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Digital Innovation & Financial Technology

ACADEMIC CONFERENCE PROCEEDINGS

1ST JUNE 2024

INTERNATIONAL COLLEGE
OF DIGITAL INNOVATION,
CHIANG MAI UNIVERSITY



PROCEEDINGS

Book of Proceeding of Digital Innovation and Financial Technology
2024-1

Conference 1st June 2024 at International College Digital Innovation,
Chiang Mai University

Organized by
International College Digital Innovation, Chiang Mai University

Introduction

The DIFT 2024-1 Conference is organized by International College Digital Innovation, Chiang Mai University, International College Digital Innovation Building, Chiang Mai, Thailand on 1st June 2024

The conference aims to bring together policy makers, researchers, and experts in the domain of policy making to share their ideas, experiences, and insights. We welcome experts, researchers and practitioners from academia, industries, research institutions, R&D enterprise services and governmental organizations to exchange innovative contributions around the topics.

All papers were reviewed by members of the DIFT 2024-1 Committee for rating and presentation content. Further details in accordance with the instructions of provided at: <https://icdi.cmu.ac.th/dift/2024-1/>

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For Women

Conference Schedule



AGENDA (Main Room)

08:30 – 09:15 hrs.	Registration
09:15 – 09:30 hrs.	Opening Ceremony Asst. Prof. Dr. Rujira Ouncharoen, Dean of International College of Digital Innovation
09:30 – 10:30 hrs.	Keynote, topic “Digital Assets & Social Impact” by Ms. Isreyah Pradabvate
10:30 – 11:00 hrs.	Coffee Break
11:00–12:00 hrs.	Oral Session
12:00–13:00 hrs.	Lunch
13:00–14:30 hrs.	Oral Session
14:30–14:50 hrs.	Break
14:50–15:10 hrs.	Close Speech



Keynote Speaker
Ms. Isreyah Pradabvate
NFT Creator & Educator



INFORMATION

[HTTPS://ICDI.CMU.AC.TH/DIFT/2024-1/](https://icdi.cmu.ac.th/dift/2024-1/)



REGISTRATION

Room number 1 (ICB1102)

Morning Session, Chairpersons: Asst. Prof. Dr. Ahmad Yahya Dawod

Afternoon Session, Chairpersons: Dr. Michael John Harris

Committees: Asst. Prof. Dr. Kittawit Autchariyapanitkul, Dr. Michael John Harris, and Dr. Siva Shankar Ramasamy

Time	Topic
11:00-11:20	Automation of Data Extraction from Documents in a Paraguayan Accounting Firm using Artificial Intelligence. By Fabián Guillén and Ahmad Yahya Dawod
11:20-11:40	Cloud Computing Security in the Banking Industry: A Case Study from Singapore. By Hsu Thitsar and Nathee Naktnasukanjn
11:40-12:00	The Impact of Smart Homes based on IoT Technology on the Home Furnishing Industry in China's Developed Cities. By Yuyin Sun and Naret Suyaroj
12:00-13:10	Lunch Break
13:10-13.30	CEO Social Capital and ESG: Evidence from China. By Hongyu Peng and Tirapot Chandarasupsang
13:30-13:50	Social Network Analysis and Key Influencer Evaluation of Chinese Community on Blockchain Online Social Media Steemit. By Xinke Li and Nathapon Udomlertsakul

Room number 2 (ICB1211)

Morning Session, Chairpersons: Dr. Naret Suyaroj

Afternoon Session, Chairpersons: Dr. Chakkrapong Kuensaen

Committees: Dr. Watcharin Sarachai, Asst. Prof. Dr. Thacha Lawanna, and Dr. Payakorn Saksuriya

Time	Topic
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11:20-11:40	Using Artificial Intelligence Technology to Improve the University Education in China. By Yun Gu and Naret Suyaroj
12:00-13:10	Lunch Break
13:10-13:30	A Review of Human Abnormal Behavior Recognition Methods based on Video. By Chunman Zhu and Ahmad Yahya Dawod
13:30-13:50	Analysis of Sentiment from an Online Learning Platform: Model Selection. By Lin Bao and Piyachat Udomwong
13:50-14:10	Digital Human Technology in the Application of Live Streaming in Social Media. By Xi Chen and Siva Shankar Ramasamy and Piyachat Udomwong and Bibi She
14:10-14:30	Economic Policy Uncertainty, Investor Sentiment, and the Growth Enterprise Market Return in China - an Empirical Study based on TVPSV-VAR Model. By Junxiao Gui and Nathee Naktnasukanjn and Xi Yu and Siva Shankar Ramasamy

Room number 3 (ICB1210)

Morning Session, Chairpersons: Dr. Worawit Tepsan

Afternoon Session, Chairpersons: Dr. Phillip Y Freiberg

Committees: Asst. Prof. Dr. S P Gayathri, Dr. Nathee Naktnasukanjn, and Dr. Phillip Y Freiberg

Time	Topic
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11:20-11:40	Research on the Sales Model of Chinese Tea E-commerce in the Digital Wave. By Qiujin Jiang and Piang-or Loahavilai
11:40-12:00	The Influence of Social Media on Travelers' Decisions of Destinations in Thailand. By Jiacheng Chang and Pintusorn Onpium
12:00-13:10	Lunch Break
13:30-13:50	Deciphering Customer Sentiments: An Exploration of Preferences and Attitudes in Online Reviews A Study of Longji Rural Hotels. By Yunmeizi Tang and Pintusorn Onpium and Piyachat Udomwong and Naret Suyaroj
13:50-14:10	Factors Influencing Consumer Purchase Intentions in Food Live Streaming. By Feng Han and Worawit Tepsan
14:10-14:30	The Trade Efficiency and Trade Potential of Cross Border Commerce between Sichuan and ASEAN. By Yaxian Ran and Annop Tananchana

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Automation of Data Extraction from Documents in a Paraguayan Accounting Firm using Artificial Intelligence

