary President Xi pointed out in the 34th collective study of the Political Bureau of the Central Committee: "It is necessary to promote the integrated development of the digital economy and the real economy, grasp the direction of digitalization, networking and intelligence, promote the digitalization of manufacturing, service industry, agriculture and other industries, and use new Internet technologies to carry out an all-round and full chain of traditional industries. To improve total factor productivity and give full play to the amplification, superposition and multiplier role of digital technology in economic development. Therefore, improving enterprises to better adapt to the Internet environment from the outside, improving the digital financial process, and realizing the digital construction of the industry as a whole is inseparable from the digital development of finance.

JD has the characteristics of large-scale product categories, portability, platform security, etc., in addition to providing a variety of payment methods, in which the rapidity of JD's logistics is its biggest feature and special features, basically receive the goods on the same day after placing an order without a long time of waiting, which greatly meets the psychological needs of consumers. Importantly, JD, as China's leading e-commerce logistics company, has been committed to digital transformation, the digital transformation of logistics enterprises research has played an excellent role in demonstrating the digital transformation of logistics companies, through the digital transformation of the JD company's research can be used by other similar logistics companies to learn from the transformation program, and to solve their problems. However, JD in the digital logistics information technology, there are still some management and technical bottlenecks, in the digital input costs and capital return there are still inefficient and irregular behavior. Based on the requirements of promoting enterprise quality and efficiency, improving information quality, accelerating the road of enterprise digital transformation and the existing research literature on this issue is not sufficient. This paper will focus on the impact of digital transformation on corporate financial performance, combined with case studies to analyze the above issues.

The research in this paper is not only an in-depth analysis of JD financial digital transformation practice, but also a comprehensive examination of the application effect of digital transformation in the field of financial management. By revealing JD's strategic choices, implementation paths, and effectiveness in the process of financial digital transformation, this paper provides a new perspective on understanding the relationship between digital transformation and corporate financial performance.^[12] At the same time, for a large number of enterprises, the research conclusions of this paper have important reference value, which helps them seize the opportunities of digital transformation, optimize financial management processes, improve decision-making efficiency, and thus occupy a favorable position in future market competition.

2 THEORETICAL BASIS AND LITERATURE REVIEW

2.1 Theoretical Basis

2.1.1 Theory of synergistic effect

Synergy, simply put, is the effect of "1+1 > 2". Synergy effect can be divided into two cases, external and internal, external synergy refers to a cluster of enterprises due to mutual collaboration and sharing of business behavior and

specific resources, and thus will be higher than as a separate operation of the enterprise to achieve higher profitability; internal synergy refers to the enterprise production, marketing, management of the different segments, different phases, different aspects of the common use of the same resources to produce the overall effect. In the digital era, JD should utilize digital technology to achieve information-driven business transformation in order to adapt to new market demands, achieve real-time data sharing and better management, and support the enterprise's decision-making and operational needs[1]. This approach will help improve efficiency, reduce errors and better meet regulatory requirements for sustainable development.

2.1.2 Information asymmetry theory

Information asymmetric refers to the different information held by individuals in a transaction. In social, political, economic, and other activities, some members possess information that other members cannot, resulting in information asymmetry. In market economy activities, there are differences in the understanding of relevant information among various personnel; People who have sufficient information are often in a favorable position, while those who lack information are in a disadvantageous position. Asymmetric information may lead to adverse selection.

Logistics companies also suffer from serious information asymmetry. There is a phenomenon of information asymmetry between logistics enterprises and financial information. The emergence of digitalization can greatly alleviate this contradiction[1]. By innovating traditional business and marketing models, information asymmetry can be improved and the harm caused by information asymmetry can be reduced. Business finance integration organically integrates the business processes, financial accounting processes, and management processes of enterprises to better manage and process their financial and business data.

2.1.3 Signal transmission theory

Research by Western financiers shows that under information asymmetry, there are three common signals for companies to transmit internal information to the outside world: (1) profit declaration; (2) dividend declaration; and (3) financing declaration. Compared with the maneuverability of the accounting treatment of profits, dividend announcement is a more credible signal model. The application of signal transmission theory in the financial field began with Ross's research. He found that managers with a large amount of high-quality investment opportunity information can transmit information to potential investors through the choice of capital structure or dividend policy. This paper studies the capital structure of JD. The capital of an enterprise for a certain period of time can be divided into debt capital, equity capital, short-term capital and long-term capital. And the profit analysis method was used to evaluate the solvency and operating capacity of JD.

2.2 Literature Review

Digital transformation is a change measure that uses digital technologies, such as big data, cloud computing, and artificial intelligence, to drive business organizations to transform their business model, organizational structure, and corporate culture. Previous studies have shown that digital transformation has an impact on the internal of the enterprise, and the results of the study by Chenyu Zhao show that digital transformation can significantly improve the total factor productivity of the enterprise. Enterprise digital transformation can effectively improve the performance of the main business and the driving effect on performance shows a significant asymmetric effect under the influence of enterprise property rights[2]. Deng Meng believes that JD Logistics through information digitization, business digitization, supply chain digitization to achieve the information sharing, business connectivity, supply chain optimization of the point line digital type, and then realize the traditional business value appreciation and new business value creation, and ultimately enhance enterprise value[3]. It has become a consensus that enterprises enhance their value through digital transformation. The analysis of Ye Jiangfeng and Gu Mengru shows that the theoretical basis of digital transformation affecting enterprise performance mainly includes dynamic capability theory, strategic flexibility theory, social network theory, meaning construction theory and resource orchestration theory[4]. Digital transformation has positive, negative and inverted U-shaped effects on firm performance. In addition to intra-firm, digital transformation also has an impact on the industry. Zhang Zhengang found that digital transformation has a significant positive effect on business model innovation[5].

Digital transformation will also affect enterprise performance. Jiang Qinqin believes that the digital transformation of logistics enterprises mainly affects the performance of logistics enterprises by increasing media exposure, reducing production costs and managing costs. In addition, other factors will also affect the performance of the enterprise[6]. Li Zengquan found that when managers hold a certain number of the company's shares, the shareholding ratio has a significant impact on the performance of the enterprise. The human capital of the enterprise management team and the R&D investment of the enterprise are significantly correlated with the performance of the enterprise[7]. Zhu Yan believes that the human capital of the enterprise management team affects the performance of the enterprise through the implementation of the R&D investment of the enterprise[8]. Chen Deping found that there is an interaction between the capital structure of China's GEM enterprises and the performance of enterprises[9]. Zhang Xiangjian and others believe that the CEO's control determines the strategic direction and innovation ability of the enterprise, and plays a significant positive role in promoting the performance of the enterprise[10]. The continuity of government subsidies by Cao Yang and others has a positive regulatory effect on R&D investment and enterprise performance[11].

In summary, there are few studies on the impact of digital transformation on performance of logistics companies and digital transformation. Therefore, this paper chooses to study the impact of JD Logistics' digital transformation on

financial performance. Using DuPont analysis to better digitize the impact on finance, analyze the impact of JD's financial digital transformation on its financial performance[12].

3 DIGITAL TRANSFORMATION OF JD

3.1 Overview of the Case Enterprise

JD is a leading integrated online retailer in China, with its core business covering three major areas: retail, technology and logistics. JD Retail adheres to the business philosophy of “trust-based, customer-centered value creation” and relies on strong supply chain, data, technology and marketing capabilities to accurately match consumer demand and innovate consumption scenarios. JD Logistics, established in 2007, has become the world's leading technology-driven supply chain service provider, taking technology as the core to promote the efficient and sustainable development of global distribution. JD Technology, as a business sub-group, focuses on providing digital intelligence solutions for government and enterprise customers. Relying on cutting-edge technologies such as AI, cloud computing, big data, and the Internet of Things, and combining JD's profound supply chain experience, JD Technology has become an industry-leading digital intelligence service provider, and is helping to upgrade the city and industry. Through comprehensive digital transformation, JD Group has not only reshaped the retail industry, but also led the industry in innovation in logistics and services, and promoted the development of digital intelligence in the social economy.

3.2 Digital Transformation History of Case Companies

3.2.1 JD digital transformation stages

JD's digital transformation has gone through a total of four stages, mainly around the development of technological innovation and the development of the operating model of these two aspects, Figure 1 shows the digital transformation process of JD.

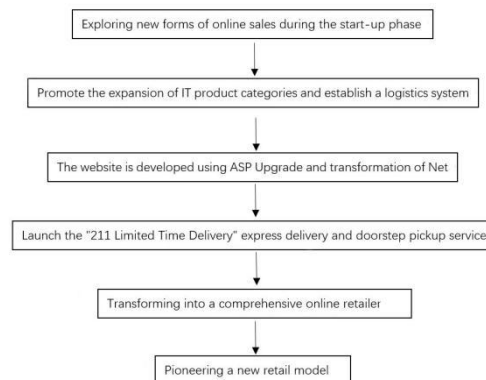


Figure 1 Digital transformation process of JD

The first stage of JD's development is the start-up period. The start-up period of JD's digital development was around 1998 to 2006. In 1998 JD was established in Zhongguancun Overseas Market, mainly selling optical and magnetic products. During the SARS outbreak in 2003, JD seized the opportunity to start experimenting with online sales as a new sales situation, and this trend-catering development provided the company with new impetus. At the same time, Liu Qiangdong began to build their own Web site, from the outside to buy a set of ASP online shopping mall software, and on this basis, gradually developed and maintained, which is the first generation of Web sites, “JD multimedia network” in its initial form. JD in 2004 launched a self-management mode website, so JD transition online into the field of e-commerce. In 2005, Liu Qiangdong closed all offline 12 stores, specializing in e-commerce, JD try to do IT digital full category, which is also a huge impact of the JD Group's measures, the end of 2006, JD sales reached a huge figure of 80 million yuan.

The second stage of JD's development is the booming period. This stage is mainly between 2007 and 2011. In 2007, JD gradually promoted the expansion of IT product categories, obtained the first large amount of financing, and began to build a logistics system. Since then, JD in the category expansion and self-built logistics continued to make great efforts, fruitful. 2008, JD using the program began to shift from ASP to .Net, at the same time in June of that year, JD also completed the category expansion of 3C products. 2008 summer, Donny and his team, completed by the ASP to .Net upgrade transformation, this new version of the site ran smoothly until 2010. Order volume from the average daily growth of a few thousand single to more than 100,000 single, can be said to have achieved a leap in development. In 2010, the POP platform on-line, JD with the launch of this platform, “211 time limit” speed delivery and door-to-door pickup service, this move led to a new standard of online retail industry. At the end of that year, JD also began to officially operate the open platform, prompting annual sales of 10.2 billion yuan. The following year, JD obtained \$1.5 billion in financing, mobile client on-line, the launch of the parcel tracking system, improve the level of service, increase the “7 × 24 hours customer service phone”, and formally enter the B2C online medicine and luxury goods field.

JD all categories gradually improve, and gradually transformed into a comprehensive online retailer, since then JD's business scope has been further expanded, sales increased greatly.

The third stage of JD's development is the period of capitalization and strategic layout, roughly between 2012 and 2016, at this stage, JD began to pursue scale, specialization, and other more in-depth development, and gradually expanded the group's strength and influence through acquisitions, investments and strategic cooperation. In May 2012, JD's Java version of the trading system was online, which also marked the system he used by the . NET to Java architecture. The newly replaced system can prohibit the system from reading the database directly while providing services to the outside world, and the system database was also changed from SQL Server to MySQL. finally, in November 2012, JD opened the logistics service system platform, and formally laid out the open logistics service and payment system.

Finally, the fourth stage of JD's development is a period of comprehensive transformation. 2019 JD established a retail group. During this period, in order to assist JD's core business and create great value for the majority of business partners, JD, with its huge business scale, perfect retail infrastructure and advanced technology, began to provide comprehensive supply chain services, and exported logistics services and technical solutions to third parties. By the end of 2019, the scope of JD's business has encompassed many areas, including retail, digital technology, logistics, technology services, health, SmartCloud and overseas. The positioning of JD Group has also changed from "a leading technology-driven e-commerce company" to "a leading supply chain-based technology and service enterprise". Since then, JD has begun a comprehensive transformation from "retail" to "retail + infrastructure service provider". At the 2021 JD Cloud Summit, JD Cloud officially released StarDB, an independently designed and developed financial-grade domestic distributed database, which is equipped to support high concurrency online transaction processing of massive data, and has important features such as sensorless distributed, financial-grade high availability, high compatibility with MySQL, elasticity and scalability, security compliance, and intelligent operation and maintenance control. JD reformed again in 2022 to create a new retail pattern.

3.2.2 JD's new mode of digitization

From the recent development trend, with the accelerated integration of the real economy and the digital economy, more and more enterprises are beginning to promote the procurement digitalization process. How to efficiently realize the channel shift from offline to online has become a problem for many industrial brands. Therefore, JD has created a new model to solve this problem, the JD New Retail Model. Under this model, JD will provide personalized recommendation services based on consumers' purchase history and preferences, making it easier for consumers to find the goods they need. This corresponds to one of the features of JD's new retail model, "new type of retail", which breaks the geographical retail limitations of the traditional retail industry and allows consumers to buy goods at any time and any place. The core of JD's new retail model is "scenario-based marketing", which combines online sales and offline experience to create a new type of retail model. It will improve the consumer shopping experience while also providing more sales opportunities for offline stores. Not only that, JD also pushes product information to more consumers through offline stores, social media and other channels, increasing sales and brand awareness. Another innovation of JD's new retail model is the "smart store". Under this model, JD provides smarter services for brick-and-mortar stores through artificial intelligence technology and big data analysis.

Overall, JD's new retail model integrates online and offline, and it provides consumers with a more comprehensive, smarter and more convenient shopping experience through innovative methods based on scenario-based marketing, new types of retail and smart stores, increasing sales opportunities and contributing to the transformation and upgrading of the retail industry.

4 THE IMPACT OF JD'S DIGITAL TRANSFORMATION ON FINANCIAL PERFORMANCE

4.1 Financial Indicator Analysis

4.1.1 Debt paying ability

This paper adopts the financial indicator analysis method, aiming to conduct a comprehensive, in-depth and detailed analysis of the overall operational status and performance of the enterprise. By selecting a series of specific accounting competency indicators, especially focusing on the company's debt paying ability and operational capability, precise and detailed local analysis is implemented in order to provide a more thorough and specific examination of the company's operating conditions.

This paper calculates five indicators from 2016 to 2023, including current ratio, quick ratio, asset liability ratio, cash flow ratio, and ROE, to analyze JD's debt paying ability. The calculation results are shown in Table 1.

Table 1 Solvency Analysis of Jingdong 2016-2023

measures/year	2016	2017	2018	2019	2020	2021	2022	2023
current ratio	2.20	2.00	1.60	1.33	1.35	1.35	1.32	1.16
quick ratio	2.00	1.82	1.40	1.17	1.01	0.99	1.01	0.89
Asset liability ratio	55.14%	59.28%	60.41%	58.56%	59.13%	50%	54%	53%
cash flow ratio	0.24	0.53	0.41	0.33	0.24	0.19	0.22	0.22
ROE	10.00	0.30	4.30	16.60	0.26	0.04	0.01	0.08

After digital transformation, the company's current ratio is at a relatively safe level, indicating that the company has sufficient current assets to cover its short-term debt. This reflects the company's relatively strong debt paying ability, with a higher balance of current assets than current liabilities, which reduces short-term debt paying risks. In the past two years, the current ratio has slightly decreased, but the company still has sufficient current assets to cover its current liabilities, although this ability has slightly weakened compared to before. A decrease in the current ratio may indicate a decrease in the company's current assets or an increase in current liabilities. The difference between the company's current assets and current liabilities will further narrow in 2023. Although the company is still able to repay its short-term debts, its debt paying ability has significantly weakened. In general, the quick ratio of a company should reach 1:1. From the above table, it can be seen that JD's quick ratio fluctuated around 1:1 from 2020 to 2023. JD's quick ratio is close to 1, indicating that JD's short-term debt paying ability has been low in the past two years. Repaying short-term liabilities requires the use of other non current assets, which imposes a certain interest burden on the sale of inventory, etc. The total debt of a company is slightly higher than the total shareholder equity, which is generally considered a relatively safe level, indicating that the company has sufficient shareholder equity to support its debt.

In 2021, the company's debt paying ability is relatively strong, and the balance of shareholder equity can cover most of the debt, which reduces the risk of debt repayment. The increase in debt-to-equity ratio in the second year indicates an increase in the total liabilities of the company relative to the total shareholders' equity. This may mean that the company has increased debt financing or reduced shareholder equity. In 2023, the debt-to-equity ratio slightly decreased, which means that the difference between the company's total liabilities and total shareholder equity has decreased. Notwithstanding the company still has a certain debt burden, its debt paying ability has slightly improved. The decrease in debt-to-equity ratio may indicate that the company is adjusting its debt management strategy or taking measures to increase shareholder equity to reduce debt repayment risk. From 2020 to 2023, JD's ROE will first decrease and then increase, remaining relatively stable. Meanwhile, ROE will grow rapidly from 2022 to 2023. In 2023, JD.com will enhance its profitability by adjusting its capital structure, increasing debt, and increasing buybacks. The asset liability ratio is a comprehensive indicator for evaluating a company's debt level. It is also an indicator that measures a company's ability to use creditor funds for business activities, and reflects the safety level of creditors issuing loans. JD's asset liability ratio has remained relatively stable, with some growth from 2020 to 2023, but within a controllable range. The financial structure is relatively healthy and has high asset utilization efficiency.

4.1.2 Capacity analysis

This paper calculates the operating capacity of JD.com by calculating the turnover rate of accounts receivable, inventory turnover rate, sales profit margin, total asset turnover rate and current asset turnover rate in 2016-2023. The calculation results are shown in Table 2.