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Abstract

In the modern landscape of digital transformation, the integration of Robotic Process Automation (RPA) and Artificial Intelligence (AI) into accounting practices is crucial for boosting operational efficiency and competitive edge. This study examines the implementation of Orux, an AI-driven software that automates the extraction of data from financial documents, within a prominent accounting firm in Paraguay. This transition from manual to automated systems aims to revolutionize the firm's data management practices and assesses impacts on efficiency, error rates, compliance, and resource allocation. Orux significantly increased the firm's document processing capacity from 145,000 to over 700,000 documents annually, reducing processing time from a year to approximately two and a half months and markedly cutting down error rates. This underscores AI's role in transforming business operations and enhancing accuracy and compliance with regulatory standards. A mixed-methods approach was utilized, combining quantitative data from pre- and post-implementation reviews with qualitative insights from semi-structured interviews with stakeholders. This provided a nuanced understanding of Orux's effectiveness and its influence on employee satisfaction and client relations. The automation facilitated a strategic reallocation of staff from routine tasks to more analytical roles, optimizing productivity and job satisfaction. Financially, the adoption of Orux involved initial investments but promised a break-even within two years, followed by substantial profitability due to efficiency improvements and market expansion. Overall, Orux's implementation not only showcased the extensive benefits of AI and RPA in the accounting sector but also set a precedent for future technological advancements. This case study offers valuable insights into the strategic integration of technology in business processes, promoting a forward-thinking, efficient, and compliant accounting practice.

KEYWORDS: Robotic Process Automation (RPA), Artificial Intelligence (AI), Automated Data Extraction, Operational Efficiency, Digital accounting solutions, Financial Document Processing, Strategic Resource Allocation, Technological Innovation in Accounting

1 INTRODUCTION

1.1 Pain points

Automated data extraction from documents in accounting primarily aims to mitigate the pain points associated with manual processes. Traditional manual data entry is not only time-consuming but also prone to errors, leading to financial discrepancies and compliance issues.

This manual process can significantly delay decision-making and affect the overall efficiency of accounting operations. One major pain point is the high exposure to human error in manual data entry, which can result in significant financial inaccuracies. Automated data extraction helps reduce these errors, ensuring more accurate financial records and reports. Additionally, manual data processing is extremely time-consuming, often requiring extensive man-hours that could be better utilized in strategic decision-making or client engagement. Another relevant pain point is compliance risk. Accounting standards and regulations are continuously evolving, and keeping up with these changes manually is challenging. Automated systems can be updated more quickly and efficiently, ensuring that businesses remain compliant with the latest regulations. In Paraguay, many private accountants and tax preparer professionals rely on paper-based processes to handle their clients' invoices and receipts gathered throughout the month. This causes tax payers not to feel encouraged to be involved in their own tax declaration, often doing it wrongly and needing to hire someone to do it for them. On the accountant side, this usually leads to misplacement of their client's documents and complications when trying to organize them and give them some sort of tidiness.

1.2 The proposed research questions of this independent study were

- Q1:** How do professionals implement process automation in accounting firms in Paraguay?
- Q2:** How long does it take an accountant to process an invoice? How many daily, monthly?
- Q3:** How does AI-powered automated data extraction from documents increase efficiency in this process?
- Q4:** How do employees perceive these automations in the workplace, do they embrace it or rather see it as a threat to their jobs?
- Q5:** How do accountants see the future of AI automation and its applications in public accounting in Paraguay?

1.3 Objectives of proposal

- O1:** To conduct semi-structured interviews with accounting professionals from an accounting firm in Paraguay to establish what the state of process automation is in their workplace.
- O2:** To find out the invoice processing times and the number of processed invoices before and after automated data extraction implementation.
- O3:** To compare the effectiveness of the firm's document processing before the data extraction software implementation, and after.
- O4:** To find similarities between this independent study's results and studies done in other countries, as there is currently no research on this topic in Paraguay.
- O5:** To propose further use cases and applications of the firm's own AI automated data capture software to keep improving its accuracy and be able to offer better service to their clients.

1.4 Research Advantages

Pursuing this research brings several benefits which different groups could take advantage of, namely professionals, their clients, be it individuals or SMEs, and the government itself,

regardless of the country, since there are taxes to be declared everywhere. Some of the advantages of owning and/or implementing software to automate data capture/extraction are:

For professionals:

1. It allows them to connect more closely with their current clients and reach out to new ones, since it is a service they provide for them, to make their lives easier.
2. It speeds up every step of the process, starting with the way they receive the documents from their clients; instead of paper documents, they can start receiving them digitally.
3. Automation in data extraction from documents allows employees a more efficient and productive time allocation, spending more time and energy on higher-value tasks.
4. Additional income for the company since automated data capture would allow them to serve a greater number of clients, simplifying their current cost structure and avoiding the management of large teams.
5. The payment module integrated into the mobile version of the software allows for easy collection of the services provided.

For individuals and SMEs:

1. It allows clients to stay more closely in touch with accounting professionals and tax advisors.
2. It skips the whole situation of having the accountant come to collect the paper documents, or the clients to prepare a folder with all of them every month, three months, yearly, and so on. They just have to take a photo or scan each document in real-time or do it all together whenever they decide to, but it will no longer require them to take it to the accountant or arrange a meeting with the accountant to come to pick up the documents.
3. Online information on compliance status.
4. Easy payment for services from the client's phone.

For the government and tax authorities:

1. It would open up a more practical and innovative way to control taxpayers.
2. By making tax document preparation easier, faster, and more automated, taxpayers would feel more encouraged to do it appropriately and in a timely manner, so this would also translate into increased tax collection by the government authorities.
3. Given that the government hires several teams of auditors to intervene in big companies and verify tax compliance, making use of automation software such as the one this accounting firm provides would come in handy for them on a national scale.