Table 2 Analysis of JD's Operating Capacity from 2016-2023

measures/year	2016	2017	2018	2019	2020	2021	2022	2023
Accounts receivable turnover ratio	20.28	22.30	33.64	66.69	55.31	10.85	7.15	7.87
Inventory turnover	8.93	8.82	9.24	9.66	10.90	21.76	11.71	12.67
Sales profit margin	1.50	-0.144	0.91	1.52	4.12	-0.62	3.78	1.22
Total Asset turnover	2.12	2.10	2.35	2.46	2.19	2.07	1.92	1.77
Current asset turnover	3.99	3.56	3.22	3.29	3.99	3.56	3.22	3.29

From the above table, it can be seen that the turnover rate of accounts receivable of JD.com from 2020 to 2023 is gradually decreasing. In 2021, the turnover rate of JD.com's accounts receivable is high, indicating that the capital operation ability is strong and the debt repayment capacity is good. However, it began to decline to about 7 in 2022, indicating that JD.com's working capital is too much to stay on the accounts receivable, and the collection of accounts is not good, which affects the normal capital turnover and solvency, resulting in the non-flow of current assets and reducing its operating capacity. At the same time, it can be seen from the above table that JD.com from 2020 to 2023 The number of inventory turnovers is gradually decreasing. JD.com has a large inventory turnover, indicating that the sales are good. But too big is also detrimental to the enterprise. JD.com may encounter problems such as untimely repayment, insufficient supply of products, shortage of inventory, and poor capital turnover. However, the number of inventory turnover of JD.com has decreased in the past two years, indicating that the storage realization of JD e-commerce stores is fast, the time spent on the inventory is short, and the inventory management is efficient. At the same time, JD.com is facing some operational challenges. The negative sales margin indicates that the cost of the company's operating activities this year exceeded the sales revenue, resulting in losses. This may mean that the company has problems with cost control, pricing strategy or market expansion. In terms of resource management, JD.com may fail to make effective use of its resources, such as raw materials, labor or capital, resulting in high costs. In terms of sales strategy, the sales strategy may not be effective enough to attract enough customers or fail to sell products at a profitable price.

In the past two years, the operation of JD.com has improved, and the significant increase in sales margins shows that the company has significantly improved its operating capacity in this year. From the above table, it can be seen that the cost profit margin of JD.com's cost and expense profit margin from 2020 to 2023 is gradually increasing, indicating that the

cost of JD.com's profit is gradually reduced, the cost and expense control is getting better and better, and the profitability is getting stronger. The company has adopted effective cost control measures, optimized pricing strategies, or successfully expanded market share. In terms of resource management, JD.com has managed its resources more effectively, reduced waste, and improved production efficiency. At the same time, in terms of market expansion, JD.com may have successfully expanded the market and attracted more customers, thus increasing sales revenue, and the company has entered a period of stable operation. Although the sales profit margin has decreased compared with the previous year, it still remains positive, indicating that the company's operating capacity is relatively stable. From the above table, it can be seen that the four-year current asset turnover rate of JD.com shows a trend of decreasing first and then increasing. The turnover rate of current assets has increased, the turnover rate of current assets of JD.com has accelerated, and the profitability of JD.com has increased relative to saving current assets.

4.1.3 Performance benchmarking analysis

Using the performance benchmarking method, it first benchmarks the history of its own digital development within the JD enterprise, which established a retail group in 2019. During this period, JD, with its huge business scale, perfect retail infrastructure and advanced technology, began to provide comprehensive supply chain services, and exported logistics services and technology solutions to third parties. Since then, JD has begun to gradually develop the road of mature digital display, creating a new retail model. So the four years before and after the key step of its digital transformation are chosen for comparison.

Overall, the logistics and warehousing system of JD Group is more complete after the digital transformation. There are very complete warehouses and distribution networks throughout the country, which makes inventory and accounts receivable turnover fast. In the past five years, JD's operating income is a continuous increase. As of December 31, 2022, JD's operating income reached 295.41 billion yuan, doubled compared to 2019. In terms of net profit, although JD shifted from a loss-making status to a profitable status, it has realized a profit in the three years of 2019, 2020, and 2022, with 2019 and 2020 being years of rapid development for the company. 2021 to 2023 cost and expense margins of -2.33%, 12.17%, 26.99%, respectively, a gradual increase in the trend. It shows that the price JD pays to obtain profits is gradually reduced, cost and expense control is getting better and better, and profitability becomes stronger. In terms of profit structure, in the past five years, JD's performance of all profit margins is at an excellent level in the industry, and continues to increase, and the proportion of revenue and all expense structures are stable. For net profit, in addition to 2021 are steadily increasing, but also in 2019 for the first time to achieve profitability, indicating that JD is in a stable upward stage, JD's digital transformation makes the performance in a positive impact.

4.2 Cost Benefit Analysis

From a cost-benefit perspective, the initial cost of digital transformation for enterprises is relatively high, but the long-term economic benefits are also considerable. The improvement of digital technology and open environment has led to changes in market structure, allowing enterprises to grasp market and customer demands at any time, shorten business operation time, reduce business processing errors, lower trade management costs and inventory costs, improve service quality, accelerate capital flow, and thus enhance the economic benefits of enterprises.

From the perspective of the development stage of JD's digital transformation, the cost of system construction in the early stage is essential, which is a variety of costs incurred in the process of establishing the system of the enterprise, mainly including the cost of human, financial and material inputs for the construction of the system's badlands. From JD's financial statements, it is calculated that the degree of its scientific research and development investment is shown in the figure, which is a stable upward trend from 2016 to 2023. Moreover, in order to catch up with the trend of the times and seize business opportunities, JD must also update its system at the right time, and the costs required in this regard are also huge. These above costs are invested heavily in the early stages while also bringing direct, indirect and potential economic benefits to JD's future.

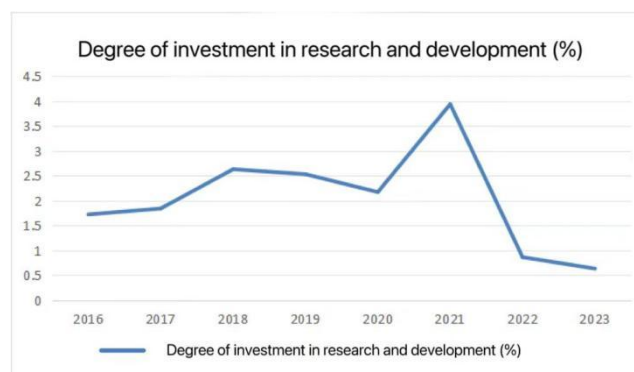


Figure 2 JD 2016-2023 R&D Investment

4.2.1 Direct benefits

By establishing an online JD digital website and using online publicity to establish intermediary image and product information, online advertising can transmit the promotion information of enterprises to potential customers around the

world to increase the sales and purchase opportunities of enterprises; use the digital network to trade to reduce transaction costs and improve marketing efficiency. In traditional logistics, the supply chain consumes 25% of the operating cost, while JD improves supply chain management by using the convenience of digitalization, thus reducing the cost by more than 10%; digitalization can reasonably arrange the purchase of raw materials and production according to order, thus reducing inventory and accelerating capital turnover; reducing intermediate links to save information. Cost creates conditions for enterprises to obtain accurate information in a timely manner.

4.2.2 Indirect benefits

It has improved JD's management efficiency and service level to improve JD's competitiveness in the industry. According to the data of Oriental Fortune Network, the valuation level of JD is now in the industry 11; it has expanded its business scope and scale to achieve economies of scale, and strengthened communication with customers to expand the market scale. According to the statistics of scholars, this indirect benefit can increase the market share of enterprises by about 15%; it can gain the recognition of society and traders with advanced digital trading mode and digital management model, so as to improve social and economic benefits.

4.2.3 Potential benefits

Sometimes the benefits that digitalization brings to enterprises are long-term and significant, with subtle effects and strong momentum. From a macro perspective, this is the potential benefit.

5 RECOMMENDATIONS FOR JD'S DIGITAL TRANSFORMATION

5.1 JD should Reduce the Cost of Digital Transformation

The analysis of JD's financial statements shows that digital transformation wastes a lot of money, and the difficulty in returning funds leads to liabilities and a slight decrease in the current ratio from 2022, although it still has enough current assets to cover its current liabilities, although this ability is slightly weakened relative to the previous year. A decline in the current ratio may indicate a decrease in the company's current assets or an increase in current liabilities and continues to decline in 2023, the company is able to service its short-term debt, but its solvency has weakened significantly, and it is possible that the company's financial position is deteriorating or that its debt management strategy has become more aggressive. This could increase the company's short-term debt service risk. It is suggested that JD may consider reducing the cost of digital transformation and refinancing its capital with the capital it already has to make it liquid and improve the company's solvency.

5.2 JD should Innovate the Path of Digital Transformation and Deepen Digital Empowerment

From this paper, we look at the JD digital transformation development road has experienced a total of four stages, mainly around the development of technological innovation and the development of the operating model of these two aspects. 2022 began the development of the retail model, and now it is a more mature model, the development of the era of technological rapid change, JD also needs a new digital transformation development. The suggestion is that JD can accelerate the use of new AI technology, innovative digital transformation development road. Through the study found that AI technology also has its own advantages, and as the industry leader JD, always leading the progress of science and technology, so JD can take artificial intelligence technology as the core, and actively promote the intelligent transformation and upgrading, widely used AI, and the combination of multiple industries.

5.3 JD should Strengthen the Introduction of Scientific and Technological Talents

With the popularization of 5G, IoT, edge computing and other technologies, the demand of enterprises for digital talents has shown explosive growth. Digital talents have become the key to the development of the industry in areas such as human data analysis, cloud computing platform construction, and artificial intelligence applications. Digital talent is an important force for social progress, so it is recommended that the logistics industry should have a deep understanding of digital talent, expand the recruitment of digital talent[13] and increase the digital training of existing employees to improve their digital skills and thinking.

6 CONCLUSION

In summary, we can conclude that the digital transformation of JD has a positive effect on the financial performance of enterprises, after the digital transformation of JD enterprises, the market found that the market did respond positively in the short term, and from the aspect of net profit, JD has changed from a loss-making state to a profitable state. It not only addresses the challenges in the digital transformation of logistics companies from a financial accounting perspective, but also provides companies with strategies to effectively address these challenges. This project scenario reflects the great potential of digital transformation in enhancing enterprise performance and competitiveness, and therefore, we encourage logistics enterprises to actively adopt digital transformation and incorporate it into their long-term strategic planning.

COMPETING INTERESTS

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REFERENCES

- [1] Wang Fangling. Research on the impact of digital transformation on financial performance of retail enterprises under S2B business model. *Henan University of Technology*, 2022.
- [2] Chen-Yu Zhao, Wen-Chun Wang, Xuesong Li. How digital transformation affects enterprise total factor productivity. *Finance and Trade Economics*, 2021, 42(07): 114-129.
- [3] Deng Meng. Digital Transformation and Value Analysis of Logistics Enterprises--Taking Jingdong Logistics as an Example. *Market Weekly*, 2023, 36(04): 38-41.
- [4] Ye Jiangfeng, Gu Mengru. The impact mechanism of digital transformation on enterprise performance: research framework and outlook. *Finance and Accounting Monthly*, 2023, 44(13): 153-160.
- [5] Zhengang Zhang, Junqiu Zhang, Baosheng Ye, et al. Impact of enterprise digital transformation on business model innovation. *Science and Technology Progress and Countermeasures*, 2022, 39(11): 114-123.
- [6] Jiang Qinqin. Research on the impact of digital transformation on logistics enterprise finance. *China Logistics and Purchasing*, 2023(21): 71-72.
- [7] Li Zengquan. Incentive Mechanisms and Corporate Performance--An Empirical Study Based on Listed Companies. *Accounting Research*, 2000, (01): 24-30.
- [8] ZHU Yan, ZHANG Mengchang. An empirical study on human capital, R&D investment and enterprise performance of enterprise management team. *Accounting Research*, 2013(11): 45-52+96.
- [9] CHEN De-Ping, ZENG Zhi-Hai. Research on the interaction between capital structure and corporate performance--an empirical test based on GEM listed companies. *Accounting Research*, 2012(08): 66-71+97.
- [10] Zhang Xiangjian, Xu Jin, Xu Longbing. Can executive elite governance model enhance corporate performance? --A study based on the moderating effect of social ties. *Economic Research*, 2015, 50(03): 100-114.
- [11] Cao Yang, Yi Qiqi. The impact of government subsidies on corporate R&D investment and performance-an empirical study based on biomedical manufacturing industry. *Science and Technology Management Research*, 2018, 38(01): 40-46.
- [12] Zhang Li. Path research on the impact of enterprise digital transformation on financial performance. *Business Accounting*, 2022, (13): 34-39.
- [13] Gan Lin. Research on digital transformation problems and countermeasures of logistics enterprises under the background of digital economy. *Logistics Science and Technology*, 2024, 47(08): 59-61.

THE INSPIRATIONS ON REGENERATION OF THE HISTORICAL AND CULTURAL DISTRICT OF TAISHAN IN LIGHT OF “EUROPEAN CAPITAL OF CULTURE”

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Abstract: The culture-oriented regeneration of the historical and cultural districts has been a significant trend in Europe. In this study, three strategies for regeneration of the historical and cultural district of Taishan are constructed in light of the successful experiences of “European Capital of Culture”: “Target-Plan” master planning, “Government-Public” multi-participant organization and “Space-Action” synergy. And some inspirations regarding the regeneration of the historical and cultural district of Taishan are stated tentatively.

Keywords: European capital of culture; Culture-oriented policy; Taishan; Historical and cultural district; Regeneration

1 INTRODUCTION

In recent years, cultural construction has attracted more and more attentions in the regeneration of historical and cultural districts (HCD). As a culture-oriented policy tool and implementation strategy for the regeneration of HCD, “European Capital of Culture” (ECC) has been adopted around the world constantly since the end of last century. Concerned cultural development policies are formulated in order to promote the expression of urban characteristic cultural values, strengthen local people’s self-identity and drive urban development and social integration[1]. Since 1985, more than 60 cities and regions in Europe have been awarded as ECC (Table 1), such as Ruhr[2] in Germany and Liverpool[3] in the UK etc., which have broken a new ground for urban regeneration to present local cultural feature, cultural heritage and cultural innovation by exploring the original urban cultural characteristics. Similar renewal programs also have been implemented for the HCDs in China, such as Yong Qing Fang[4] in Guangzhou and Blue House Conservation[5] in Hongkong and so on, demonstrating the vitality and effectiveness of the culture-oriented regeneration of HCD.

However there are rare systematic studies regarding the influence of ECC on regeneration of HCD at present. It is discovered existing studies typically focus on individual cases of the awarded cities in Europe when the keywords such as “cultural capital”, ECC, “culture-oriented” and “cultural city” etc. are inputted for literature retrieval, which are the small sample research and inadequate to guide the construction project for regeneration of current HCDs due to lack of systematic applicability.

This study mainly discusses the three aspects as follow: the regeneration modes of HCDs under the policy of ECC in a holistic view, suggestions to regeneration of the HCD of Taishan based on the guidelines of ECC and the analysis on the motivation and social background of ECC for providing some experiences and inspirations.

2 REGENERATION MODES OF HCDS UNDER THE POLICY OF ECC

As a practice of urban regeneration, ECC has formed relatively completed regeneration modes after 35 years of development since 1985. The study attempts to elaborate the key points of the implementation of ECC and its application in the regeneration of HCDs (Table 2) and takes Ruhr in Germany which was awarded as ECC in 2010 as the typical case for analysis (Figure 1 & Table 3). Total three types of modes are classified and summarized including the “Target-Plan” master strategy planning mode, “Government-Public” multi-participant mode and “Space-Action” synergistic mode as below:

Table 1: Cities Awarded as ECC from 1985 to 2021

Stage of Development	Selected Cities	Distribution Area	Development Feature
Stage 1 1985 - 1996	1985 Athens (Greece)	Twelve countries EEC	1. The project was hosted by the 12 EEC countries internally in turn, the cities were nationally nominated and 1 city was nominated per year (most of which were capitals or important cultural cities) 2. The planning term was no more than 2 years 3. Cultural festivals and celebrations were the main events
	1986 Florence (Italy)		
	1987 Amsterdam (Netherlands)		
	1988 Berlin (Germany)		
	1989 Paris (France)		
	1990 Glasgow (UK)		
	1991 Dublin (Ireland)		
1992 Madrid (Spain)			

	1993	Antwerp (Belgium)		
	1994	Lisbon (Portugal)		
	1995	Luxembourg (Luxembourg)		
	1996	Copenhagen (Denmark)		
	1997	Salonica (Greece)		
	1998	Stockholm (Sweden)		
	1999	Weimar (Germany)		
Stage 2		Avignon (France), Bergen (Norway), Bologna (Italy), Brussels (Belgium), Helkising (Finland), Krakow (Poland), Reykjavik (Iceland), Prague (Czech Republic) and Santiago de Compostela (Spain)	13 EU nations, 2 nations about to join in EU and 1 non-EU nation	1. The selection scope was expanded to other European nations 2. The procedural selection criteria were fulfilled 3. The balance among different areas selected was considered 4. The number of applicant cities was increased at the millennium
1997 - 2004	2000			
	2001	Rotterdam (Netherlands) and Porto (Portugal)		
	2002	Bruges (Belgium) and Salamanca (Spain)		
	2003	Graz (Austria)		
	2004	Genoa (Italy) and Lille (France)		
	2005	Cork (Ireland)		
	2006	Patras (Greece)		
	2007	Luxembourg (Luxembourg) and Sibiu (Romania)		
	2008	Liverpool (UK) and Stavanger (Norway)		
	2009	Vilnius (Lithuania) and Linz (Austria)		
	2010	Eisenruhr (Germany), Pegg (Hungary) and Istanbul (Turkey)		1. The legal documents formally established the selection criteria, procedures and evaluation system 2. The applicant cities submitted their application materials 6 years in advance, the cities selected were announced 4 years in advance and 2 cities selected per year prepared for the 1-year cultural events 3. Initiatives of ECC were adopted in the whole Europe 4. The applicant cities must provide a project plan regarding European Dimension 5. The EU Commission conducted a short-term and long-term evaluation after the events were finished
Stage 3		Turku (Finland) and Tallinn (Estonia)		
2005 - 2021	2011			
	2012	Guimaraes (Portugal) and Maribor (Slovenia)		
	2013	Marseille-Provence (France) and Kosice (Slovakia)	28 EU members and 2 non-EU members	
	2014	Umea (Sweden) and Riga (Latvia)		
	2015	Mons (Belgium) and Bilsen (Czech Republic)		
	2016	SAN Sebastian (Spain) and Wroclaw (Poland)		
	2017	Aarhus (Denmark) and Paphos (Cyprus)		
	2018	Valletta (Malta) and Leeuwarden (Netherlands)		
	2019	Matera (Italy) and Plovdiv (Bulgaria)		
	2020	Rijeka (Croatia) and Galway (Ireland)		
	2021	Timisoara (Romania), Elefsina (Greece) and Novisa (Serbia)		

The "Target-Plan" master strategy planning mode mainly involves a strategic plan, nation/region selection and application program, master plan for the city concerned, the development of the themes for annual cultural events and a long-term cultural strategy and cultural promotion initiatives for the near future etc.

The "Government-Public" multi-participant model includes the establishment of a cross-regional selection mechanism, foundation of a dedicated preparatory organization, raising and appropriation of EU/regional government/private funds, an evaluation on annual and long-term benefits for the host city and relevant EU official agencies and civil participation in construction and voluntary service.

The "Space-Action" synergistic model contains urban infrastructure renewal, construction of urban cultural space nodes, media publicity of cultural project and planning on cross-regional cultural events and activities etc.

Table 2: Regeneration Modes of HCDs of ECCs

“Target-Plan” Master Strategy Planning Mode	“Government-Public” Mode	Multi-participant	“Space-Action” Synergistic Mode
Applicant Region or City: to formulate the cultural development plan, construct a local cultural axis, set up a characteristic cultural area and design the cultural nodes	EU: The European Parliament revises its cultural policies, organizes evaluation teams and other departments to select the applicant cities, sets up special funds for construction and evaluates ECC regularly.		Spacial Construction: renewal of the urban green spaces, restoration of cultural heritages, improvement of urban infrastructures and construction of cultural activity venues
Cultural Project Planning: planning on the annual project “Cultural Year” for the short term and consideration for the subsequent extension of the project for the long term to improve the overall benefits	Applicant Country and City: to collect city campaign posters, select and determine the candidate cities, prepare construction funds, formulate development themes and other plans, implement the plan after winning the selection and conduct post-evaluations		Event Planning: to introduce urban events for continuous activation of urban space, plan urban touring routes and hold events and activities in conjunction with peripheral areas
Establishment of Institutions and Organizations: to establish a project operating company, introduce a consultation and post-evaluation agency and develop relevant fund and implementation plans	Operating Company: to coordinate architects, developers, local governments, foundations and other organizations, take charge of cultural projects, publicity and promotion of governmental plans and fund raising		Community Participation: the volunteers participate in project construction, project publicity, supervision and post-evaluation

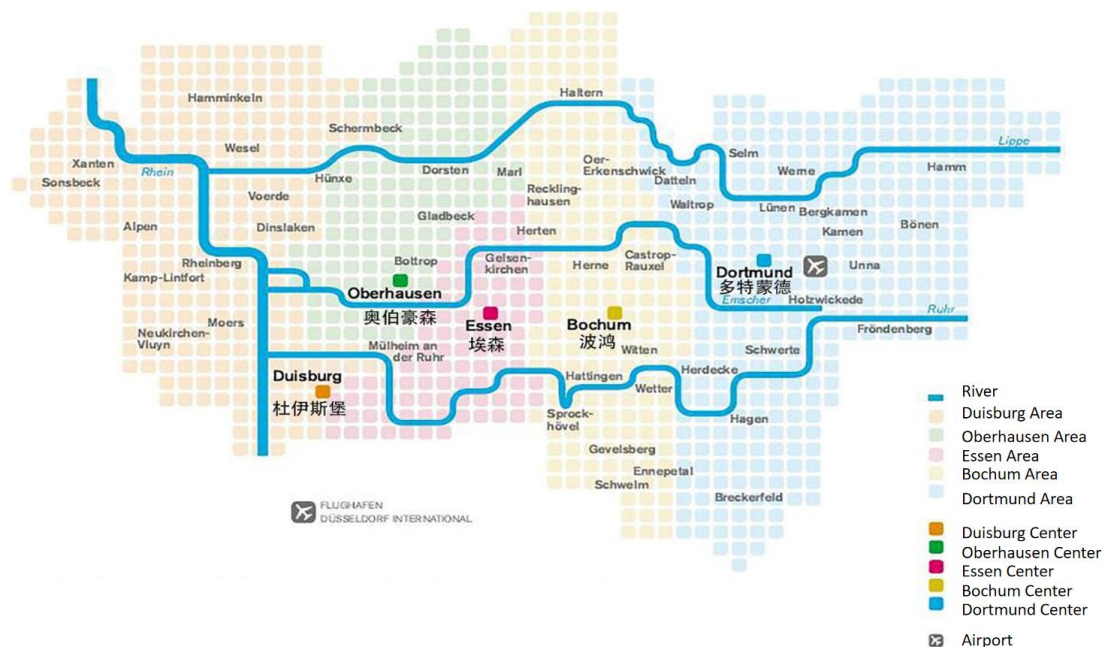


Figure 1: Tourist Map of ECC - Ruhr in Germany in 2010[6]

Table 3: Key Points for Implementation of the ECC Regeneration Project in Ruhr of Germany[7]

Establishment of Goals for Cultural Development	The overall goal is to establish the metropolis of Ruhr, making it a new cultural district in Europe. The core agenda of “Cultural Transformation - Reshaping Cultural Development” is proposed to drive a culture-oriented reformation and reconstruct the culture in Ruhr. The short-term goal is to create experiences with projects and communications and the subsequent goal is to innovate the social mechanism and improve the buildings and infrastructures.
Cultural Planning for Regional Integration	The 53 cities and towns in Ruhr, Germany participate in the construction of ECC through regional cooperation and development jointly, focusing on 5 portal areas including the UNESCO World Heritage Site in Essen, Bochum Festival Center, Dortmund Music and Multimedia Center, Cultural Harbor of Duisburg and Industrial Recreation Site of Oberhausen
“Target-Plan” Master Planning	The path of “Experience Creation”: "Legend of Ruhr", "Reconstruction of Metropolis", "Stage Transformation", "On-site Music", "Language Exploration", "Creative Industry Activation", "Celebration Moment", "Europe Forward" and other initiatives are put up in respect of project planning. With regard to communication, connections and project exchanges are strengthened by brand building and image development based on the concept of promoting marketing and communication.
Two paths to "cultural transformation" : experience creation and infrastructure reconstruction	The path of “Infrastructure Reconstruction”: "Development of Regional Network Planning", "Trans Regional and Institutional Cooperation", "Development of Culture Jointly with Infrastructure ", "Structure Expansion of Creative Industry" are proposed for network mechanism and planning. With respect to construction and urban structure, the cultural planning is combined with architectural planning, construction of transportation infrastructures (public transportation stations, local transportation network construction and bicycle paths etc.) and establishment of tourist facilities (5 tourist centers)
Contributions from Both Government and Private Sectors	The total budget of ECC is nearly 81 million euros, including the governmental funds (from Ruhr Regional Association, Essen, North Rhine-Westphalia, The Federal Government of Germany and the EU) which accounts for 74.9%, contributions (21.7%) from third-party organizations (including sponsors etc.) and some incomes (e.g. ticketing income etc.) which takes up 3.5%. RUHR.2010 GmbH is responsible for the control of project budget.
"Government-Public" Multi-participant Operation	Composed of Ruhr Tourismus GmbH, RUHR.2010 GmbH, The Agencies Invent GmbH and Tao GmbH and relevant urban tourism experts
Expansion of Original Urban Project Organizations	Original urban project organizations are expanded and integrated as the resources of project organization: EmscherLandscape Park, Route of Industrial Heritage, CultureRuhr, Ruhr Tourism and Wirtschaftsfoerderung metropoleruhr GmbH
Public Participation in Project Consultation and Third-party Organization's Evaluate on Construction	Public: to provide advices and suggestions to project construction and participate in volunteer programs individually or as an organization. According to relevant statistics, 1165 volunteers have participated in 9600 projects. And the cultural projects were evaluated by RUHR.2010 GmbH and related experts after they were completed.
"Space-Action" Synergistic Planning	Establishments of 7 spatial nodes are the construction emphases as below: The North Duisburg Landscape Park, the Oberhausen Gasometer, the Zollverein Pit Shaft12, the “Nordstern Tower”, the Dortmund U, the Emscherblick Spoil Tip-Tetrahedron and the “Slab for the Ruhr”
Planning of Large-scale Urban Theme Activities	The big festivals are held as joint projects: the Ruhrfestspiele Recklinghausen, the Klavier-Festival Ruhr and the Ruhrtriennale

Strengthening Publicity and Public Participation	Residents of communities are encouraged to join in the construction of cultural projects for children, young people and the disabled etc.. Publicity and guidance to the public are strengthened with roadshows, publications and websites
Regional Planning	More than 200 sister cities peripheral in Europe have been brought together to create twin-city programs and over 100 activities have been held jointly.

3 RENOVATION PRACTICE OF HCD OF TAISHAN

3.1 Overview of HCD of Taishan

The HCD of Taishan exhibits the distinctive characteristics and cultural resources of a hometown of overseas Chinese. Taishan is well known for “the first hometown of overseas Chinese in China” and its HDC was built up approximately in the 1920s and 1930s featured with the historical arcades. The material carrier of culture and activities of the residents shows the cultural atmosphere of a hometown of overseas Chinese in modern times, which is all-inclusive, delicate and elegant with commercial elements (Figure 2 & Table 4). Today the reserved area mainly includes the Central District of Taicheng Ancient Town and HCD of Xining City, which was honored as a provincial HCD in 2009.

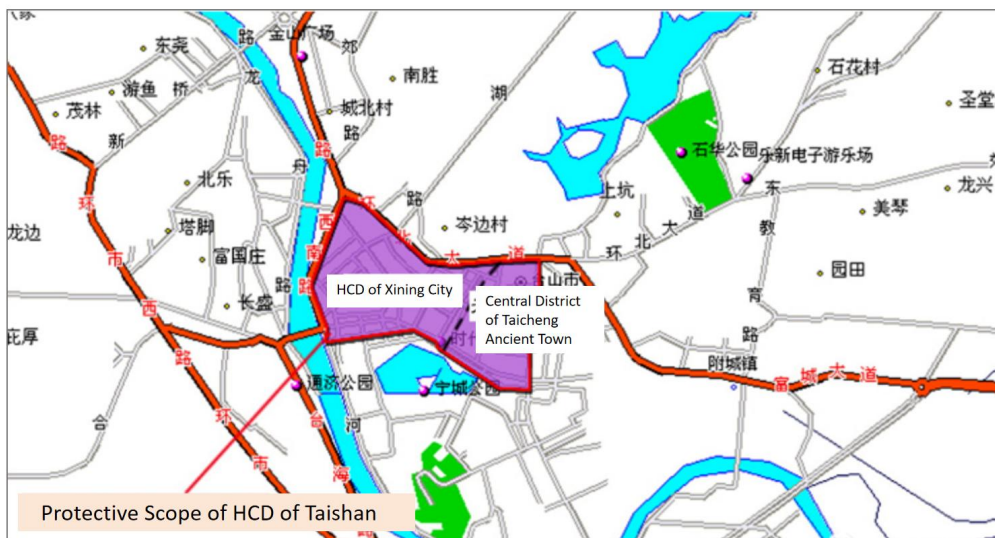


Figure 2: Protective Scope of HCD of Taishan[8]

Table 4: Summary of Cultural Elements in HCD of Taishan

<p>Texture of HCD of Taicheng</p>	<p>Material Elements</p> <p>Decorative elements of the arcade street, historical buildings, texture of the arcade street, postal agency of overseas Chinese, Nanchang Vegetable Market, Taishan specialty, Historic Site of Sunning Railway etc.</p>
	<p>Cultural Events</p> <p>Festivals, fairs, Taishan dialect, stories about remittances of overseas Chinese, deeds of patriotic overseas Chinese, Cantonese opera and religious beliefs etc.</p>

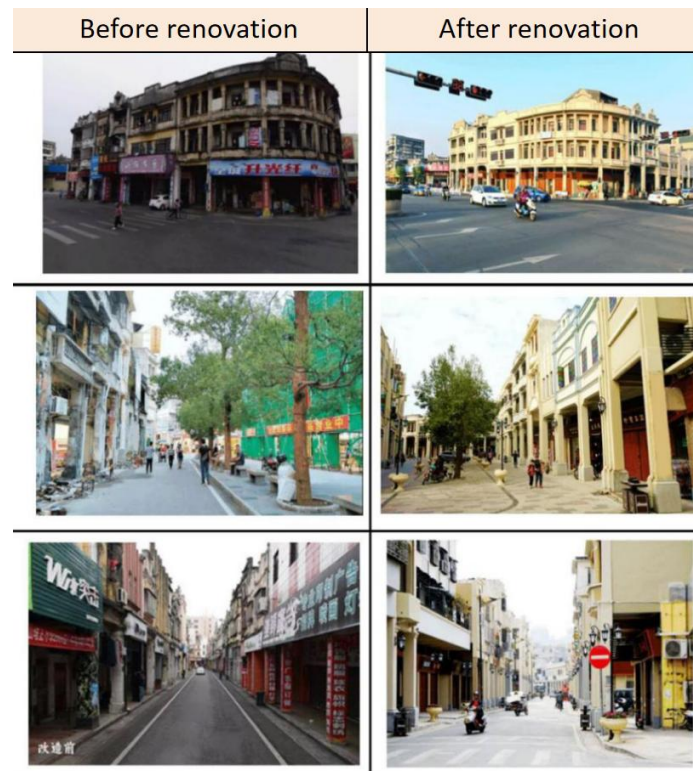


Figure 3: HCD of Taishan before and after the Renovation[9]

3.2 Core Issues in Regeneration of HCD of Taishan

The regeneration project of the HCD of Taishan is in the preliminary stage at present. The local government has commenced the design work for the HCD since 2011 and implemented the revitalization and renovation project for the HCD since 2017 step-by-step[9]. By now the renewal of the HCD has made some progresses (Figure 3). Meanwhile some downsides have been found in the regeneration of the HCD based on my observation and participation, mainly involving the three aspects as below.

The organization in charge of the regeneration is relatively simple as the local government is the main actor and dominates the urban constructions. Civil participation in the constructions is relatively inadequate. Plus the lack of local cultural creative industry, the regeneration of HCD hasn't created a significant positive effect on local economic development and autonomous initiatives from the private sectors for the regeneration are not sufficient.

And the fund for renewal of the HCD mainly comes from the fiscal budget of local government. Thus the regeneration of the HCD is short of effective funding support. For example, some programs of node space have been canceled due to fund shortage and the post-construction maintenance expenditures of some construction projects are not taken into consideration. In addition, the uncertainty of approval time for some fiscal investments makes it difficult to carry out the construction projects for HCD regeneration orderly.

In regard of the implementation effect, HCD regeneration emphasizes on physical space restoration and renovation currently, such as street facade renovation and improvement of municipal roads, sidewalks and public facilities and so forth. These measures commonly are restricted by existing unified and routine practices, creating a result similar to other districts without exploring the cultural values behind the HCD, which may affect the presence of local cultural highlights to some extent.

3.3 Discussion on Regeneration Strategies for the HCD of Taishan

The regeneration of the HCD in Taishan with a long history is similar to the small and medium-sized cities of Europe in the 1980s and 1990s in some ways. In this study, it is intended to explore a unique regeneration pathway in terms of the three aspects stated below for the HCD of Taishan in light of some construction experiences of ECC.

Some cultural strategic plans and action plan guidelines may be introduced as a whole for the "Target-Plan" master strategy planning. Specifically, the strategic positioning should be made satisfactorily for the master urban planning especially cultural promotion planning in respect of the regeneration of the HCD of Taishan, which should make the best of the advantages of Taishan as the No. 1 hometown of overseas Chinese and show the multi-cultural characteristics of Taishan. Policies regarding cultural and artistic encouragements and rewards may be established tentatively during the regeneration so as to facilitate the protection and revitalization for the cultural and art resources in Taishan and relevant annual cultural events and monthly action plans may be developed to strengthen the supports for local cultural and creative industries and literary and artistic talents.

In the regard of "Government-Public" multi-participant, the mechanism of governmental leadership, common prosperity of industries and civil participation should be enhanced. A project coordination and operation organization that is of governmental nature and similar to Glasgow Action[10] in the UK may be established to take charge of the promotion and publicity of cultural projects and government programs, related matters including fund raising and coordination of all parties involved during the regeneration of the HCD of Taishan. A certain proportion of the public construction fund may be appropriated for cultural project planning and the mode of cooperative development between local government and private capital may be set up tentatively for establishing the scope and intensity of cultural improvement. The third-party mechanism without project stakeholder may be introduced to conduct regular supervision and evaluation, collect opinions and suggestions from local residents and strengthen the publicity of the measures, processes and results associated with regeneration of the HCD.

The planning of public cultural activities should be integrated in the reconstruction of urban infrastructure in respect of the "Space-Action" synergy. Experts in the field of historic preservation may be invited to evaluate and value the cultural facilities in the HCD. The historical stories and clues hidden in the space should be explored and transformed into tailor-made literary and artistic creations for the symbolic cultural nodes in the HCD especially the spaces of significant historical value. The public service facilities should be improved, regional traffic conditions should be optimized, a linear cultural touring route for the hometown of overseas Chinese should be planned, event planning should be made in conjunction with peripheral areas and public art activities should be used as the catalyst to continuously activate the HCD.

4 REFLECTION AND CONCLUSION

Initiatives those are similar to ECC and related to the culture-oriented regeneration of HCDs have been implemented in European cities for many years and expanded to Americas, Middle East and East Asia etc., such as "Arab Culture Capital (1996)", "American Culture Capital (1997)" and "Cultural Capital of East Asia (2013)", demonstrating that the culture-oriented urban renewal presents a trend of globalization to a certain extent. The social background and motivation of the initiatives are discussed preliminarily besides using their key points for reference during the research. The policies and measures related to culture-oriented regional integration construction have some explicit and implicit demands[11]. As a cultural policy carried out in Europe for many years, ECC takes the renewal of old urban spaces and planning of urban cultural activities as the explicit media to promote the European integration process in terms of culture, implying the intent of the EU to expand its power transregionally to a certain degree. In particular, the European Commission added "the European Dimension"[12] into the selection criteria in 2007, requiring the host and non-host countries to strengthen their cultural exchanges and inter-regional cooperation in Europe, reflect the whole European consciousness and highlight the European cultural consensus that is both diversified and unified. The impetus behind these EU initiatives can be interpreted easily relatively according to the statement of Soft Power[13] proposed by Joseph Nye. After World War II, some EU countries have lost their political, economic and military superiority gradually. But the series of cultural construction measures based on ECC can promote EU's external image to a certain extent in an effort to alleviate the political and economic confrontation, economic sanctions and other estrangements during the Cold War, convert the cultures into a kind of "Soft Power" and create a vision of common prosperity of diverse cultures in Europe.