1.5 Business Opportunities

The above mentioned pain points in general and in Paraguay open up very interesting business opportunities introducing automated data extraction in accounting. Firstly, there is the opportunity for increased efficiency and cost savings. Automation allows for the rapid processing of large volumes of data, freeing up human resources for more analytical and value-added tasks. This efficiency can significantly reduce operational costs and improve profitability. Secondly, there is a business opportunity in market differentiation and competitive

advantage. Firms that adopt advanced automated data extraction technologies can offer faster, more accurate, and more reliable services than those that rely on traditional paper-based methods. This technological edge can be a significant selling point in attracting new clients and retaining existing ones. Furthermore, automated data extraction opens up new avenues for data analytics and business intelligence. By harnessing the power of AI and machine learning, firms can provide clients with deeper insights into their financial health, trends, and potential risk areas. This added value can strengthen client relationships and enhance customer satisfaction. Finally, there is a significant opportunity in addressing the needs of underserved market segments, such as small and medium-sized enterprises (SMEs), which may lack the resources to implement large-scale data extraction solutions.

1.6 Current existing market in Paraguay

The automation in tax preparation and declaration processes are still in the early stages in Paraguay, slowly transitioning from paper-based to a more digital environment, so there is a big market to take advantage of when it comes to businesses and individuals who seek more efficient, error-free methods for handling their tax affairs. In this context, innovative applications like "Conto" and "TAXit!" have emerged in Paraguay, offering users the ability to upload invoices and receipts directly to the app for processing. These solutions signify a shift towards digital, streamlined tax management, appealing particularly to those looking for user-friendly, time-saving options. However, these examples of mobile applications start-ups are focused on offering accounting and the tax preparation service itself to their clients. They do business by looking for clients to provide these services through their platforms. The accounting firm is already providing Orux to some companies (sample users): the outsourcing department is allowing their clients to use the software so they can receive documents from them, and for the clients themselves to account for the expenses their employees had in a given period, this way they do not have to transport documents. More specifically, three of the outsourcing department's small clients are using it. One of these companies has around ten employees, another has fifteen employees, and the third one has twenty employees. Moreover, an external accounting firm is also using Orux with its clients, which is what Orux as a company and as a business ultimately wants to achieve, that the larger accounting firms or studios acquire the service, that they in turn give the software to their clients, and thus the intended use of Orux is replicated with their own clients, creating an accountant-client relationship, where Orux would simply be a provider of accounting computer systems. In the case of this external accounting firm, they started using Orux with limited access to 20 users, and after using it for two months they requested to increase the capacity to 32 users. On average, a small accounting firm can handle the accounting of 100 or 200 individual clients. With individual clients, it is meant individual physical persons, not companies, but someone with the need to get their accounts in order who hires the services of an accounting firm, which in turn puts them in contact with one of the accountants working there. The more organized the accountant in charge of a particular client is and the more effective their work, the less time will be dedicated to each client and the more time will be available to take on additional tasks, or more clients. On the other hand, what sets Orux apart from the existing solutions is that it focuses specifically on automated data extraction from documents used in the accounting

industry, and it stands as pioneer in this market in Paraguay. The main difference between Orux and other digital solutions, is that it does not intend to provide accounting services, but rather target accounting firms and private accountants who are interested in automating their processes and could make use of a software such as Orux to provide accounting services to their clients. Although Orux is being developed by an accounting firm, it does not fall within their scope to provide accounting services themselves, but just training and support to their users for the Orux implementation. The adoption of such technology can lead to transformative changes within firms, allowing them to reallocate resources from tedious manual entry to more strategic activities, thereby enhancing service quality and client satisfaction. Despite the promising advancements, the Paraguayan market also faces challenges, such as the digital divide and resistance to change, particularly in more traditional firms. The evolving regulatory environment and the increasing complexity of tax legislation further drive the demand for sophisticated solutions like Orux, positioning it as a valuable tool for ensuring compliance and reducing the risk of errors.

1.7 Governmental digital platform for tax declaration in Paraguay

The Marangatu system is an online tax administration platform utilized by the Subsecretaría de Estado de Tributación (SET), which is Paraguay's tax authority. The name "Marangatu" reflects a commitment to transparency and efficiency, as it means "saint" or "holy" in Guaraní, one of the official languages of Paraguay alongside Spanish. This system represents a significant step towards modernizing tax administration and compliance processes in Paraguay, offering several key features: **Electronic Filing and Management:** Marangatu enables taxpayers to file various tax returns electronically, including VAT, income tax, and corporate tax. This digital approach streamlines the submission process, making it faster, more efficient, and environmentally friendly by reducing paper use. **Tax Payment:** apart from filing returns, the system allows for the electronic payment of taxes, facilitating a more convenient way for businesses and individuals to fulfill their tax obligations without the need to visit a tax office physically. **Document Storage and Access:** it serves as a central repository for tax documents, providing taxpayers and their authorized representatives with easy access to their tax records, submissions, and receipts. This feature enhances transparency and simplifies record-keeping. **Tax Registration and Updates:** businesses and individuals can use the Marangatu system to register as taxpayers, update their registration details, and manage other administrative tasks related to their tax profile. **Audit and Compliance Tools:** the system offers tools for the SET to conduct audits and ensure compliance more efficiently. It can analyze data submitted by taxpayers to identify discrepancies or anomalies that may require further investigation. The implementation of the Marangatu system is part of Paraguay's broader efforts to leverage technology to improve public services and combat tax evasion. By making tax administration more accessible and user-friendly, the Marangatu system helps to encourage voluntary compliance, increase the efficiency of tax collection, and foster a culture of transparency within Paraguay's tax system.

2 LITERATURE REVIEW

2.1 RPA for Accounting

Narrowing it down to the accounting profession, many of the tasks that exist among these services are rule-based, such as the steps in audit and tax preparation processes. This is the main reason why this field is very likely to be automated more and more frequently in the near future, even considered to be in the top 10% of jobs to be performed by automation, according to some studies [19]. Research has been done to first identify the state of RPA in the accounting profession. The theoretical benefits and challenges to its implementation were addressed in research done in 2018 by Cooper and col. [25], where they conducted individual, semi-structured interviews with accounting professionals and RPA leaders, including firms among the Big 4 (Deloitte, Ernst & Young, KPMG, and PricewaterhouseCoopers), and got statements from the interviewees, who reported that :

- RPA was being implemented in all areas of the firm, but with more relevance in tax services, followed by advisory and assurance services.
- This implementation increased quality and resulted in great increases in efficiency, improving processing times to up to 80%, and reducing over one million human work hours in 2017.
- Regarding the fear of their job being replaced by RPA, the surveys showed that nobody was fired, and that job satisfaction increased, repurposing their duties to higher-level management tasks. [8,24].