The small and medium-sized cities like Taishan have been staying in a state of isolated development for a long time with insufficient influence and regional synergy; thus they are likely to be left behind while other cities around are developing jointly and rapidly. In the context of integration of culture and tourism[14] in the Guangdong-Hongkong-Macao Greater Bay Area constructed by the nine cities of the Pearl River Delta, the potential of Taishan may be developed if it joins in the integration process to strengthen the brand positioning for the regional construction of culture and tourism and complementarity of the cultural industry.

The culture-oriented regeneration reflects the intention of local government to seek a role transformation and promote social integration and economic reconstruction in the new era. Modern Western urban planning has always been acting as a tool to shape the cities for the governments and markets[15]. The imperative planning was prevailing in some areas with emphases on scale economy and agglomeration effect and the measures including urban master planning and large-scale construction of new districts etc. during the period of urban rapid development from the beginning to 70s of the 20th Century. And the phenomenon of excessive development of land and industries had attracted more and more concerns in some European and American countries after experiencing a period of sustained high growth in the 1970s,

showing it is not advantageous any more to develop simply by means of economic growth planning. ECC that was prompted in such context exhibited the intent of the local governments to release development vitality by transformation to the service economy and create an atmosphere for industrial innovation by implementation of service-oriented governance and inclusive cultural development. For instance some strategic initiatives for cultural development were put up and fulfilled in London, Britain in succession to stimulate the formation of new economic pattern[16]: “London: Cultural Capital - Discovering The Potential of The World” (2004), “Cultural Metropolis: The Mayor’s Priorities for Culture 2009 - 2012” (2008) and “Cultural Metropolis 2012: The Mayor’s Culture Strategy for London” (2010). Stimulated by relevant cultural policies, London has gradually moved from an industrial city to a creative metropolis, laying the foundation for a new urban development trend driven by the creative economy.

The development of Taishan has been mostly benefited from the top-down guidance of the local government and regulated investment of the private capitals[17]. The HCD of Taishan was built up approximately in the 1920s and 1930s, during which the construction of Sunning Railway that was advocated and supported by Chen Yixi, an overseas Chinese in the United States, brought the prosperity to Taishan. As the intersection of Sunning Railway, Sunning Station was located in the area belonging to Taicheng and the convenient regional transportation could reach out to Guangzhou, playing an important role in establishment of the local commercial center. The vitality of autonomous regeneration was released in Taishan after it was granted as a pilot city of autonomy by Sun Yat-sen in 1924. And the local government implemented the policies including the “Taishan Material Construction Plan” to establish the mode of unified management and commissioned development for introducing investments from the overseas Chinese and allow the local residents to elect the members for the District Office for administration on relevant urban constructions. These measures had the government and the civil organizations to play their roles fully and shaped the distinctive image of Taishan as a hometown of overseas Chinese. Nowadays the development environment is better than before; thus the historical experiences and wisdoms should be learned to enhance the inclusive construction and public service and introduce more civilian forces to construction of the HCD during the regeneration promoted by the government.

Reshaping HCD with culture construction, to a certain extent, is in favor of the construction of social environment necessary for external investors. In 1998, Richard Rogers of Britain mentioned in his book “Towards the Revival of the City” that urban revival required a change in cultural cognition, which was a change in beliefs and values[18]. The regional construction of Taishan in modern times was the result of the in-depth interactions of economic and social environment. In the late of Qing Dynasty, Zhao Tianci, a provincial graduate from Taishan once described that “Local production often was in the condition of food shortage and needed import of foreign food”, indicating Taishan often needed the external investors to improve the local industrial structure due to limited land resource, shortage of manpower and land and weak industries in history. The local government intended to attract the groups of overseas Chinese, especially the overseas Chinese with some economic strength to settle down in the city and promote the commercial development. That’s why the exotic arcade block representing the lifestyle of overseas Chinese businessmen in the modern times has become an important part of urban construction in Taishan. Under the multi-culture influence, Taishan had developed from a maritime village into community of overseas Chinese with “Taishan Wall Street”, which owned nearly 100 financial institutions founded by the overseas Chinese, showing a flourishing societal landscape: western lifestyle and concepts had gradually been integrated into the life of ordinary citizens, the social environment was open and the local people supported some new economic patterns and new ideologies.

ECC has become the regeneration mode prevailing in Europe without doubt; but there are still some issues in its implementation. As some studies mentioned, the culture-oriented regeneration focused on cultural image excessively and a large number of investments were used in not the community development and long-term cultural construction but the large-scale events and flagship infrastructures advocated by the social elites, seldom beneficial to the urban bottom population etc., which should be noticed and improved for the regeneration of HCD.

In general, EEC displays the mature and stable development of European cities, the orderly construction of urban culture and economic development and the inclusiveness and vitality of the social environments. In recent years, the regeneration of HCD has emerged in many areas of China, aligning with the development trend that more and more attentions are paid to urban cultural connotations and endogenous values in the transformation of urbanization[19]. Although there are some discrepancies in ideology and social culture between European cities and the areas in China, we should notice the meaningful aspects: we should emphasize on the adaptation of cultural policy to regional development situation, advocate the mechanism combined governmental guidance with non-governmental participation and promote urban space renewal and cultural activity planning when exploring the way for culture-oriented regeneration of HCDs so as to achieve an overall balance among the space for culture promotion, economy and society.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Zhong Sheng. The Idea and Inspiration of Cultural City Development: from the Policy and Practice of European Capital of Culture. *Studies on Cultural Soft Power*, 2018 (3): 86 - 88.

- [2] Zhang Xinguo & Zhou Ting. European Capital of Culture 2010 "Essen for the Ruhr": New Transformation in Ruhr Area". *New Architecture*, 2011 (4): 108.
- [3] Ju Dedong. Liverpool: From Maritime Mall to European Capital of Culture. *Human Settlements*, 2020 (1): 32.
- [4] Wen Shixian, Liao Jianhao, Cai Haohui & Chen Xiaoliang. Spatial Reconstruction and Cultural Practice of Historic Districts in the Process of Urbanization: The Case of Yongqingfang, Guangzhou. *Progress in Geography*. 2021, 40 (01): 161 - 170.
- [5] Rong Xiaojun, Sun Yao, Wang Anqi et al. Different Business Models for Adaptive Reuse of Heritage Conservation in Hong Kong. *Urban Planning International*, 2017, 32 (03): 42 - 49.
- [6] Chen Wei & Wu Zhinan. From Functional City to Cultural City: A Study on the Construction of Public Culture of European Capitals of Culture. *Journal of Shandong University (Philosophy and Social Sciences Edition)*. 2017 (5): 72 - 83.
- [7] Evaluation of the European Capital of Culture RUHR. 2020.
- [8] Jiangmen Taishan City Taicheng Sub-district Office: Two blocks of Taishan Awarded As Provincial Historical And Cultural Blocks . 2020. http://www.cnts.gov.cn/jmtsstcj/gkmlpt/content/2/2059/post_2059808.html#4662.
- [9] Sohu.com. Taicheng Is About to Change Again. The Remaining 33 Historical Blocks Will Be Revitalized and Upgraded This Year - More Beautiful . 2020. https://www.sohu.com/a/343928177_738135.
- [10] Dong Qi & Dai Xiaoling. Practice And Reflection on Culture-Led Urban Regeneration Policy in UK. *Urban Planning*, 2007, 31 (4): 59 - 64.
- [11] He Rong. Analysis on Explicit And Implicit Cultural Policies in the European Union. *Journal of Southwest Minzu University (Humanities and Social Sciences Edition)*, 2014 (5): 27 - 31.
- [12] Fang Danqing, Chen Keshi & Chen Nan. An Urban Regeneration Mode of Using Cultural Mega-events as a Catalyst:Practices and Inspirations of "European Capital of Culture". *Urban Planning International*, 2017, 32 (2): 102 .
- [13] Huang Sansheng. The Background,Content and Implications of Joseph Nye's American Soft Power Research. *Cultural Soft Power*, 2018 (2): 38-48.
- [14] Huang Xiaohui & Zou Kaimin. A Study of the Integration Development of Culture,Commerce and Tourism under the background of "the Belt and Road" Strategy in Guangdong-Hong Kong-Macao Big Bay Area. *Journal of South China Normal University (Social Science Edition)*, 2016 (4): 106 - 110.
- [15] Zhu Jieming. The Gap between Western Planning Theories and China's Planning Practice—Taking Public Participation and Community Planning as Examples. *Urban Planning Forum*, 2012 (1): 10.
- [16] Wang Linsheng. Historical Context and Theoretic Connotation of "Cultural City". *Urban Problems*, 2014 (4): 17 - 23.
- [17] He Ge & Xiao Yiqiang. A Study on the Modern Suburbanization of Taishan Rural Markets. *South Architecture*, 2011 (2): 9 - 13.
- [18] Urban Task Force. *Towards an Urban Renaissance*. Urban Task Force,1998: 5.
- [19] Huang He. *Cultural Planning: An Overall Urban Development Strategy Based on Cultural Resources*. Beijing: China Architecture Publishing Press, 2010: 3.

ETHNOGRAPHIC RESEARCH ON HUMAN-COMPUTER INTERACTION BEHAVIOR IN THE INTELLIGENT ERA

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Abstract: This study uses the COFE+ robot coffee kiosk as a case study to explore the current application of artificial intelligence and robotics in human-computer interaction and its limitations. Through ethnographic research, this study found that although robots perform well in automated operations and efficiency improvement, they still have obvious deficiencies in emotional interaction and social feedback, which are specifically manifested in the lack of emotional communication, the one-way and asymmetric interaction, the irreplaceable nature of interpersonal communication when human-computer interaction is not smooth, and differences in technical adaptability. These findings suggest that although robots have broad application prospects in the service industry, their ability to understand emotions and handle complex scenarios still needs further development. This study highlights the future development direction of AI and suggests improving robots' capabilities in emotion recognition and feedback, language assistance, etc. to achieve more effective human-machine collaboration and improve user experience.

Keywords: COFE+ robot coffee kiosk; Human-machine interaction; Emotional communication; Field research

1 INTRODUCTION

Significant progress has been made in the fields of artificial intelligence (AI) and robotics over the past few decades. These technologies have not only transformed industrial production, but have also gradually penetrated into daily life and the service industry. However, although robots have demonstrated high efficiency and precision in many areas, they still face major challenges in handling tasks involving emotions and complex social interactions. Current research shows that while robots are able to perform highly standardized tasks such as assembly on production lines and simple customer service, their capabilities in emotion recognition and feedback are still limited [1]. In particular, this limitation becomes evident when it comes to complex social and emotional interaction scenarios. Research on human-robot interaction not only involves how technologies work, but also how to design and deploy these technologies in different social and cultural contexts.

With the advancement of technology, more and more robots are being used in service industries such as catering, hospitality, and retail [2]. This transformation not only changes the way services are provided, but also the way customers interact with service providers. In this context, it is crucial to understand the dynamics of human-computer interaction and the challenges facing it for future technological development and transformation of human lifestyles. Especially in China, with the acceleration of urbanization and changes in social structure, innovation and technological application in the service industry have become one of the important ways to enhance economic vitality [3]. As an innovative service model, the COFE+ robot coffee kiosk in Shanghai not only represents technological progress, but also reflects the pursuit of efficiency and convenience in modern society. However, how this new service model interacts with customers in actual operation, especially how to deal with interactions involving emotions and personalized needs, is still a question worthy of in-depth study. In this context, studying how people interact with these automated machines and how this interaction affects their daily behavior and social relationships has become an important research topic. This study focuses on the following core questions: (1) What is the performance of human-robot interaction in the COFE+ robot coffee kiosk? (2) What are people's behavioral and emotional responses when using robot services? (3) What impact does this human-robot interaction have on social relations and cultural expressions?

Therefore, this study attempts to reveal the performance of robots in actual service scenarios, especially the performance and challenges in human-robot interaction, through a field survey of the COFE+ robot coffee kiosk. This not only provides valuable empirical data for understanding and optimizing current robotic services, but also provides an important reference for future technology design and social applications. This exploratory research not only helps to improve the application effect of robotics technology, but also provides support for all sectors of society to understand and accept new technologies, thereby promoting the harmonious development of technology and society.

2 LITERATURE REVIEW

2.1 Theoretical Basis of Human-Computer Interaction

Human-computer interaction (HCI) is a multidisciplinary field involving computer science, psychology, sociology, and anthropology. The human-computer communication theory proposed by Guzman [4] points out that with the advancement of technology, machines have gradually transformed from passive information transmission tools to active

communication subjects. This shift challenges traditional interaction models because machines have the ability to interact with humans to a certain extent, not only in verbal communication, but also in emotional communication through non-verbal cues. Nass et al.'s [5] "Computers Are Social Actors Paradigm" further explored that when machines can provide sufficient social cues or anthropomorphic cues, people will tend to apply human social habits to human-computer interactions. This phenomenon shows that although robots are not real social subjects, humans will naturally give them certain social roles so as to interact with them. With the development of artificial intelligence, the traditional field of human interaction has gradually expanded, and machines have begun to participate in information transmission and emotional communication as subjects in the communication process. Xiao et al. [6] pointed out that as machines gradually become the main body of communication, the relationship in human-computer interaction is also changing. In this context, human-computer communication has gradually become an important research field. Guzman [4] and his subsequent research [7] proposed that human-machine communication refers to the communication behavior after one party in the communication becomes a machine. However, when robots become the new subject of communication, what changes will occur in the relationship between humans and machines? What challenges and difficulties will be faced in the process of human-machine interaction? These issues have become particularly important with the emergence of human-machine coexistence situations.

Anthropomorphism is as the attribution of some human characteristics to non-living objects, so that these objects are perceived as living and sentient beings [8]. Nowadays, machines are not only media, but also objects of communication and interaction. As machines become more and more anthropomorphic, they increasingly reflect social characteristics. Nass et al. [5] states that as long as the machine provides enough "social cues" or "anthropomorphic cues" to make it consistent with the reality of interpersonal communication, people will be more likely to apply relevant social habits and methods in the process of communicating with the machine. Liu [9] further revealed that the relationship between humans and AI or intelligent machines has gradually surpassed the traditional logic of "ownership and belonging" and added interaction and emotional connection on this basis. Therefore, how robots express emotions during interaction has become a question worth studying.

In addition, another core issue in human-computer communication is bodily communication. The concept of bodily communication proposed by Piran and Teall [10] emphasizes the subjectivity of body perception in the process of cognitive and social interaction. Ihde [11] used the concept of "body" to concretize technological practice, obtain perception through technology, and transform this perception into human cognition, thus constructing a new relationship between humans and the world. In the process of human-computer communication, body is highlighted. This is because there are rich linguistic and non-linguistic symbols in human-computer communication. More importantly, scholars are aware of the key role of the body in the interaction process and emphasize that communication research should return to the body.

Although the above studies provide a good theoretical and empirical basis for studying new forms of human-computer communication, there are still some areas that need further exploration. In particular, practical research on human-computer communication in specific scenarios is still relatively lacking. Therefore, entering the scene of human-computer interaction and conducting field investigations has become a necessary and important basis for practical research. COFE+ robot coffee kiosk provides a good case study for solving these problems.

2.2 The Social Role and Emotional Interaction of Robots

As robots are increasingly used in public services, their roles are gradually changing. From being service tools to becoming part of human social networks, the status and functions of robots in society have surpassed those of traditional mechanical devices. In his discussion of anthropomorphism, Ricoeur [12] pointed out that when humans endow non-living objects with certain human characteristics, these objects are regarded as having life and perception. This anthropomorphism phenomenon is clearly reflected in the design and use of modern robots, especially in the process of interaction with humans, the behavior and performance of robots are often interpreted as having human attributes. Nass et al. [5] further showed that when machines have sufficient "social cues", users tend to apply the same patterns of interaction with humans to their interaction with machines. These social cues include voice intonation, facial expressions, movements, and the context of the conversation. When robots show these cues, people tend to view them as "acting subjects" with social roles, which leads to robots being gradually incorporated into human social circles and becoming a new medium of communication.

This social role not only changes the way people interact with robots, but also makes robots occupy a new position in the social structure. Liu [9] further explored the emotional connection between people and intelligent machines in their research, pointing out that this connection has gone beyond the traditional logic of "owning and being owned" and entered a more complex level of interaction and emotional connection. As robotics technology continues to advance, the relationship between humans and machines is changing from simple tool use to a more complex and multi-layered interactive relationship that is not only functional but also includes emotional and social identity factors. In addition, the research also shows that as robots play an increasingly important role in human society, how to design and build robots to better support such emotional interactions has become an important direction for technology development and social science research.

In summary, the application of robots in public services has gone beyond simple tool roles. They are becoming part of human social networks and establishing complex emotional connections with humans through the expression of anthropomorphism and social cues. This trend poses new challenges and opportunities for future technology design and

social applications, prompting researchers and developers to continuously explore how to better achieve emotional interaction and social integration between humans and machines.

3 RESEARCH METHOD

Ethnography is a qualitative research method that is mainly used to study the lifestyle, beliefs, customs and behaviors of a specific society, culture or group [13-14]. Through in-depth field investigation, ethnography aims to understand the social and cultural phenomena of the research subjects from their internal perspective. Field research emphasizes the acquisition of data through in-depth observation and participation in the behavior of people in a specific social environment. Wolcott [15] believes that field research is not only a means of data collection, but also a "personal observation mode". In this process, the researcher himself becomes a research tool, able to capture people's behavior, culture and lifestyle in a natural environment.