More recently in 2021, a similar study was conducted at a more local scale in Poland, with a similar methodology through surveys within Polish accounting firms that were in different stages of RPA implementation. Overall, they obtained the same findings as Cooper's research, among them :

- Finance and accounting processes are most often robotized.
- Benefits such as cost reduction, faster processing, improved process control and performance visibility, higher quality of data (accuracy, consistency, compliance), and positive impact on employees as repetitive, low-value tasks are taken away from them, freeing up employee time.
- The interviewees' role as an accountant was affected not by getting replaced, but by turning them more into accounting managers in order to focus on other high-value tasks [8,22,24].

Specifically, what taxes pertains, automated software can capture relevant data from invoices, record the entries by recognizing the fields with a certain type of information inside them, and if comb then learns from the process to replicate the same task, depending on the file format and location of said fields in the invoice. Big accounting firms such as Price Waterhouse Coopers and Ernst & Young have developed and implemented such systems, and along the way saved hundreds of thousand hours of process time annually [20, 21]. These studies succeeded in closing the gap that existed in regard to the state, benefits, and possible challenges of automated processes in general in the interviewed companies. Nevertheless,

later studies focused on filling the gap in how to improve processes by combining RPA with AI components. Automations are slowly moving from process-driven to data-driven events, meaning that data is constantly increasing. Therein lies the need, or the opportunity to introduce AI into the already implemented RPA tools in place. In order for RPA systems to be more effective, they require some kind of AI augmentation through algorithms, so that it not only takes care of the task it is created for but also improve its performance by learning over time, this is called Intelligent Process Automation. Only 15% of companies consider themselves to be mature in their use of RPA, and only 5% in AI [24]. AI and RPA together mean that a large amount of data can be turned into actionable insights, which allows full automation of entire processes. Automation through AI and RPA will also bring big changes to the accounting and auditing industry. Mundane and repetitive tasks typically done by junior staff will be taken over by automated software. Instead, human expertise can be used at a higher level to make decisions that require judgment [24]. An important augmenting technology for AI is OCR (Optical Character Recognition) [16], which is currently widely used in recognizing text in a vast variety of digitalized documents. This allows companies to eliminate time-consuming manual data entry and there are other types of automated data capture systems, as well. However, this IS proposal will attempt to research about AI-powered OCR technologies as an alternative to manual data extraction and processing of invoices and other documents involved in tax preparation processes in an accounting firm from Paraguay.

2.2 Automated Data Capture

There are two main types of OCR-based automated data capture solutions, both using OCR technology: template-based OCR systems, and the AI-powered OCR alternative.

- **Template-Based OCR:** through this technology, machine-encoded text layers are generated, using either image-based templates or text-based rules, allowing the machine to be taught to isolate a certain section of text at a certain position in the template, behind a certain word or at a certain place, and to read it in a dedicated manner. For each field that needs to be extracted (e.g., a document number, date, or address) separate configurations in the templates need to be created depending on the format each invoice has, so the software knows where and what to look for when different clients send their own format [22,23]. This aspect needs to be considered, and it makes template-based OCR extraction somewhat inflexible and human-dependent, as many clients could send their own version of an invoice. That is where AI or Machine Learning based OCR systems come into play.
- **AI-powered OCR data extraction:** to address the potential problems or limitations that a template-based OCR software could present, AI-based system components can be trained on text blocks of all sorts of different document layouts, thus eliminating much of the work involved in setting up and optimizing the software. Various machine learning technologies are becoming increasingly autonomous in the learning process and can come up with the rules necessary for qualitative extraction results themselves [22, 23].

2.3 Existing solutions in the international market

There are also companies that have been offering solutions to the manual processing of documents, which are already well-established and greatly developed. Some examples are:

- 1. ABBYY FlexiCapture [29]** Origin: Russia (Founded in 1989) ABBYY FlexiCapture is a powerful form processing platform developed by ABBYY, a global company headquartered in Moscow. This platform uses optical character recognition (OCR), machine learning, and advanced data capture technologies to transform documents of any structure into business-ready data. With over 30 years in the industry, ABBYY has honed FlexiCapture into a comprehensive solution that serves various sectors, including finance, insurance, and healthcare. It automates the extraction of information from documents, reducing manual input, and improving processing times and accuracy.
- 2. Kofax Capture [30]** Origin: United States (Founded in 1985) Kofax Capture is a robust automated data capture and integration solution from Kofax, Inc., based in Irvine, California. Originally known for its applications in imaging and data capture, Kofax has evolved its technology to support more complex workflows and data environments. Kofax Capture not only automates the process of collecting and refining data but also integrates this data into core business systems. It supports a wide range of document types and capture channels – from paper to electronic files – making it versatile for enterprise use.
- 3. DocuWare [31]** Origin: Germany (Founded in 1988) DocuWare is an integrated document management and workflow automation solution, originating from Germering, Germany. The platform excels in the automated capture, indexing, and storage of data across various document types. DocuWare has been instrumental in helping businesses transition to digital workflows, enhancing document security, accessibility, and compliance. The solution is particularly advantageous for organizations looking to simplify document governance and drive digital transformation effectively.
- 4. Hyland OnBase [32]** Origin: United States (Founded in 1991) Developed by Hyland Software, based in Westlake, Ohio, OnBase is an enterprise content management (ECM) solution that integrates document capture with data management and workflow automation. OnBase centralizes the storage of all business content in one secure location and automates repetitive tasks, facilitating efficient data handling. This solution is scalable, serving small businesses to large enterprises, and supports both cloud-based and on-premise deployments. It's particularly favored in regulatory-compliant industries, given its strong focus on data security and integrity.
- 5. IntSig Information Co.,Ltd – CamScanner [33]** Origin: China (Founded in 2009) CamScanner is a mobile application developed by IntSig Information Co., Ltd, based in Shanghai, China. It utilizes OCR technology to convert the photos taken with a mobile device into PDF documents, allowing for the capture and sharing of text from a wide range of sources instantaneously. Since its inception, CamScanner has become immensely popular among students, researchers, and professionals for its convenience and efficiency in data capture, especially useful for on-the-go scenarios where traditional scanning is not feasible.