Marcus [16] proposed that the advantage of field research is that it can discover the patterns and meanings hidden behind daily behaviors, especially in complex social interactions, field research can reveal the deep cultural connotations beneath surface behaviors. For this study, field research can help understand the behavioral patterns and socio-cultural significance of people's interactions with robots in the specific scenario of the COFE+ robot coffee kiosk. This study adopts the field investigation method and selects Shanghai COFE+ Robot Coffee Kiosk as the research site. The advantage of this method is that it can conduct continuous observation in a natural environment, thus capturing the real scene of human-machine interaction. Through observation, I recorded customers' behaviors, language, and emotional responses when using robot services, which provided first-hand data for understanding human-machine interaction.

In addition, I took on the role of a "participant observer" during the fieldwork, which meant that I not only recorded other people's behaviors as a bystander, but also personally experienced the service process of the robotic coffee kiosk. In this way, I was able to gain a deeper understanding of people's feelings and reactions in this interaction, thus providing a more comprehensive perspective for the research. Data mainly come from participant observation and field notes. In data analysis, I used thematic analysis [17], which is particularly suitable for dealing with complex and messy data. By coding and classifying the data, key themes can be found, thereby revealing the meaning and patterns behind the data.

In field research on human-computer interaction, the study follows several key ethical principles [18]. First, ensure that participants are aware of the purpose and methods of the study. Second, protect participants' information through methods such as anonymization and data encryption. Third, respect the cultural background of the participants and avoid the influence of cultural bias on the research results. Continuously reflect on the impact of one's own role on the research scenario and adjust observation methods to maintain ethical standards.

4 RESULTS

4.1 The Unidirectionality and Asymmetry of Human-computer Interaction

In the COFE+ robot coffee kiosk scenario, although the robot has highly automated operating capabilities and can effectively handle specific tasks such as coffee making to meet the basic needs of customers, it shows obvious limitations in terms of emotional communication and body language feedback. This limitation stems from the current technology's inability to process human emotions and complex body language, resulting in a one-way and asymmetric interaction process between humans and machines. As Nass et al. [5] pointed out, when machines cannot provide sufficient social cues or anthropomorphic feedback, communication between humans and machines will find it difficult to achieve a two-way interactive effect similar to interpersonal communication.

In actual observations, customers often try to interact with robots through touch, language, etc., but because the machines lack the ability to provide feedback on these interactions, the interaction process cannot continue. This not only limits the depth of interaction, but also makes customers feel that the communication with the machine is one-sided and incomplete. The research of [9] further supports this view, arguing that in current human-computer interaction, despite significant technological progress, it is still unable to completely transcend the traditional logic of "ownership and belonging" and lacks real interaction and emotion. connect. This one-way interaction model emphasizes the limitations of current artificial intelligence technology in dealing with human emotions and social interactions, and also suggests an important direction for future technological development, namely how to achieve more natural and effective two-way communication between humans and machines through more complex and detailed designs.

In addition, the lack of emotional interaction is a prominent phenomenon. The study found that when customers use the robotic coffee kiosk, they often try to interact by touching the glass or speaking to the robot, behaviors that indicate that customers want to establish some kind of emotional connection with the robot. However, the robot was unable to give any effective response to these emotional interactions. When machines cannot provide sufficient social cues or emotional feedback, humans will feel that their interaction with machines is incomplete and lacks the mutual understanding and response in interpersonal communication [19]. For example, when customers try to elicit a response from the machine through language or touch, they receive no feedback, which makes the interaction seem cold and mechanical, far from the interactive experience that customers expect. This lack of emotional interaction not only affects the customer experience, but also reveals the inherent challenges of robots in dealing with emotional communication. The relationship between humans and intelligent machines is gradually moving beyond traditional

functional use and entering the stage of emotional connection [20].

4.2 The Difference Between Technology Acceptance and User Adaptability

As technology continues to penetrate into our lives, there are significant differences in users' acceptance and adaptability to new technologies. This study found that young people are more inclined to try using robots to make coffee, while older people tend to watch from a distance and do not actively participate. This difference may be due to the fact that young people have a natural curiosity about and greater ability to learn new technologies, while older people are more unfamiliar with new technologies. For example, older people often seek help from younger people on how to operate the robotic coffee machine. This highlights the importance of young people's role as "technology intermediaries". In addition, when users are unfamiliar with the operation of the robot, it may lead to poor operation and user experience, thus affecting their overall evaluation of the technology. However, it is worth noting that the robot coffee machine also has a language guidance function, which can actively help users complete operations to a large extent. Therefore, the design of future technology should pay more attention to user diversity and provide more friendly and easy-to-understand operating interfaces and guidance methods to enhance the user experience of users of all ages.

4.3 The Irreplaceable Role of Interpersonal Communication

In the context of the COFE+ robot coffee kiosk, the irreplaceable role of interpersonal communication is particularly prominent. Although robots are highly efficient in automating services and can handle basic tasks such as making coffee, when they are unable to effectively respond to customers' complex needs, customers often turn to traditional human interaction to make up for this shortcoming. This phenomenon shows that although artificial intelligence technology has made great progress in many fields, there is still a significant gap between machines and humans in handling complex situations and emotional communication.

In particular, when customers encountered problems in their interactions with the robot, such as not being able to find coffee or being unsure how to operate the machine, they often sought help from other customers. This behavior not only illustrates the limitations of robots in responding to non-standardized human requests, but also emphasizes the core role of human communication in these scenarios. As Solomon and Theiss [21] noted, interpersonal communication has greater openness and flexibility, allowing for immediate and personalized feedback and support in complex and dynamic environments.

In addition, research by Guzman and Lewis [7] further demonstrated that although AI can surpass humans in specific tasks, human capabilities still dominate when it comes to social interaction and emotional understanding. That's because human communication is not just about information, but also about the exchange of emotions and social cues.

When robots can't understand or respond to these cues, human communication becomes an indispensable supplement. For example, when a customer couldn't find his or her coffee at a kiosk, the help of other customers not only solved the practical problem, but also established an instant social connection through interaction, which cannot be replaced by current robots. This further proves that in service scenarios where human-machine interaction has not yet fully matured, interpersonal communication still plays a key role. Although technological advances have enabled machines to handle increasingly complex tasks, human communication is still irreplaceable when it comes to emotional understanding, social interaction, and unstructured problems. This dependence also suggests the direction of future technological development, namely how to design robots that are more socially and emotionally sensitive to better support human-machine collaboration in complex service scenarios.

5 DISCUSSION AND CONCLUSION

This study reveals the current application status and limitations of artificial intelligence and robotics in the service industry through an in-depth analysis of the human-machine interaction scenarios of the COFE+ robot coffee kiosk. First, the study found that although robots perform well in automated operations and efficiency improvements, their shortcomings in emotional interaction and social feedback are still significant. Secondly, the lack of emotional interaction further highlights the limitations of current robotics technology. Although customers often try to interact more deeply with robots through touch or language, the interactive experience fails to meet customer expectations because the machines cannot respond to these emotional needs. Finally, a key finding of this study is the irreplaceable role of human communication. Although robots can handle standardized and repetitive tasks, customers often rely on human communication to solve problems when human-robot interaction is not smooth or problems arise.

Overall, the case study of the COFE+ robot coffee kiosk illustrates that although AI and robotics technology show great potential in the service industry, there are still major deficiencies in emotional interaction and complex scene processing. One-way and asymmetrical interaction patterns, irreplaceable human communication, lack of emotional feedback, and differences in technological adaptability are all areas where current robotics technology needs further development. This study suggests that future AI development should focus not only on improving operational efficiency, but also on enhancing robots' social and emotional understanding capabilities, enabling them to achieve effective human-machine collaboration in a wider range of more complex service scenarios. Additionally, this study also provides a practical reference for human-computer interaction design in the service industry. It is suggested that when designing and deploying robots, the importance of human emotional needs and social interaction should be considered, and robots should be made more humane by improving technology, thereby enhancing user experience and optimizing service

processes.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Mohebbi A. Human-robot interaction in rehabilitation and assistance: a review. *Current Robotics Reports*, 2020, 1(3): 131-144.
- [2] Gonzalez-Aguirre JA, Osorio-Oliveros R, Rodriguez-Hernandez KL, et al. Service robots: trends and technology. *Applied Sciences*, 2021, 11(22): 10702.
- [3] Jiang Yunlin, Xia Zhijie. User satisfaction analysis based on the KANO-IPA model: A case study of online reviews of intelligent personal assistant products in human-computer interaction experience. *Science and Technology and Economy*, 2024, (4): 106-110.
- [4] Guzman AL. What is human-machine communication, anyway. *Human-machine communication: Rethinking communication, technology, and ourselves*, 2018, 1-28.
- [5] Nass C, Steuer J, Tauber ER. Computers are social actors. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1994, 72-78.
- [6] Xiao Guorong, Ma Yunju, Liu Cheng, et al. A machine emotion transfer model for intelligent human-machine interaction based on group division. *Mechanical Systems and Signal Processing*, 2020, 142: 106736.
- [7] Guzman AL, Lewis SC. Artificial intelligence and communication: A human-machine communication research agenda. *New Media & Society*, 2020, 22(1): 70-86.
- [8] Coeckelbergh M. Three responses to anthropomorphism in social robotics: Towards a critical, relational, and hermeneutic approach. *International Journal of Social Robotics*, 2022, 14(10): 2049-2061.
- [9] Liu Zhen. Talking about emotions with machines: Emotional communication between humans and machines from the perspective of affordance. *Journal of Fujian Normal University (Philosophy and Social Sciences Edition)*, 2024(4): 89-98+172.
- [10] Piran N, Teall T. The developmental theory of embodiment. *Preventing Eating-Related and Weight-Related Disorders: Collaborative Research, Advocacy, and Policy Change*, 2012, 169-198.
- [11] Ihde D. *The Indiana series in the philosophy of technology*. Indiana University Press, 1990.
- [12] Ricoeur P. *The rule of metaphor: The creation of meaning in language*. Routledge, 2004.
- [13] Atkinson M. Ethnography. In *Routledge Handbook of Qualitative Research in Sport and Exercise*, 2016, 71-83.
- [14] Hammersley M. Ethnography: Problems and prospects. *Ethnography and Education*, 2006, 1(1): 3-14.
- [15] Wolcott HF. *Ethnography: A way of seeing*. Rowman Altamira, 1999.
- [16] Marcus GE. *Ethnography through thick and thin*. Princeton University Press, 2021.
- [17] Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 2006, 3(2): 77-101.
- [18] Atkinson P. *Ethnography: Principles in practice*. Routledge, 2007.
- [19] Hong Jiewen, Huang Yu. Manufacturing emotions: The generative logic and hidden dilemmas of human-machine emotions. *Journalism University*, 2024(1): 61-77+121.
- [20] Zeng Yiguo, Cao Jing. Cyber lovers: The establishment of human-machine intimate relationships and their emotional reflection. *Journal of Soochow University (Philosophy and Social Sciences Edition)*, 2023(1): 173-183.
- [21] Solomon D, Theiss J. *Interpersonal communication: Putting theory into practice*. Routledge, 2022.

REASSESSING THE ROLE OF MOBILE MEDIA IN POLITICAL MARKETING COMMUNICATIONS IN NIGERIA

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Abstract: The study focused on re-assessing the role of mobile media in political marketing communications in Nigeria. The study adopted the library research methods to ascertain scholarly opinions and assertions on the role of mobile media in political marketing communications in Nigeria. The use of mobile media in political marketing emerged as a powerful tool for political campaigns to reach and engage with voters, communicate key messages, and mobilize support in the digital age. Mobile media, including smart phones, tablets, apps, and social media platforms, offer unique opportunities for political marketers to connect with voters in a personalized and interactive way. The study concluded that the use of mobile media has facilitated direct and targeted communication between political candidates and voters, enabling real-time engagement, personalized messaging, and interactive content that can influence voter perceptions and behavior. Social media platforms have become essential tools for political campaigns to reach a wider audience, share campaign updates, and mobilize support, contributing to the democratization of information and political participation in Nigeria. The study recommended that political actors should adopt a multi-platform approach in political marketing communication, utilizing a combination of social media, messaging apps, mobile websites, and SMS to reach a diverse audience. By diversifying their mobile media strategies, political campaigns can maximize their outreach, engage with different demographic groups, and ensure a comprehensive communication strategy that resonates with voters.

Keywords: Re-assessing; Mobile media; Mobile; Media; Political; Marketing communications; Nigeria

1 INTRODUCTION

The interaction between digital technology and politics in Nigeria is evident in using digital tools for political participation, engagement, and mobilization. Technology has revolutionized almost all the activities of humans [1]. Ajayi and Adesote advance that adopting digital tools for political engagement in Nigeria results from three factors[2]: participation, interactivity and cost-effectiveness. These tools, especially the internet and social media, are relatively cheap to access, allow for constant feedback, and the barrier of entry is relatively low. The authors go on to say that these tools are now a crucial component of democratic consolidation since they solidify democratic principles and procedures in terms of information sharing, election monitoring, and evaluation, ultimately promoting accountability and openness.

Digital technology has also created a culture of online activism in Nigeria. Nigerian civic activists have begun aggressively utilizing the Internet, especially social media sites like Facebook, to advance various issues, from environmental awareness to the defense of human rights. Many young Nigerians have adopted online participation and activism as an entry into a more profound political engagement [3]. With a phone and access to the internet, one can share one's views with hundreds or even thousands of people or mobilize likeminded people for a particular cause in a way that cannot be done with the traditional media. Digital technology, including the internet and other mobile devices and platforms, connects people solely for social activities and political activities ranging from elections and mass mobilization to protests, demonstrations, views certain political actors placed or marketed on social media channels.

However, mobile media refers to digital content and communication services that are accessed and consumed through mobile devices such as smartphones and tablets. They encompass a wide range of platforms and technologies, including mobile apps, mobile websites, social media, messaging apps, and mobile advertising. Mobile media have become increasingly prevalent in our daily lives, transforming how we access information, interact with others, and engage with content on the go.

One key aspect of mobile media is their ubiquity and convenience. With the widespread adoption of smart phones and mobile internet connectivity, people can access a wealth of information and services anytime, anywhere. This has led to a shift in media consumption patterns, with more individuals turning to mobile devices as their primary source of news, entertainment, and social interaction [4]. Mobile media also offer a high level of personalization and interactivity, allowing users to customize their content consumption experience and engage with brands and services real-time. Features such as push notifications, location-based services, and in-app messaging enable businesses to deliver targeted and relevant messages to users based on their preferences, behavior, and geographic location [5].

Furthermore, mobile media have revolutionized marketing and advertising practices, offering businesses new opportunities to reach and engage with consumers through targeted campaigns, rich media content, and interactive experiences. Mobile

advertising, in particular, has seen significant growth in recent years, with brands leveraging mobile platforms to deliver ads that are highly targeted, visually engaging, and trackable in terms of user interactions and conversions [6].

The use of mobile media in political marketing has emerged as a powerful tool for political campaigns to reach and engage with voters, communicate key messages, and mobilize support in the digital age. Mobile media, including smartphones, tablets, apps, and social media platforms, offer unique opportunities for political marketers to connect with voters in a personalized and interactive way.

One of the key advantages of using mobile media in political marketing is the ability to reach a large and diverse audience quickly and efficiently. With the widespread adoption of smartphones and the increasing reliance on mobile devices for news and information, political campaigns can leverage mobile apps, social media platforms, and SMS text messaging to disseminate political messages in real-time. This allows campaigns to connect with constituents on a more personal level, engage in two-way communication, and deliver targeted messages tailored to individual preferences and interests [7].

Moreover, mobile media enable political campaigns to harness data analytics and micro-targeting strategies to reach specific demographic groups and geographic locations with precision. By collecting and analyzing user data, campaigns can customize messages, segment audiences, and deliver personalized content that resonates with voters. This level of personalization can enhance the effectiveness of political marketing efforts, increase voter engagement, and drive turnout on election day [8].

Political marketing is a strategic communication process that involves the creation and dissemination of political messages to influence public opinion, mobilize support, and shape electoral outcomes. It is a fundamental component of modern political campaigns, where candidates, parties, and interest groups utilize various tactics and channels to communicate their policy positions, engage with voters, and differentiate themselves from their competitors [9].

The practice of political marketing has evolved significantly over the past few decades, driven by advancements in technology, changes in media consumption patterns, and the growing importance of branding and image management in politics. Political campaigns have increasingly adopted marketing techniques borrowed from the commercial sector, including market research, segmentation, targeting, and message testing, to craft persuasive narratives that resonate with diverse audiences and drive voter behavior [10].

One of the key functions of political marketing is to shape voter perceptions and build support for political candidates and parties. By strategically framing issues, cultivating a favourable image, and engaging with constituents through various media channels, campaigns seek to establish a relationship of trust and credibility with the electorate. However, the use of persuasive messaging techniques, such as emotional appeals, fear tactics, and negative campaigning, has raised concerns about the potential manipulation of public opinion and the erosion of trust in political institutions [11].

Relatively, the mobile media have emerged as a critical tool in political marketing communications in Nigeria, offering political actor's unique opportunities to connect with voters, disseminate messages, and mobilize support in the country's dynamic digital landscape. Mobile media play a significant role in political marketing communication in Nigeria by enabling political campaigns to reach a wide audience across the country quickly and efficiently. With the high penetration of mobile phones and the increasing use of social media platforms, political actors can leverage mobile apps, SMS text messaging, and social media campaigns to engage with voters, share information about policy positions, and mobilize supporters in real-time. This direct and interactive communication channel allows campaigns to foster direct engagement with voters, solicit feedback, and build relationships with constituents [12].

The impact of mobile media in political marketing communication in Nigeria is evident in its ability to enhance voter engagement and mobilization. Political campaigns can leverage data analytics and micro-targeting strategies to reach specific demographic groups and geographic locations with personalized messages. By tailoring campaign content to resonate with the interests and preferences of voters, political actors can increase voter turnout, build support, and create meaningful connections with constituents. This personalized and targeted approach is crucial in engaging with Nigeria's diverse population and fostering a sense of inclusivity and empowerment among voters [13].

Furthermore, mobile media have transformed the landscape of political communication in Nigeria by providing a platform for citizens to participate in political discourse, express their views, and hold political actors accountable. Social media platforms like Twitter, Facebook, and WhatsApp have become popular channels for citizens to discuss political issues, share information, and organize grassroots movements. The democratization of information and the proliferation of user-generated content on mobile platforms have empowered citizens to engage with political processes, challenge dominant narratives, and demand transparency and accountability from political leaders [14].

However, the use of mobile media in political marketing communication in Nigeria also presents challenges and considerations. The spread of misinformation, hate speech, and fake news on mobile platforms has raised concerns about the integrity of political discourse and the potential for social unrest. Political actors must be vigilant in combating misinformation, promoting fact-based information, and fostering digital literacy among citizens to discern credible sources of information from false or misleading content [15]. Moreover, the increasing reliance on money and resources in political marketing has led to a concentration of power and influence in the hands of well-funded campaigns, potentially disadvantaging candidates with limited financial resources and marginalizing grassroots movements. The role of special interest groups, super PACs, and dark money in shaping the political discourse and influencing electoral outcomes has

raised questions about the transparency, integrity, and fairness of the political marketing process [16]. It is why this study focuses itself on re-assessing the role of mobile media in political marketing communication in Nigeria.

2. RESEARCH METHODOLOGY

This study adopted the qualitative analytical research approach, leveraging on the review of a body of literature, and scholarly opinions from the Internet, books, library, the media, and the civil society.

3. LITERATURE REVIEW

3.1 Political Marketing

The idea of political marketing builds on a fusion between marketing and politics [17]. Political marketing uses marketing tools, concepts and philosophies within policy development campaigning and internal relations by political parties and organizations. It is seen as a reaction to the rise of political consumerism, and the fall of partisanship, in western democratic societies and emergent democracies [18].

Political marketing entails “the application of marketing principles and procedures in political campaigns by various individuals and organizations” [19]. The significance of marketing in politics has increased as voters become diverse, the market fragmented, and television viewership has disintegrated [20]. Aspiring political candidates seek to create a unique brand identity to match their personality, campaign objectives and voter expectations and blend this identity effortlessly through all communication messages [21]. Imam explains that political marketing infers the usage of marketing tools [22], techniques and methods in the political process. As an activity and method, it reflects the penetration of the political space by marketing and the presence of marketing in politics has a progressively prominent role which is based on the fact that political actors nowadays do not only act according to the principles of marketing but also- think in marketing terms in their political activities [23]. Therefore, political marketing applications have changed from a communication instrument to a coherent way of managing politics, whether policymaking, election canvassing or executing decisions [22, 24]. Political marketing expresses itself in such various activities as focusing a campaign on the salient political issues of swing voters, through the application of sophisticated segmentation techniques a consequent voter- 'customer' orientation, the application of celebrity endorsement strategies as part of integrated marketing communication or the institution of influential directors of Communication [23].

Historically, before Nigeria gained its independence, the colonial administration had organised a couple of general elections without any deliberate and systematic marketing programme undertaken in any of them [25]. Nevertheless, political parties and candidates canvassed for votes through several means. Scholars aver that political marketing started gaining ground after independence, as the 1963 elections witnessed the use of advertising and sales promotions by candidates to propagate their campaign messages [26]. Scholars, such as Achumba and Dixon-Ogbechi [27]; Osuagwu [28], believe that the best of times for political marketing in Nigeria came between 1991 and 1994 when the Social Democratic Party (SDP) and the National Republican Convention (NRC), contested in the series of elections within the that period. These scholars further attributed Abiola's victory to the massive deployment of marketing strategies.

In the meantime, all forms of promotions in political marketing are carried out through a communication or political campaigning strategy [26]. For instance, the use of the name of political candidate duo, which comprises of two syllables, is anticipated to be more easily recognised and shared in the public memory, and management of image and popularity of politicians as a way of marketing which is similar to the marketing of a business product [22]. Political products and personalities are promoted via all channels consumed by the target audience. These channels could include; advertising, publicity, personal selling, and sales promotion, as Sarwate enumerated [29].

3.2 Mobile Media: towards Definition

Mobile media refers to digital content and communication services that are accessed and consumed through mobile devices such as smartphones and tablets. They encompass a wide range of platforms and technologies, including mobile apps, mobile websites, social media, messaging apps, and mobile advertising. Mobile media have become increasingly prevalent in our daily lives, transforming how we access information, interact with others, and engage with content on the go.

One key aspect of mobile media is its ubiquity and convenience. With the widespread adoption of smartphones and mobile internet connectivity, people can access a wealth of information and services anytime, anywhere. This has led to a shift in media consumption patterns, with more individuals turning to mobile devices as their primary source of news, entertainment, and social interaction [4].

Mobile media also offer a high level of personalization and interactivity, allowing users to customise their content consumption experience and engage with brands and services in real-time. Features such as push notifications, location-based services, and in-app messaging enable businesses to deliver targeted and relevant messages to users based on their preferences, behavior, and geographic location [5].

Furthermore, mobile media have revolutionised marketing and advertising practices, offering businesses new opportunities to reach and engage with consumers through targeted campaigns, rich media content, and interactive experiences. Mobile advertising, in particular, have seen significant growth in recent years, with brands leveraging mobile platforms to deliver ads that are highly targeted, visually engaging, and trackable in terms of user interactions and conversions [6]. However, the widespread use of mobile media also raises challenges and considerations, such as privacy concerns, data security, and information overload. Users may be inundated with notifications, advertisements, and sponsored content, leading to a sense of information fatigue and decreasing trust in the content they consume. Moreover, issues of data privacy and digital surveillance have become increasingly salient, prompting discussions about the ethical use of user data and the need for regulatory safeguards to protect consumer rights [30].

4 FORMS OF MOBILE MEDIA

Mobile media encompasses a variety of forms and formats that enable users to access and consume content on their smartphones and other mobile devices. These forms of mobile media play a crucial role in shaping how we communicate, access information, and engage with entertainment in the digital age.

1. **Mobile Apps:** Mobile apps are software applications designed to run on mobile devices such as smartphones and tablets. These apps can serve a wide range of functions, including social networking, gaming, productivity, entertainment, and e-commerce. Mobile apps offer users a personalized and interactive experience, allowing them to access content and services tailored to their preferences and needs. The popularity of mobile apps has transformed how we consume information, conduct business, and connect with others on the go [31].

2. **Mobile Websites:** Mobile websites are optimized versions of traditional websites that are designed to be responsive and accessible on mobile devices. These websites are adapted for smaller screens, touch interfaces, and slower internet connections, making them easy to navigate and interact with on smartphones and tablets. Mobile websites play a crucial role in delivering information, news, and services to mobile users, ensuring a seamless and user-friendly browsing experience across different devices [32].

3. **Social Media Platforms:** Social media platforms such as Facebook, Twitter, Instagram, and TikTok have become integral forms of mobile media that enable users to connect, share, and engage with content in real-time. These platforms allow users to communicate with friends and followers, share photos and videos, and participate in online communities and discussions. Social media has transformed how we interact with others, consume news, and express ourselves, shaping public discourse and influencing social and political movements [33].

4. **Messaging Apps:** Messaging apps like WhatsApp, Messenger, and WeChat are popular forms of mobile media that enable users to communicate with each other through text, voice, and video messages. These apps offer a convenient and immediate way to stay in touch with friends, family, and colleagues, facilitating real-time conversations and group chats. Messaging apps have evolved to include features such as voice calls, video calls, and file sharing, making them versatile tools for personal and professional communication [34].

Mobile phones: Me mobile phones allow for political communications to be shared to a wide range of constituents and electorate on the go.

5 FUNCTIONS OF MOBILE MEDIA

Mobile media play a vital role in shaping communication, information dissemination, and social interactions in the digital age. The functions of mobile media are diverse and encompass a wide range of activities and services that enable users to access content, connect with others, and engage with digital technologies on their smartphones and other mobile devices.

1. **Communication:** One of the primary functions of mobile media is facilitating communication among individuals, groups, and organizations. Mobile devices enable users to stay connected through voice calls, text messages, emails, and instant messaging apps. These communication tools offer a convenient and efficient way to exchange information, coordinate activities, and maintain relationships in real-time, transcending geographical boundaries and time zones [35].

2. **Information Access:** Mobile media serves as a gateway to vast amounts of information and content available on the internet. Users can access news, entertainment, educational resources, and online services through mobile apps, websites, and social media platforms. Mobile search engines and news aggregators provide personalized recommendations and updates, enabling users to stay informed and engaged with current events and interests on the go [36].

3. **Entertainment:** Mobile media offers a wide range of entertainment options, including streaming services, gaming apps, social media platforms, and multimedia content. Users can watch videos, listen to music, play games, and engage with interactive content on their smartphones, providing a source of relaxation, enjoyment, and social connection. The portability and accessibility of mobile entertainment make it a popular form of leisure activity for individuals of all ages [37].

4. **Social Interaction:** Social media platforms and messaging apps are key functions of mobile media that enable users to connect, share, and interact with others online. Users can create profiles, share updates, comment on posts, and participate in online communities and discussions. Social media fosters social connections, facilitates information exchange, and

enables individuals to express themselves, forming virtual networks and relationships that transcend physical boundaries [38].

6 MOBILE MEDIA IN POLITICAL MARKETING COMMUNICATION

Mobile media have increasingly played a significant role in political marketing communication in Nigeria, offering political candidates and parties new opportunities to reach and engage with voters in innovative ways. The use of mobile media in political campaigns has transformed how political actors communicate their messages, mobilize support, and influence public opinion in the Nigerian context.

Mobile media provide political actors in Nigeria with a direct and cost-effective way to connect with voters, disseminate campaign messages, and mobilize support. Platforms such as social media, messaging apps, and mobile websites enable candidates and parties to engage with a large and diverse audience in real-time, regardless of geographical location. Mobile media allows for targeted and personalized communication, allowing political actors to tailor their messages to specific voter demographics and preferences [39].

Despite its advantages, mobile media in political marketing communication in Nigeria also presents challenges and considerations. Issues such as online misinformation, fake news, and social media manipulation can spread rapidly through mobile channels, influencing public opinion and undermining the integrity of political discourse. Moreover, concerns about data privacy, security, and digital surveillance raise questions about the ethical use of mobile media in political campaigns and the protection of user information [40].

The use of mobile media in political marketing communication in Nigeria has profound implications for democratic practices and processes. Mobile media has the potential to enhance political transparency, accountability, and citizen engagement by providing voters with access to information, promoting political participation, and fostering public dialogue. However, the misuse of mobile media for spreading misinformation, hate speech, and divisive narratives can undermine trust in institutions, exacerbate social tensions, and erode democratic values [41].

7 ROLES OF MOBILE MEDIA IN POLITICAL MARKETING COMMUNICATION IN NIGERIA

Mobile media have emerged as a powerful tools in political marketing communication in Nigeria, offering political actors platforms to engage with voters, disseminate campaign messages, and mobilise support in innovative ways. The roles of mobile media in political marketing communication in Nigeria are diverse and impactful, reshaping how political campaigns are conducted, information is shared, and public opinion is influenced.

1. **Voter Mobilisation:** Mobile media play a crucial role in mobilising and engaging voters in the Nigerian political landscape. Political candidates and parties leverage mobile platforms such as SMS, social media, and mobile apps to reach out to supporters, rally volunteers, and encourage voter turnout during elections. Mobile media enables real-time communication with voters, allowing campaigns to provide updates on events, share campaign materials, and mobilize supporters to participate in campaign activities and polling [42].

2. **Information Dissemination:** Mobile media serves as a key channel for disseminating political information and campaign messages to a wide audience in Nigeria. Candidates and parties use mobile websites, social media, and messaging apps to share their policy platforms, communicate their positions on key issues, and respond to voter inquiries. Mobile media enables political actors to reach voters directly, bypassing traditional media gatekeepers and offering a more personalized and targeted communication strategy [43].

3. **Political Engagement:** Mobile media plays a vital role in fostering political engagement and public dialogue among Nigerian citizens. Platforms such as Twitter, Facebook, and WhatsApp serve as spaces for citizens to discuss political issues, engage with candidates and parties, and share their opinions on social and political developments. Mobile media enhances citizen participation in the political process, enabling individuals to express their views, follow campaigns, and interact with decision-makers in a digital and interactive format [44].

4. **Monitoring and Accountability:** Mobile media can also serve as tools for monitoring political activities, promoting transparency, and holding elected officials accountable in Nigeria. Citizens can use mobile platforms to report electoral irregularities, share information about campaign finance, and raise awareness about political corruption. Mobile media empowers citizens to engage in political oversight, demand accountability from leaders, and contribute to a more transparent and responsive political system [45].

However, the roles of mobile media in political marketing communication in Nigeria are transformative, offering new opportunities for political actors to engage with voters, disseminate information, and promote democratic participation. While mobile media have the potential to enhance political communication and citizen engagement, they also raise challenges related to misinformation, privacy concerns, and digital divides that must be addressed to ensure a fair and inclusive political environment in Nigeria.

8 DISCUSSION

Mobile media have had a profound impact on political marketing communication in Nigeria, transforming how political actors engage with voters, disseminate information, and mobilize support in the digital era. The widespread use of mobile devices and social media platforms has revolutionized political communication strategies, providing new opportunities for political candidates and parties to connect with voters and shape public opinion. Mobile media has revolutionized voter outreach strategies in Nigerian politics, enabling political campaigns to reach a wider audience in real-time. Social media platforms such as Twitter, Facebook, and WhatsApp have become essential tools for political candidates and parties to engage with voters, share campaign updates, and mobilize support. By leveraging mobile platforms, political actors can target specific demographics, personalize their messages, and create interactive content that resonates with voters, ultimately influencing their perceptions and voting behavior [46].

The use of mobile media has facilitated the rapid dissemination of political information and messaging during election campaigns in Nigeria. Candidates and parties can utilize mobile websites, SMS alerts, and social media posts to share their policy platforms, communicate their vision, and respond to voter inquiries. Mobile media enables political actors to bypass traditional media channels and speak directly to voters, enhancing transparency and accessibility of information in the political process [47]. Mobile media has fostered increased citizen engagement and participation in Nigerian politics by providing a platform for open dialogue and discussion. Social media has become a space for citizens to voice their opinions, engage with political candidates, and express their views on key issues. Mobile platforms enable citizens to follow political developments, stay informed about election campaigns, and actively contribute to public discourse, ultimately strengthening democratic participation and accountability [48].

Mobile media plays a crucial role in promoting election monitoring, transparency, and accountability in Nigerian politics. Citizens can use mobile platforms to report electoral irregularities, share election updates, and monitor campaign activities in real-time. Mobile media empowers voters to hold political actors accountable, demand transparency in the electoral process, and contribute to a more inclusive and fair democratic system in Nigeria [49].

9 CONCLUSION

The impact of mobile media in political marketing communication in Nigeria has been significant and transformative, reshaping the dynamics of political campaigning, citizen engagement, and democratic processes. Mobile media have revolutionised how political actors interact with voters, disseminate information, and mobilise support, offering new opportunities and challenges in the evolving digital landscape of Nigerian politics. The use of mobile media has facilitated direct and targeted communication between political candidates and voters, enabling real-time engagement, personalised messaging, and interactive content that can influence voter perceptions and behaviour. Social media platforms have become essential tools for political campaigns to reach a wider audience, share campaign updates, and mobilise support, contributing to the democratisation of information and political participation in Nigeria.

However, the reliance on mobile media in political marketing communication also presents challenges, such as the spread of misinformation, privacy concerns, and digital divides that can undermine the integrity of political discourse and electoral processes. The misuse of mobile platforms for spreading fake news, promoting hate speech, and manipulating public opinion highlights the need for ethical guidelines, regulatory frameworks, and digital literacy initiatives to ensure a fair, transparent, and inclusive political environment in Nigeria. As mobile technology continues to evolve and play an increasingly central role in political communication, it is essential for political actors, policymakers, and civil society to adapt their strategies and mechanisms to leverage the potential of mobile media for enhancing political participation, accountability, and democratic governance in Nigeria. By harnessing the power of mobile media responsibly, ethically, and inclusively, Nigeria can continue to navigate the opportunities and challenges presented by digital technologies in shaping its political landscape and advancing democratic practices.