6. Rossum.ai [34] Origin: Czech Republic (Founded in 2017) Rossum.ai is an artificial intelligence company that creates state-of-the-art technology for automated document processing. Based in Prague, Rossum's primary product is an AI-powered OCR solution that aims to eliminate manual data entry in document management workflows. What sets Rossum apart is its cognitive data capture technology, which does not rely on template-based data extraction, allowing it to understand and process invoices and similar documents much like a human would. This capability enables businesses to significantly reduce the time spent on data entry while increasing data accuracy and the speed of document throughput. Rossum has quickly established itself as a key player in the automation sector, with a strong focus on usability and integration flexibility. Each of these solutions demonstrates the evolving capabilities of automated data capture technology and its critical role in modern data management strategies. Whether improving operational efficiencies, enhancing data accuracy, or supporting digital transformations, these platforms provide substantial benefits across industries globally.

3 METHODOLOGY

3.1 Research Scope and Methods Scope of the Study

This study was carried out following the processes which take place within an accounting firm located in Paraguay's capital city, Asunción. Said company has been in business for over 25 years, offering accounting, auditing, and tax advisory services to both national and international companies based in Paraguay and abroad. Striving to offer high quality services to their clients, in the past three years they have been automating their internal processes, to the extent of even developing their own data extraction software to process documents, mainly invoices, within the tax department. This software functions on two types of platforms, namely web browser and mobile, both for iOS and Android operating systems. Seeing that it is in their own interest to find out how process automation has impacted on their overall processes and the employees' jobs, they kindly agreed to cooperate with this independent study by assisting in the design of a questionnaire to be submitted to the different departments where automations have been deployed.

Methodology: the research methods to be applied to conduct this independent study are:

Literature review: in order to find out what previous information could be gathered from existing research studies, literature review was performed in the field of accounting related to process automations, mainly searching the keywords: RPA, IA+RPA in accounting, automation processes in accounting, Automated Data Capture/Extraction, types of ADC/ADE, OCR technology, OCR template-based, AI-powered OCR, RPA in Paraguay, Intelligent Automation in Paraguay, IA+RPA accounting in Paraguay. After extracting the most relevant information from the studies found, a total of 24 papers were selected to prepare this IS proposal. From the existing literature, what can be concluded is that there is still little awareness of the implications of RPA in accounting firms' processes around the world. There are studies which discuss RPA and its uses in accounting firms in Europe, others describe the reach of RPA implementation withing accounting services processes, along with its benefits and obstacles, and others address the impact its implementation has had on both the individual and organizational behaviour, focusing on the responses the firm's employees and their managers gave in semi-structured interviews. Similar studies have put their focus on the perception the employees have towards

AI, what understanding they have about its benefits and challenges, and whether they perceive automation and AI as a threat that might impact employability. In Paraguay, there are no previous studies on RPA, or AI-powered RPA in accounting firms whatsoever, so this research would prove to be very enlightening and informative for the participating accounting firm as a whole and its employees, equally. Additionally, it would set a precedent for any future research on the topic in Latin American countries.

Semi-structured interviews: a series of semi-structured interviews will be conducted with accounting professionals from an accounting firm in Paraguay, namely the main partner representing the firm, and the different department managers, who have agreed to assist with the making of a questionnaire which will later on be distributed to their employees. This method approach of semi-structured interviews was chosen over structured or unstructured interviews, for two main reasons:

1. To leave room for unconsidered and very likely useful insights that could come up during these interviews which could influence the tailoring of the questions and the type of data to be gathered from the questionnaires to be designed afterwards. Furthermore, talking with these high positioned professionals will give some additional insight to whom to contact after, depending on the type of information needed if there is anything they cannot answer themselves.
2. To prepare some predetermined questions in alignment with the objectives 1 to 4 of this IS research, so that the interview is not just unstructured and free flowing, but rather a guided conversation, aimed at considering the purpose of the questionnaires to be distributed and how the questions should be written to minimize any possible misunderstanding from the respondents.

Questionnaires: once the interviews have finished, the questions will be drafted and checked prior to submission. The preliminary categories for these questions are:

1. Current use of the software at the firm and/or clients,
2. Software implementation scope,
3. Efficiency and quality of work performed by automated data capture software,
4. The future use of RPA software in the accounting firm.

Some of these categories are subject to modification or removal from the questionnaire, depending on the outcome of the previously conducted semi-structured interviews.

4 RESULT AND DISCUSSION

4.1 Questionnaire results

The research employed a primary data collection methodology through semi-structured interviews and questionnaires focused on the implementation and effects of the AI automated data extraction software, called Orux, within the accounting firm and its clients. The intention was to explore the current usage, implementation scope, efficiency, and future prospects of Robotic Process Automation (RPA) software in accounting processes according to the accounting firm representatives. It highlighted the transition from manual to automated data

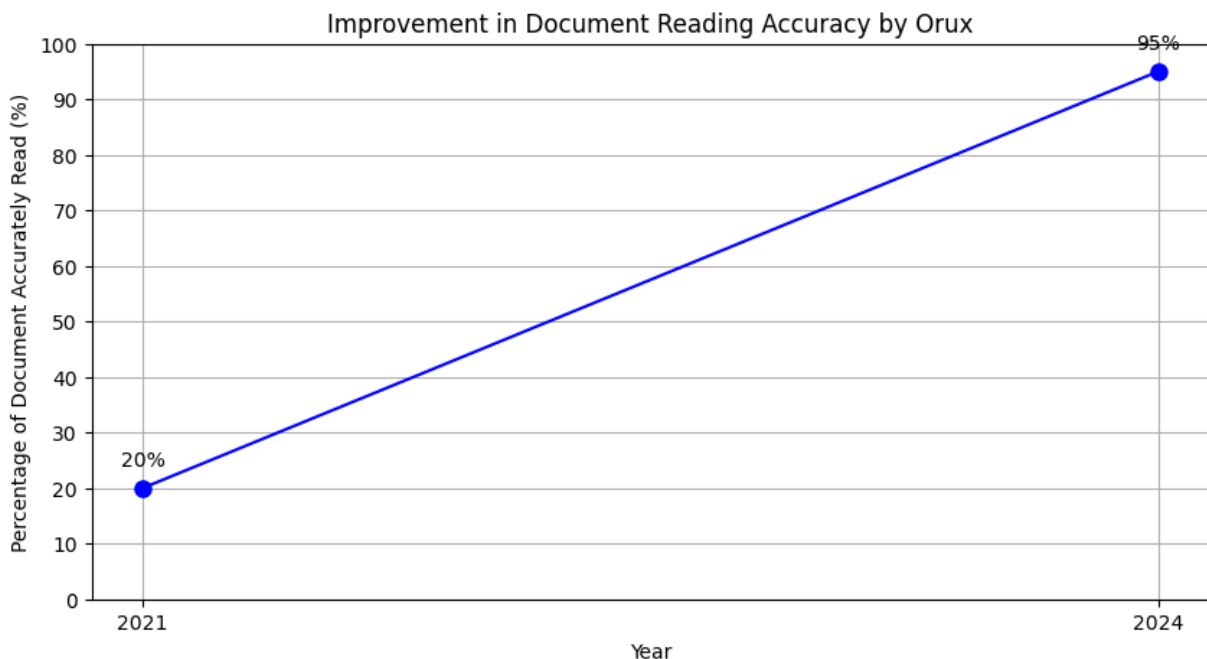


Figure 4.1: Visually representation of the substantial enhancements in the accuracy of document reading by Orux from 2021 to 2024.

processing, detailing improvements in document processing efficiency, error reduction, and operational adjustments post-implementation. The data reflects both quantitative aspects, such as the number of documents processed, and qualitative insights, such as employee and client perceptions and impressions towards transitioning to automation. This primary data allows for comprehensive understanding of the practical implications of AI and RPA in enhancing accounting workflows and future industry transformations. Below, the questions addressed to the different employees involved in the use of the Orux software and a summarized recollection of their viewpoint.

1. Current use of the software at the firm and/or clients:

- What is the state of use of Orux within the firm and clients (non-existent, in training, already being implemented, other, please specify)?

From November 2021 it was put into use within the Taxes department. Throughout 2022, almost 145,000 documents were processed by the platform. Even so, we are still making adjustments for other uses. Currently Orux is being used within BDO to bring services to customers. From the Tax department, it is being used for a service called Tax Credit Certification, where they have to compare what was declared to the National Tax Revenue Department (SET in Spanish) against the existing sales and purchase papers. Normally, these customers are important exporters (refrigerated or agricultural warehouses), and since there is a great volume (thousands of documents per month), they are processed via Orux. The Outsourcing department also used it for some time for the Outsourced Accounting service. They received the clients' documents at the office and received access to their accounting system from Orux. That is, they first processed the receipts or invoices with Orux, and later downloaded an Excel spreadsheet that allowed them to greatly enhance the accounting system.

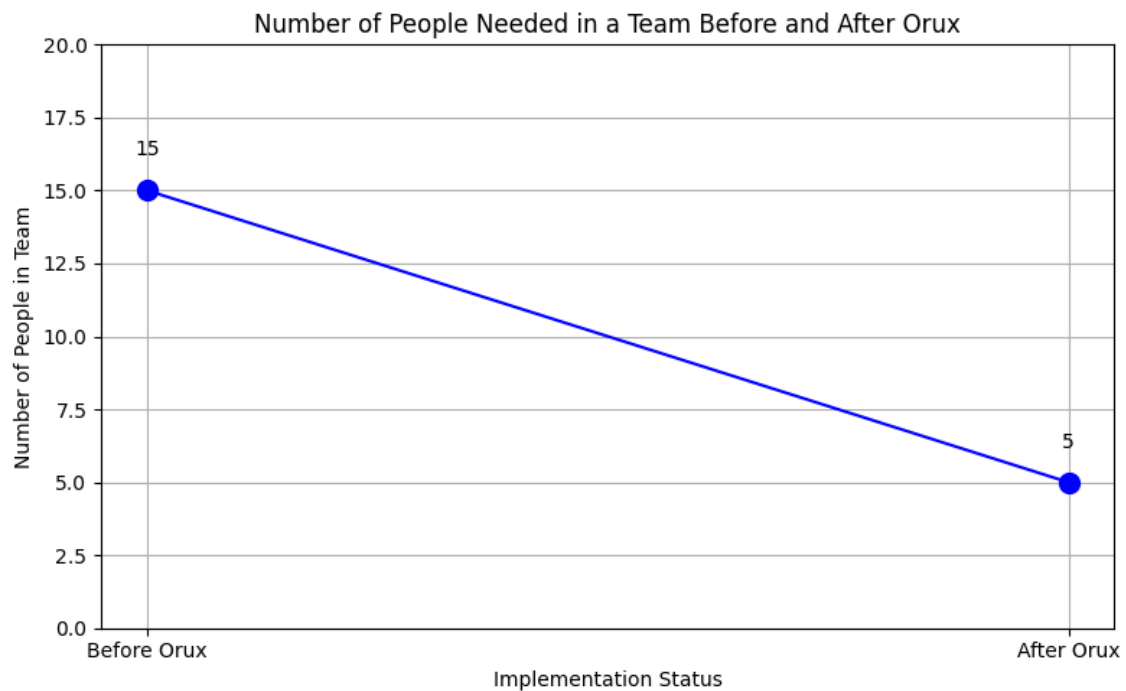


Figure 4.2: Illustration of the change in the number of people needed in a team to process documents before and after the implementation of Orux.

They stopped using it because the volume of documents they received from the client on a daily basis was very low, so it was more practical for them to load them directly into the accounting system manually.

2. Software implementation scope:

- What is the extent of the use given to Orux in the firm and in the clients (what is it used for)?