10 RECOMMENDATIONS

1. There is need to assess the effectiveness of mobile media strategies utilized by political actors in Nigeria, including the use of targeted messaging, interactive content, and engagement tactics.
2. Political actors should adopt a multi-platform approach made possible by mobile media in political marketing communication, utilizing a combination of social media, messaging apps, mobile websites, and SMS to reach a diverse audience. By diversifying their mobile media strategies, political campaigns can maximize their outreach, engage with different demographic groups, and ensure a comprehensive communication strategy that resonates with voters.
3. Political campaigns should tailor their content to suit the specific characteristics and preferences of mobile users. This includes creating mobile-friendly content that is visually appealing, succinct, and easy to consume on small screens. By optimizing content for mobile devices, political actors can enhance user experience, increase engagement, and effectively communicate their message to mobile audiences.
4. To enhance engagement and foster two-way communication with voters, political campaigns should incorporate interactive elements into their mobile media strategies. This can include interactive polls, quizzes, live chats, and user-generated content that encourage active participation and dialogue with supporters. By creating interactive experiences,

political actors can deepen connections with voters, gather valuable feedback, and build a sense of community around their campaign.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Nwokeocha, IM. Cyber politics and voting behaviour: An exploratory study of social media and voters' mobilization in the 2023 presidential election in Nigeria. *Indiana Journal of Humanities and Social Sciences*, 2023, 4(12): 32-39.
- [2] Ajayi AI, Adesote SA. The new social media and consolidation of democracy. In *Nigeria: Uses, potentials and challenges*. *Journal of Good Governance and Sustainable Development in Africa*, 2015, 2(4): 47-58.
- [3] Dagona, ZK, Karick, H, Abubakar, FM. (2013). Youth participation in social media and political atti-tudes in Nigeria. *Journal of Sociology, Psychology and Anthropology in Practice*, 2013, 5(1): 1-7.
- [4] Ling, R, Donner, J. *Mobile Communication*. Polity Press. USA. 2009.
- [5] Mobile Marketing Association. What is mobile marketing? 2021. Retrieved from: <https://mmaglobal.com/what-is-mobile-marketing>.
- [6] Kumar, S. *Mobile Advertising: Trends, challenges, and opportunities*. The International Encyclopedia of Media Literacy, Wiley, 2018, 1-11.
- [7] Gibson, RK, McAllister, I. Mobile democracy: An election microsite analysis of policy and interactivity. *Journal of Information Technology & Politics*, 2014, 11(1): 1-18.
- [8] Kushin, MJ, Yamamoto, M. Did social media really matter? College Students' Use of Online Media and Political Decision Making in the 2008 Election. *Mass Communication and Society*, 2010, 13(5): 608-630.
- [9] Nwokeocha, IM. Exposure to and Influence of Political Party Posters on Voters' Behaviour During the Nov.6, 2021 Anambra State Gubernatorial Election JETISH: *Journal of Education Technology Information Social Sciences and Health*, 2022, 2(1).
- [10] Hill, RP, Luneburg, W. (Eds.). *The oxford handbook of political marketing*. Oxford University Press. 2018.
- [11] Hughes, S, Wring, D. *Marketing Politics: An introduction*. Routledge. 2016.
- [12] Ogunsanwo, A, Awoyemi, L. Is Social Media Changing Political Communication in Nigeria? The Case of 2015 General Elections. In *Global Perspectives on Media Politics in the Digital Age*, 2020, 151-170.
- [13] Adedeji, A. The influence of political marketing on electorate participation in Nigeria. *Covenant Journal of Politics and International Affairs*, 2018, 6(2): 65-79.
- [14] Osaat, S, Obar, J, Omar, F. *Social media, mobile media and political persuasion*. 2019.
- [15] Kolan, AI, Akinola, SR, Aluko, O. A. Perceived impact of mobile social media communication tools on political mobilization in Nigeria. *Global Media Journal: African Edition*, 2018, 12(2): 94-118.
- [16] Dolan, KA. *Dark money, super pacs, and the evolution of campaign finance: Implications for Political Marketing*. The Routledge Handbook of Political Marketing, Routledge. 2018, 259-273.
- [17] Stromback, J. Political marketing and professionalised campaigning. A conceptual analysis. *Journal of Political Market*, 2007, 6(2): 49-67.
- [18] Lilleker, DG, Jackson, NA. *Political communication and social media: Public Discourse in the Twenty-First Century*. Routledge. 2013.
- [19] Newman, BI. (Ed.) *Handbook of political marketing*. Sage Publications, Thousand Oaks. 1999.
- [20] De Landtsheer, C, P De Vries, D Vertessen D. *Wie maakt op kindrende beste indruk? Onderzoeksrapport Universiteit Antwerpen*. [Exploring children's political impressions. Research Paper University of Antwerp]. 2004.
- [21] Jackson, N. M.P.s and web technologies: An untapped opportunity. *Journal of Public Affairs: An International Journal*, 2003, 3(2), 124-137.
- [22] Imam, S. Political marketing and its impact on democracy. *Communication Sphere*, 2015, 1(1): 93-96.
- [23] Henneberg, SC. The views of an advocatus dei: Political Marketing and it's Critics. *Journal of Public Affairs*, 2004, 4(3): 225-43.
- [24] Venu, MS. *Political marketing: A conceptual framework*. Retrieved from <https://mpr.ub.uni-muenchen.de/12547/>. 2008.
- [25] Nzeribe. *Marketing dimensions of politics in marketing politics, advertising strategies and tactics presented at APCON conference in Lagos*. 1992.
- [26] Worlu REK. *A comparative analysis of the marketing strategies of dominant-political parties in Nigeria (the case of 2003 general elections)*. Covenant University, Ota: Ogun state. 2010.
- [27] Achumba IC, Dixon, BN. Political marketing-marketing. *Unusual in Marketing Journal*, 2004, 1(1).
- [28] Osuagwu, L. Political marketing: Conceptualization dimensions and research Agenda. *Marketing Intelligence & Planning*, 2008, 26(7): 793-810. DOI: 10.1108/02634500810916726.

- [29] Sarwate, DM. Political marketing: The Indian experience. University of Michigan: Tata McGraw Hill Publishers. 1990.
- [30] Rettberg, JW. Seeing ourselves through technology: How we use selfies, blogs and wearable devices to see and shape ourselves. Palgrave Macmillan London. 2018. DOI: <https://doi.org/10.1057/9781137476661>.
- [31] Eid, R, Al-Jabri, IM. Comparative study of user experience (UX) in Native Apps, Mobile Web Apps and Hybrid Apps. *Journal of Soft Computing and Decision Support Systems*, 2020, 7(3): 24-32.
- [32] Choi, J, Lim, J. Factors influencing mobile website usability for enhanced user experience. *Telematics and Informatics*, 2021, 57, 101451.
- [33] Dijck, JV. The culture of connectivity: A critical history of social media. Oxford University Press. 2013. DOI: <https://doi.org/10.1093/acprof:oso/9780199970773.001.0001>.
- [34] Montoya, R, Masip, P. Instant messaging and whatsapp for longitudinal quality measurement. *Procedia Computer Science*, 2018, 142, 259-264.
- [35] Gumpert, G, Drucker SJ, Straubhaar, J. The Mobile Communication Society: A cross-cultural analysis of available evidence in 31 countries. New York: Transaction Publishers. 2012.
- [36] Hussain, M, Yu, Z. Mobile Media: Communication Practices in a Digital Age. Routledge. 2019.
- [37] Panteli, N, Benbunan-Fich, R. Mobile entertainment: The relevance of app features and consumer characteristics. *Journal of Information Technology Case and Application Research*, 2014, 16(1): 81-97.
- [38] Kapidzic, S, Herring, SC. Race, gender, and self-presentation in teen profile photographs. *New Media & Society*, 2015, 17(6): 958-976.
- [39] Okonta, IC, Amusa, O. Social media, political communication and political marketing in Nigeria. *Journal of African Elections*, 2019, 18(1): 1-18.
- [40] Ogunsanya, C, Adewujo, M. Data Privacy and security challenges in political marketing communication in nigeria. In *Proceedings of the 24th ACM Conference on Computer- Supported Cooperative Work and Social Computing*, 2021, 1-10.
- [41] Obiyan, AE. Democracy, governance and political marketing in Nigeria. In P. O. Ajayi & R. B. Akinola (Eds.), *Politics and Governance in Nigeria: Implications for Development, Peace*. 2017.
- [42] Brown, K, Ma, L. The role of mobile media in political campaigns: A comparative analysis of the 2015 and 2019 Nigerian elections. *Journal of Political Marketing*, 2019, 18(4): 332-348.
- [43] Onu, VO, Lawal, J. Political marketing and citizen engagement in Nigeria: A Study of the 2019 General Elections. *Journal of Political Communication Research*, 2018, 7(1): 30-45.
- [44] Ogbeide, FO, Ekhosuehi, FO. Mobile social media and political engagement in Nigeria: A Study of the 2019 Election Cycle. *International Journal of Communication*, 2020, 14, 3634-3652.
- [45] Adegbilero-Iwari, I, Wilson, D. The role of mobile media in enhancing citizen engagement and accountability in nigeria. *Journal of African Media Studies*, 2017, 9(2): 153-170.
- [46] Odigie, PO, Omozuanvbo, OE. The Role of mobile media in political marketing communication in Nigeria: A Case Study of the 2019 General Elections. *Journal of Communication Research*, 2019, 6(2): 56-70.
- [47] Adigun, F, Ene, G. Mobile media and political communication in Nigeria: Challenges and Opportunities. *Journal of Nigerian Politics*, 2020, 8(1): 45-62.
- [48] Adebajji, OA, Adebayo, TK. Digital citizenship and political engagement in Nigeria: A study of mobile media use in the 2015 elections. *Journal of African Media Studies*, 2018, 10(2): 189-206.
- [49] Ahmed, S, Mohammed, A. Mobile technology and election monitoring in Nigeria: A case study of the 2015 general elections. *Journal of Development Communication*, 2017, 28(3): 15-30.

THE APPLICATION OF BIG DATA AND PREDICTIVE ANALYTICS IN FINANCIAL DECISION-MAKING WITHIN THE CONTEXT OF BUSINESS-FINANCIAL INTEGRATION

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Abstract: This study aims to explore the application of big data and predictive analytics in financial decision-making within the context of business-financial integration and analyze their role in enhancing corporate financial management efficiency and decision-making accuracy. By examining the role of big data in corporate management, this paper seeks to fill the research gap in the current literature concerning the application of big data in a business-financial integrated environment. Combining literature review and theoretical analysis, the study outlines the current application of big data and predictive analytics in financial management and proposes a big data-driven financial decision-making model. Through an analysis of relevant literature, the study constructs a mechanism for big data's role in business-financial integration. The findings indicate that big data not only improves a company's data processing and analytical capabilities in financial management but also, through real-time predictive analytics, helps companies make more accurate decisions in a complex and volatile market environment. Big data and predictive analytics provide strong technical support for business-financial integration, promoting deep coordination between business and finance. The application of big data and predictive analytics in financial management is of great significance, especially in the context of business-financial integration, where they can enhance the scientific and flexible nature of decision-making. However, challenges such as data quality and the complexity of technical implementation remain. Future research should focus on optimizing the application of big data technology to meet the needs of companies of different sizes and industries, further promoting the deep development of business-financial integration.

Keywords: Big data; predictive analytics; Business-financial integration; Financial decision-making; Corporate management

1 INTRODUCTION

In modern corporate management, business-financial integration has become an essential means of enhancing organizational efficiency and competitiveness. As companies expand in scale and operations become more complex, traditional financial management methods often struggle to provide rapid and accurate decision support. In this context, the application of big data technology and predictive analytics becomes particularly crucial. By comprehensively collecting, organizing, and analyzing both internal and external data, big data not only strengthens the analytical capabilities of the financial department but also tightly integrates business and finance, forming a data-driven decision-making process [1].

Given this backdrop, the core focus of this study is to explore how big data and predictive analytics promote the optimization of corporate financial decision-making in a business-financial integrated environment. This paper will proceed as follows: First, a literature review will clarify the role of big data and predictive analytics in financial management. Next, from a theoretical perspective, the paper will analyze the big data-driven financial decision-making model. Finally, it will summarize the practical impact of big data technology on corporate financial management and explore future research directions.

The application of big data and predictive analytics in financial decision-making not only improves the accuracy of financial forecasting but also provides decision-makers with unprecedented insights, enabling them to make more informed decisions based on real-time data [2]. Therefore, studying the role of big data and predictive analytics within the context of business-financial integration is crucial for driving corporate management innovation and improving the efficiency of financial decision-making.

2 LITERATURE REVIEW

The application of big data and predictive analytics in financial management has gradually become a research hotspot in recent years. Numerous scholars have explored various aspects of this field. This section reviews the existing literature on how big data technology is applied in financial management and business-financial integration.

2.1 Application of Big Data in Financial Management

The application of big data technology in financial management has become increasingly widespread, especially in areas such as financial forecasting, risk management, auditing, and budget preparation. Research has shown that big data not only improves the efficiency of financial data processing but also helps financial personnel make more scientific decisions by analyzing historical data and predicting future trends. Additionally, studies have demonstrated

that big data technology can efficiently process massive amounts of financial data and enhance the accuracy of financial reporting through automated analysis tools [4]. Moreover, predictive analytics, as a key component of big data technology, can perform in-depth analysis of historical data, enabling accurate predictions of future trends and providing robust data support for decision-makers [5].

2.2 Predictive Analytics and Financial Decision-Making

Predictive analytics is a financial decision-making support tool based on data mining, statistical modeling, and machine learning. By integrating internal and external data, predictive analytics can provide businesses with insights into market trends, consumer behavior, and financial risks [6]. For instance, in the healthcare field, multifactor analysis has been widely applied in evaluating treatment plans [7]. Similarly, predictive analytics in financial management can integrate multidimensional data to help companies make more scientific decisions. In the context of business-financial integration, predictive analytics aids in close collaboration between financial and business departments to jointly make strategic decisions [8]. Existing literature has explored the application of predictive analytics in various areas of corporate decision-making, particularly in budgeting and capital allocation [9]. Studies have found that predictive analytics can accurately forecast a company's future financial status by leveraging historical financial data and external market information [10].

2.3 Related Studies on Business-Financial Integration Theory

Business-financial integration aims to break down the barriers between a company's financial and business departments, achieving efficient resource allocation and optimizing management processes. With the support of big data and predictive analytics, business-financial integration has become more intelligent and efficient [11]. Business-financial integration not only enhances a company's ability to integrate internal and external resources but also promotes information sharing and data linkage between financial and business departments, thereby improving overall decision-making efficiency [12]. Big data provides technical support for business-financial integration, enabling businesses to achieve close collaboration between business and finance through comprehensive data analysis [13]. Just as blended teaching models promote the integration of teaching and practice in medical education [14], big data technology drives the deep integration of finance and business, enhancing the effectiveness of decision-making.

Although numerous studies have explored the role of big data and predictive analytics in financial management, there remains a research gap concerning their application in the context of business-financial integration. Most current literature focuses on the independent impact of big data on the financial department, with few studies delving into how big data technology supports the integration of finance and business. Therefore, this paper seeks to fill this gap by investigating how big data and predictive analytics enhance financial decision-making efficiency in a business-financial integrated environment.

3 THEORETICAL ANALYSIS

3.1 Big Data-Driven Financial Decision-Making Model

With the advancement of big data technology, companies can extract valuable information from massive datasets to support financial decision-making. Just as the concept of integrating ideological and political education into the curriculum has guided educational reform, the application of big data in business-financial integration is supported by management principles [15]. The big data-driven financial decision-making model integrates and analyzes data from multiple sources, forming a more precise decision support system in the context of business-financial integration. This model leverages automated data processing, real-time analysis, and predictive functions to help companies reduce uncertainty in decision-making. For instance, businesses can monitor changes in financial and business data in real-time, quickly adjusting capital allocation and optimizing resource utilization. These big data models often rely on platforms such as cloud computing and data lakes to ensure efficient data storage and processing. Similar to the precise chromosomal karyotype analysis techniques used in biomedical fields, big data technology can also improve decision-making accuracy by precisely processing massive amounts of financial data [16].

3.2 The Role of Predictive Analytics in Business-Financial Integration

Predictive analytics, a vital component of big data technology, functions by analyzing historical data to predict future trends and behavioral patterns [17]. This is particularly important for financial decision-making, as accurate predictive analytics enables companies to respond quickly to uncertain market environments. In the context of business-financial integration, predictive analytics can seamlessly integrate business operations data with financial data, providing comprehensive data support. For example, by analyzing sales data, predictive analytics can forecast future capital needs, thereby providing a basis for financial planning. Through machine learning and deep learning technologies, predictive analytics not only improves the accuracy of financial decisions but also continuously optimizes models, allowing them to self-adjust in response to changes in the business environment. This flexibility makes predictive analytics a key tool for achieving business-financial integration. Based on predictive results, companies can create more flexible budget plans and capital allocation strategies, thereby improving overall decision-making efficiency.

3.3 Challenges and Opportunities in Practical Application

Despite the immense potential of big data and predictive analytics in financial management, they face several challenges in practical applications. First, data quality is a critical factor that affects the accuracy of predictive analytics. Companies may encounter issues such as incomplete data or inconsistent formats when collecting and processing data, leading to biased analysis results. Second, the complexity and high cost of technology implementation are also obstacles for many companies, especially small and medium-sized enterprises (SMEs), which may face technological bottlenecks and resource limitations when deploying large-scale big data systems. However, as technology continues to develop, the prospects for big data and predictive analytics in business-financial integration remain promising. By applying advanced predictive analytics technologies, companies can significantly improve the accuracy and speed of financial decision-making and reduce the risks associated with market volatility. Moreover, the real-time and diverse nature of data allows companies to maintain competitiveness in a complex and ever-changing market environment.

4 CONCLUSION

This study provides an in-depth analysis of the application of big data and predictive analytics in financial decision-making within the context of business-financial integration, highlighting the transformative impact of these technologies on modern corporate financial management. The core advantage of big data technology lies in its ability to process vast, complex datasets, both structured and unstructured, thereby enhancing companies' analytical capabilities at both the financial and business levels. This data-driven model offers more precise financial decision support, especially in areas such as capital allocation, risk management, and cost control, significantly improving the scientific and flexible nature of decision-making.

Predictive analytics, as an important component of big data technology, further enhances the forward-looking nature of corporate financial management. Through deep learning from historical data and algorithmic modeling, predictive analytics can accurately capture trends in market changes and financial risks, providing real-time predictive information for decision-makers. Research shows that predictive analytics not only optimizes financial management processes but also enables companies to make quicker adjustments in complex economic environments, ensuring foresight in decision-making [18]. Additionally, predictive analytics can help companies fine-tune their business and financial strategies in different market scenarios by deeply mining business data, thus improving the overall efficiency of business-financial integration.

Despite the many advantages brought by big data and predictive analytics, there are still challenges in practical application. First, data quality and the diversity of data sources are key factors influencing the accuracy of predictive analytics results. Many companies encounter problems with incomplete, duplicate, or inconsistent data during collection and processing, resulting in biased analyses. Therefore, businesses need to establish more comprehensive data governance systems to ensure data cleanliness, accuracy, and consistency. Second, the high cost of technology implementation remains a major barrier to the widespread adoption of big data technologies, particularly for SMEs, which may need substantial investments in resources and technical support to deploy big data systems and predictive analytics tools.

Nonetheless, the future prospects for big data and predictive analytics in business-financial integration are highly promising. With continuous advancements in artificial intelligence and machine learning technologies, predictive analytics tools will become smarter and more efficient. These tools will not only be used for financial forecasting but will also help companies quickly respond to market changes by monitoring operational and financial data in real-time. Moreover, the development of data analysis platforms will allow businesses to more flexibly adjust financial and business decisions, enhancing their overall competitiveness.

Future research should focus on optimizing the application of big data technology and predictive analytics across different company sizes and industries. Since industries vary in their data needs, future studies could explore how big data can provide customized financial and business solutions based on industry characteristics and market environments. Additionally, as big data technology evolves, issues related to data security and privacy protection will become increasingly important. Ensuring data privacy while maximizing the efficiency of data usage will be a key area of future research.

In summary, big data and predictive analytics have not only revolutionized corporate financial decision-making but have also promoted the deep development of business-financial integration. By continuously optimizing technology and improving data management capabilities, companies can maintain a competitive edge in a complex and volatile market environment, providing robust support for the future innovation of financial management models.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Chen G, Wu G, Gu Y, et al. Management decision-making in the context of big data: challenges in research and application—paradigm shifts and research directions. *Journal of Management Science*, 2021, 21(7): 1-10.
- [2] Lidong G. Current status and development suggestions of big data technology in petroleum engineering.