We have provided use of the software to one small external accounting firm, and we are now developing a version for three of the outsourcing department's clients, so that they use the application to process the receipts received on their premises. For example, Cervepar (the biggest beer and other beverages importer and distributor in Paraguay) has a direct sales business unit, with approximately ten storage rooms. Our firm does the accounting for these sales units by facilitating the collection of receipts that are generated in each one of them. The staff in charge of each unit have the Orux mobile application, which allows them to take a picture and simply upload it to the platform. This same version of the mobile app is also going to be used by a client who has staff members traveling to the countryside. This means there will be some costs to be covered which will afterwards be written off as company expenses. The client will make their staff use Orux to justify or report on the purchases made during the trip. We are making more adjustments to reach out to other accounting firms and other use cases, for instance, companies that have several branches can send images of the receipts that are generated daily, facilitating document collection logistics and speeding up their transactions processing. There is still much room for improvement; the software is still in a very experimental and developmental stage. In Paraguay, there are good applications

Staffing levels at the accounting firm before and after Orux

Year	Number of Employees Pre-Orux	Number of Employees Post-Orux	Percentage Reduction
Pre-Orux	15	-	-
2022	15	10	33%
2023	15	5	66%
2024	15	5	66%

Figure 4.3: Changes in staffing levels at the accounting firm before and after the implementation of Orux, highlighting significant reductions in the workforce required to process documents.

and systems for managing the accounting of individuals or preparing tax declarations. These applications are quite well developed and even incorporate the ability to generate reports or expense statistics. The difference in functionality with other digital solutions in the field of accounting is that Orux focuses on the automated reading of data from accounting documents and its complementation with AI to interpret expense concepts, thus being able to integrate into the process of the SET (National Tax Revenue Authority), which is also being automated. Regarding the business approach, the main difference is that these other companies of digital accounting solutions focus their business on seeking clients and providing the accounting services themselves through the applications they developed. That is, they make their money by selling those accounting services. On the other hand, Orux seeks to be a software provider for accounting firms, and the accountants working in those firms are the ones who use the software to offer a better and more efficient service to the accounting firm's clients.

3. Efficiency and quality of work performed by automated data capture software:

- How would you describe the efficiency and time needed for the processing of these documents, before and after Orux implementation? How has it improved overall, and what needs to be adjusted for improvement?

Before Orux (end 2021):

1. Each document was loaded manually.
2. Teams of 10 to 15 people had to be formed to process the large number of existing documents. This involved time to select new members, time to train them, and budget for computers and scanners to be used.
3. A long time was needed for the client to finish the revision of these documents (approximately five times more than with Orux.)
4. Documents had to be physically mobilized, or the team of accountants needed to be located at the client's premises to work with their documents on site.
5. The business had to stop running in order to gather the documents needed only to be able to work, creating a bottleneck by not having enough time to process them, as the deadlines came closer.

With Orux (2022-present):

- 1) Documents are processed digitally and massively; manual loading is reduced as employees

Distribution of Time Savings Across Tasks Due to Orux

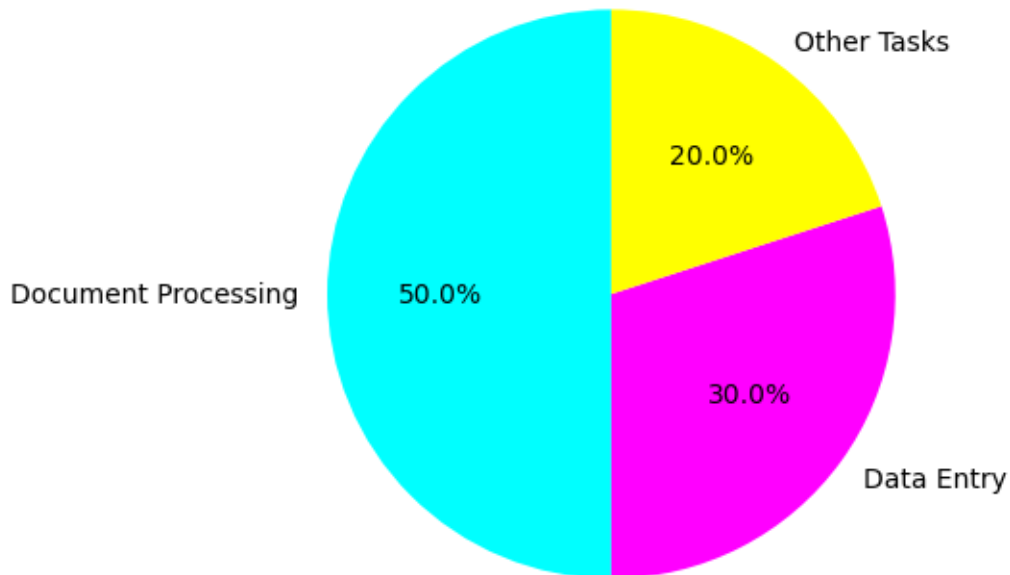


Figure 4.4: Distribution of time savings across different accounting tasks due to automation.

only need to adjust the AI document reading where needed. At the beginning, the software was only able to accurately read around 20% of a given document. There are still errors, but mainly associated with the problems of the actual document (bad ink, out-of-frame printing, non-readable letters, incomplete image, bad handwriting, typos, etc.). Today, given the same type of documents as in the beginning, Orux manages to accurately read up to 95% of all the fields on it Figure 4.1.

Efficiency Increase: the rapid processing capability post-Orux implementation allows handling the same volume of documents in significantly less time, showcasing a major efficiency boost. 2) There is no need to hire a whole team of additional people every time a deal is closed with a client, since the same team is already able to cover most of the work. The number of people needed in each team processing the documents was reduced by a third (Figure 4.2 and 4.3). Other processes were incorporated to get the images scanned or photographed and uploaded directly to Orux.

Resource Optimization: reducing the team size from 15 to 5 not only cuts down labor costs but also suggests that Orux allows staff to be reallocated to other tasks, improving overall productivity (Figure 4.4). Together, these graphs and tables provide compelling evidence of the improvements brought by Orux in terms of operational efficiency, both in reducing the time needed to process documents and in optimizing the size of teams required for document processing tasks. They highlight Orux's impact on reducing labor costs and increasing productivity.