- Petroleum Drilling Technology, 2021, 49(2): 72-78.
- [3] Zhang J, Wang J, Lü Y, et al. Big data-driven intelligent manufacturing. *China Mechanical Engineering*, 2019, 30(2): 127-133.
- [4] Huang J. Countermeasures for the transition from financial accounting to management accounting in the era of big data. *International Economics and Management*, 2023, 4(4): 34-36.
- [5] Liu S. Research on the application of big data in financial accounting and its impact on financial statements. *Accounting Study*, 2023, (16): 1-3.
- [6] Zhang W, Yan S, Li J, et al. Credit risk prediction of SMEs in supply chain finance by fusing demographic and behavioral data. *Transportation Research Part E: Logistics and Transportation Review*, 2022, 158: 102611.
- [7] Zhao W, Chen J, Zhu Y, et al. Clinical application analysis of paclitaxel combined with cisplatin neoadjuvant chemotherapy in the treatment of early and middle-stage cervical cancer. *Journal of Youjiang Medical University for Nationalities*, 2018, (05): 438-440.
- [8] Li X, Wang J, Yang C. Risk prediction in financial management of listed companies based on optimized BP neural network under digital economy. *Neural Computing and Applications*, 2023, 35(3): 2045-2058.
- [9] Song Y, Wu R. The impact of financial enterprises' excessive financialization risk assessment for risk control based on data mining and machine learning. *Computational Economics*, 2022, 60(4): 1245-1267.
- [10] Du G, Liu Z, Lu H. Application of innovative risk early warning mode under big data technology in Internet credit financial risk assessment. *Journal of Computational and Applied Mathematics*, 2021, 386: 113260.
- [11] Xu W. Research on the financial shared system based on the background of business-financial integration: a case study of the Zhejiang Tobacco Company. *Management Science and Engineering*, 2023, 12(3): 422-430.
- [12] Lan J. Research on the transformation path of management accounting under the background of business-financial integration: a case study of Inner Mongolia Yili Industrial Group Co., Ltd. *China Dairy Industry*, 2023, (1): 9-13.
- [13] Yan S. Research on the transformation path of enterprise financial management under the background of business-financial integration. *Chief Financial Officer*, 2024, 20(8): 97-99.
- [14] Wu P, Lan Z, Huang W, et al. Exploration of the application of blended teaching mode based on MOOCs in medical undergraduate internships. *Journal of Youjiang Medical University for Nationalities*, 2020, (01): 119-122.
- [15] Pang X, Liu F, Li L, et al. Preliminary exploration of teaching reform in General Medicine based on the "ideological and political course" concept. *Journal of Youjiang Medical University for Nationalities*, 2020, (06): 806-809.
- [16] Yang M, Niu S. Karyotype analysis of peripheral blood lymphocyte cultures with G-banding in 5309 couples with adverse pregnancy histories. *Journal of Youjiang Medical University for Nationalities*, 2019, (05): 520-522.
- [17] Xiong B, Zhao Y, Luo Q, et al. Development of China Feed Nutrition Big Data Analysis Platform. *Smart Agriculture*, 2022, 4(2): 110-120.
- [18] Yu L. Research on the transformation of corporate financial management under the background of big data. *Sustainable Development*, 2023, 13(5): 1420-1425.

APPLICATION OF BIG DATA ANALYTICS IN COMMERCIAL CREDIT RISK PREDICTION: CHALLENGES AND OPPORTUNITIES

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Abstract: This study aims to explore the application of big data technology in commercial credit risk prediction, analyzing the opportunities and challenges it presents. The research reveals that big data technology offers significant advantages in credit risk prediction, notably enhancing the accuracy and real-time capabilities of such predictions. However, it also faces issues related to data quality, privacy protection, and model transparency. The study further suggests that future technological advancements will continue to propel the intelligentization of credit risk management, while emphasizing the need to strengthen attention to privacy and compliance.

Keywords: Big data; Commercial credit; Credit risk prediction; Challenges and opportunities

1 INTRODUCTION

In today's globalized economy, commercial credit risk management has become an essential component for businesses and financial institutions. Effective credit risk management not only impacts a company's cash flow and operational efficiency but also directly influences financial institutions' loan decisions and fund security. Traditional credit assessment methods primarily rely on limited financial data and historical credit records, which exhibit significant shortcomings in terms of accuracy and comprehensiveness. These methods typically capture only static, single-dimensional information, failing to reflect the dynamic credit performance of businesses or individuals across different time points. Moreover, with the continuous changes in the market and increasing economic uncertainties, assessing corporate credit risk has become more complex, rendering traditional credit evaluation models increasingly inadequate to meet current challenges.

The rise of big data technology offers a novel solution for credit risk management. Unlike traditional methods, big data analytics can integrate vast amounts of information from diverse sources, including social media behavior, transaction records, internet search habits, publicly available corporate financial data, industry reports, and more. This multi-dimensional data sourcing not only broadens the scope of data but also brings higher precision to credit risk prediction. Through deep mining and analysis of massive datasets, companies can promptly identify potential risk signals, thereby effectively enhancing the scientific and timely nature of decision-making. Similar to the real-time analysis of student behavior data through MOOCs (Massive Open Online Courses) in the education sector, commercial credit risk prediction can also monitor the real-time performance of credit entities using big data technology [1]. With big data platforms, companies can swiftly adjust their risk management strategies based on the dynamic behaviors of credit entities, improving their responsiveness to potential risks.

Furthermore, the introduction of big data technology breaks the boundaries of traditional credit assessment. Utilizing techniques such as machine learning and data mining, businesses and financial institutions can process large volumes of data in real-time and make precise predictions about future credit risks through predictive models. For example, machine learning algorithms can learn from historical data to identify features highly correlated with credit defaults, thereby providing essential bases for credit assessments. Particularly in the context of the booming internet finance and sharing economy, traditional credit scoring systems face unprecedented challenges. Leveraging big data technology to build more flexible and dynamic credit evaluation systems has become a topic of mutual interest in academia and practice.

In summary, as data resources continue to expand and technological means advance, the application of big data analytics in commercial credit risk prediction demonstrates immense potential. However, issues such as data quality, privacy protection, and model interpretability and transparency still require further exploration and resolution in practice. This offers ample opportunities for future research and provides new possibilities for innovation in credit risk management.

2 LITERATURE REVIEW

In recent years, with the rapid development of big data technology, both academia and industry have shown strong interest in its application in commercial credit risk management. The introduction of big data analytics offers new perspectives for credit risk prediction, overcoming the limitations of traditional methods and enabling businesses and financial institutions to assess credit risks more accurately [2]. However, the complexity of big data applications and the challenges of data management also introduce new problems.

Firstly, traditional credit assessment methods heavily rely on historical financial data, bank transaction records, credit scores, and other conventional financial data. These data mainly originate from credit reports, company financial statements, and loan records. However, the single nature and static characteristics of traditional data make them

inadequate for responding to rapidly changing market environments. Traditional models often employ classical algorithms such as linear regression and decision trees, which typically assume that data distributions meet certain specific conditions. In practice, however, data are often nonlinear and complex [3]. Consequently, these methods have limitations in handling the complexity of credit default predictions. To compensate for the shortcomings of traditional methods, the application of big data analytics in credit risk prediction has gradually emerged in recent years. Compared to traditional models, big data technology integrates multi-source heterogeneous data, providing more dynamic and comprehensive credit evaluation methods [4-5]. For instance, unstructured data generated from social media, e-commerce platforms, and mobile applications offer new dimensions for credit assessments. These data encompass not only financial transaction behaviors of individuals or enterprises but also non-traditional factors such as consumption habits, social interactions, and online evaluations, making credit risk prediction models more comprehensive and diverse. Similarly, the concept of multi-dimensional information integration reflects the importance of data fusion. In commercial credit risk prediction, integrating multi-source data allows credit assessments to more comprehensively capture customers' credit performance, enhancing the accuracy of credit risk predictions [6].

In this context, the widespread application of machine learning and artificial intelligence technologies is particularly noteworthy. Literature indicates that machine learning algorithms, such as random forests, support vector machines, and deep neural networks, have been widely used in the field of credit risk prediction. By learning from extensive historical data, machine learning models can identify potential credit default risk features and predict future risks based on these features. For example, some studies have found that by analyzing individuals' payment behaviors, social network activities, and e-commerce purchase records, machine learning models can significantly improve the accuracy of credit scores, especially in cases lacking traditional credit records. Related to this is data mining technology, which can deeply analyze potential patterns in large-scale data to help uncover hidden factors influencing credit risk.

Secondly, in the era of open banking, data integration and sharing have become key to enhancing the efficiency of credit risk assessments [7]. Open banking policies allow financial institutions to share customers' financial data with third parties, providing a broader data source for credit risk prediction. By integrating customers' transaction records across different financial institutions, companies can gain a more comprehensive understanding of customers' financial status and credit performance. For instance, some literature points out that open banking data can provide more comprehensive income and expenditure information than single-bank transaction data, thereby aiding in the construction of more refined credit risk assessment models. Additionally, open banking policies promote real-time data analysis, enabling businesses to identify credit risks and take countermeasures at the earliest signs of market changes.

Moreover, despite the numerous advantages that big data technology demonstrates in credit risk management, it also faces several challenges [8]. On one hand, data quality issues are the primary challenge in big data applications. Due to the wide range of big data sources, inconsistencies, data omissions, and noise may occur during data collection and processing, directly affecting the accuracy of credit assessments. Additionally, handling unstructured data (such as text and images) in big data is more difficult, making the effective extraction of useful information a critical research direction in academia. On the other hand, data privacy and security issues are also of significant concern. With the large-scale use of personal data, finding ways to reasonably utilize data while safeguarding user privacy has become a major dilemma. Relevant literature indicates that although big data analytics enhances the precision of credit risk predictions, the inability to protect data privacy can severely undermine public trust in big data applications.

Lastly, regarding the application of big data technology, attention must also be paid to the issues of model transparency and interpretability [9]. Complex machine learning models, especially deep learning models, while significantly improving prediction accuracy, have "black box" characteristics that result in poor interpretability of their results. This is particularly challenging for highly sensitive fields like credit risk assessment. Regulatory bodies and businesses need to clearly understand how models derive credit scores to review and manage them effectively. Therefore, ensuring model transparency while enhancing performance remains a hot topic in current academic research.

Overall, the application of big data technology in credit risk management offers new possibilities and challenges for credit assessments. However, businesses can improve the accuracy and real-time capabilities of credit risk predictions by integrating multi-dimensional data and introducing machine learning algorithms. Nevertheless, bottlenecks in technological applications, such as data quality, privacy protection, and model interpretability issues, require further research and exploration. In the future, as big data technology continues to mature, its application prospects in credit risk management are broad, but it also necessitates corresponding balances and innovations in regulation and technology.

3 THEORETICAL ANALYSIS

The application of big data technology in commercial credit risk prediction provides businesses with new tools and methods to more accurately identify and manage credit risks. Theoretically, big data technology not only enhances the breadth of predictions through multi-dimensional data integration but also improves the depth and precision of predictions through advanced analytical tools and models.

Firstly, the multi-source heterogeneous characteristics of big data significantly expand the range of data acquisition. Traditional credit assessment models rely heavily on single data sources such as financial data and credit reports, whereas big data technology extends data sources to non-traditional areas like social media, e-commerce platforms, and industry analysis reports. By comprehensively processing these multi-dimensional data, businesses can gain a more thorough understanding of an individual's or enterprise's credit performance. For example, social media data can reveal

a person's consumption habits, social relationships, and even job stability—all of which are crucial factors in credit risk assessment.

Secondly, in the process of handling big data, the widespread application of machine learning and artificial intelligence algorithms provides robust analytical capabilities for credit risk prediction. Machine learning can identify complex risk patterns through training on historical data, thereby establishing more forward-looking credit risk models. These models can not only predict potential default risks but also offer targeted management strategies for individuals or enterprises with different levels of credit risk. For instance, models like random forests and support vector machines can automatically classify data across various dimensions and refine credit scores based on historical performance data.

Furthermore, the introduction of deep learning algorithms further enhances the precision of credit risk predictions. Unlike traditional linear models, deep learning constructs multi-layer neural networks that can handle vast amounts of complex nonlinear data relationships. Particularly in processing large-scale and unstructured data, deep learning models exhibit high efficiency and accuracy. For example, through deep analysis of massive transaction data and social interaction data, deep learning models can effectively identify credit default risk factors hidden behind surface-level information.

Additionally, techniques such as text mining and network analysis within big data technology provide new perspectives for credit risk prediction. Text mining can extract valuable information from unstructured textual data, such as social media comments and risk indicators in industry reports. These pieces of information are often absent in traditional credit assessment data but play a significant supplementary role in predicting credit risks. Similarly, network analysis can reveal the interconnectedness of individuals or enterprises with other credit entities by analyzing their social network relationships, thereby aiding in the prediction of future credit performance. However, despite the numerous innovations that big data technology brings to credit risk prediction, the theoretical community also points out some challenges in its application. On one hand, data quality remains a core issue in big data analytics. Due to the wide range of data sources, differences in data formats and data integrity exist between different sources, making effective data cleaning and processing essential prerequisites for ensuring the accuracy of prediction models. On the other hand, the complexity of models introduces the "black box" problem—although big data models can provide highly accurate prediction results, their decision-making processes lack transparency and interpretability. This may lead to distrust in model results, especially in highly sensitive fields like credit risk management. Therefore, improving both model performance and its interpretability and transparency has become a joint focus of the theoretical and practical fields.

Lastly, data privacy and legal compliance issues are also significant challenges in the application of big data technology [10]. In the era of big data, credit risk prediction relies on vast amounts of personal and enterprise data. Ensuring reasonable use of this data for prediction while safeguarding data privacy is a major challenge faced by businesses and regulatory bodies. In recent years, with the continuous improvement of data privacy protection laws and regulations, businesses must strictly comply with relevant legal requirements when using big data technology to ensure that data usage does not infringe on personal privacy.

In conclusion, big data technology provides robust theoretical support and practical tools for commercial credit risk prediction. Through multi-dimensional data integration and the application of advanced algorithms, businesses can predict credit risks more accurately. However, issues such as data quality, model interpretability, and privacy protection still require further research and improvement. In the future, as technology continues to advance, the potential for big data technology in credit risk management will be further unleashed.

4 RESEARCH CONCLUSIONS AND PROSPECTS

This study has two main findings: First, the application of big data analytics in commercial credit risk prediction offers unprecedented advantages for businesses, particularly in enhancing the accuracy and real-time capabilities of credit risk predictions. By integrating multi-source heterogeneous data and applying machine learning algorithms, businesses can gain a more comprehensive understanding of credit entities' credit performance and identify potential credit risks early on. This not only optimizes the credit risk management processes of businesses but also enhances the overall stability of financial markets. Second, the application of big data technology in credit risk assessment breaks the limitations of traditional credit scoring models. The use of multi-dimensional data sources makes evaluations more comprehensive, and the introduction of advanced algorithms like machine learning improves the precision and efficiency of predictions. These technologies enable businesses to make more accurate predictions of credit risks based on diverse information such as historical behaviors and unstructured data. Especially in cases lacking traditional credit records, big data technology provides important supplementary means for credit assessment, greatly expanding the applicability of credit evaluations.

However, despite the numerous benefits that big data technology brings to credit risk prediction, there are still some challenges that need to be overcome in practice. Firstly, data quality directly affects the accuracy of prediction models. Issues such as inconsistent data formats across different sources, data omissions, and noise can all lead to biased prediction results. Secondly, the issue of model transparency urgently needs to be addressed. While machine learning and deep learning models excel in prediction accuracy, their complexity results in poor interpretability of results. In highly sensitive fields like credit risk assessment, businesses and regulatory bodies need to clearly understand the basis of model decisions. Additionally, with the continuous improvement of personal privacy protection laws and regulations, finding ways to reasonably utilize big data while ensuring data privacy has become a significant challenge for

businesses. Compliance and privacy protection issues not only involve the ethical responsibilities of businesses but also directly impact their reputation and customer trust.

Looking ahead, as big data technology continues to develop, its application prospects in commercial credit risk management are broad. Technological advancements will provide more intelligent tools for credit risk prediction, particularly achieving further breakthroughs in data integration, model optimization, and real-time risk monitoring. However, while enjoying the dividends brought by big data, businesses also need to continuously improve data management and compliance mechanisms to address challenges related to data privacy protection and model transparency. By reasonably utilizing big data technology, businesses can not only enhance their own credit risk management capabilities but also contribute to the healthy development of financial markets.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Wu PX, Lan ZY, Huang W, et al. Exploration of the application of a MOOC-based blended teaching model in medical undergraduate interns. *Journal of Youjiang National Medical College*, 2020, (01): 119-122.
- [2] Gao L, Xiao J. Big data credit report in credit risk management of consumer finance. *Wireless Commun Mob Comput*, 2021, 2021: 4811086.
- [3] Ilic I, Görgülü B, Cevik M, et al. Explainable boosted linear regression for time series forecasting. *Pattern Recognit*, 2021, 120: 108144.
- [4] Hasan MM, Popp J, Oláh J. Current landscape and influence of big data on finance. *J Big Data*, 2020, 7(1): 21.
- [5] Wang Y, Xiuping S, Zhang Q. Can fintech improve the efficiency of commercial banks?—An analysis based on big data. *Res Int Bus Finance*, 2021, 55: 101338.
- [6] Pang XR, Liu F, Li L, et al. Preliminary exploration of teaching reform for "Introduction to General Medicine" based on the concept of "Curriculum Ideological and Political Education". *Journal of Youjiang National Medical College*, 2020, (06): 806-809.
- [7] Bello OA. Machine learning algorithms for credit risk assessment: an economic and financial analysis. *Int J Manag*, 2023, 10(1): 109-133.
- [8] Luan H, Geczy P, Lai H, et al. Challenges and future directions of big data and artificial intelligence in education. *Front Psychol*, 2020, 11: 580820.
- [9] Xu Y, Hu M, Liu H, et al. A hierarchical deep learning approach with transparency and interpretability based on small samples for glaucoma diagnosis. *NPJ Digit Med*, 2021, 4(1): 48.
- [10] Thapa C, Camtepe S. Precision health data: Requirements, challenges and existing techniques for data security and privacy. *Comput Biol Med*, 2021, 129: 104130.