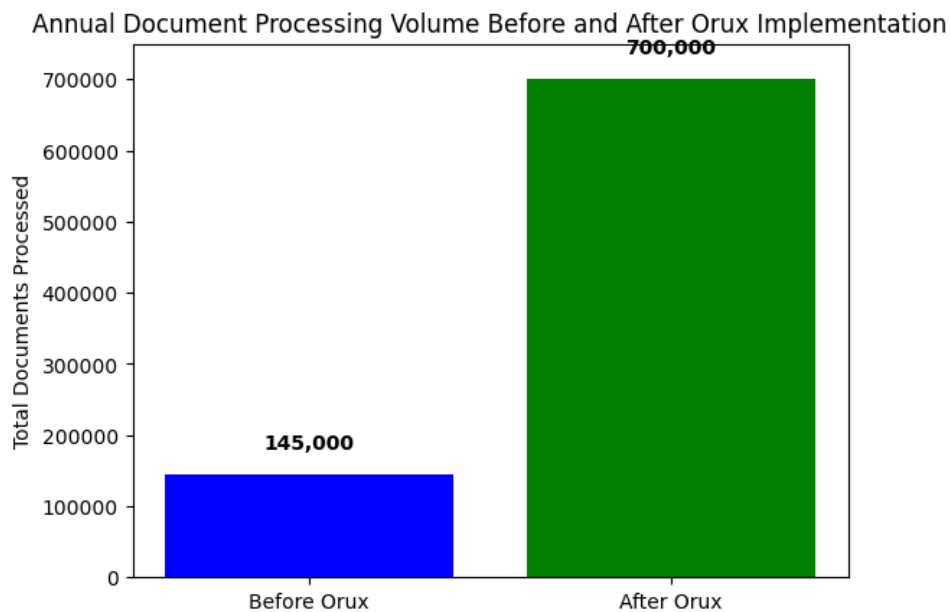


Figure 4.5: Annual Document Processing Volume Before and After Orux Implementation.

3) The revision time with Orux was reduced by five times. The total number of documents processed in a year before the automated data capture implementation was 145,000. That amount can now be processed in a fifth of that time, meaning approximately two and a half months. In a year, the total number of processed documents goes up to more than 700,000 (Figure 4.5 and Figure 4.6).

This graph presents a strong visual comparison of the number of documents processed before and after the implementation of Orux. Both bars reach the same height, representing an equal number of documents processed (145,000), but the labels indicate a difference in the time frame required: The blue bar represents the period "Before Orux (2022 1 Year)", where it took a full year to process 145,000 documents. The green bar indicates the period "After Orux (2022 2.5 Months)", showcasing the enhanced efficiency of processing the same number of documents in just 2.5 months.

4) Physical transportation of documents is not required, making logistics and the provision/receipt of services more bearable on both sides: the accountant, and the client.

5) As logistics become easier to deal with by becoming digital, there is greater integration between client and accountant so that documents can be processed in the days in which the transactions take place and not wait until the end of the month to gather all the documents and submit them to the accountants.

5 CONCLUSION

As the Orux software makes its way through the Paraguayan accounting environment, it becomes evident that the automation of data extraction using Artificial Intelligence is not merely a technological upgrade but a transformative shift in operational activities and strategic thinking.

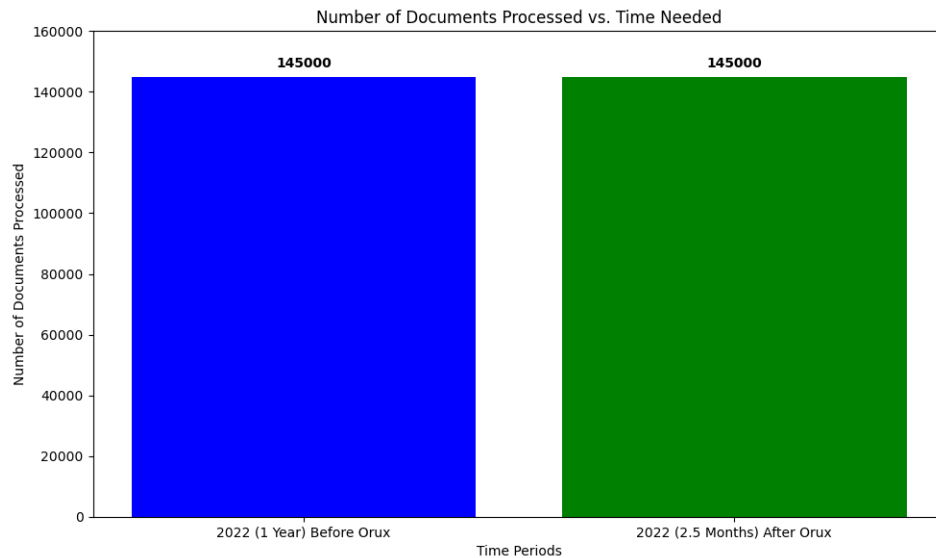


Figure 4.6: *Number of Documents Processed vs. Time Needed.*

5.1 Operational Efficiency and Error Reduction

The introduction of Orux has transformed the way the accounting firm handles its documents. The change from a labor-intensive, error-prone manual process to a more streamlined, automated system has significantly enhanced operational efficiency. Prior to Orux, the firm processed approximately 145,000 documents annually with substantial human input and the inherent risk of errors. Post-implementation, these documents are now processed in just two and a half months, illustrating a marked increase in process efficiency, scaling the annual document handling capacity to over 700,000. This acceleration in processing capability is not just a reflection of speed but also of the reduced error rate, which in turn enhances the reliability of financial reports and compliance with regulatory standards. Such improvements are crucial in a field where accuracy is of the utmost importance and the consequences of errors can be extensive.

5.2 Strategic Resource Reallocation

The implementation of Orux has allowed the firm to reallocate valuable human resources from tedious data entry tasks to more analytical and strategic roles. This repurposing of duties not only optimizes the use of human capital but also increases employee satisfaction by reducing monotony and enhancing the meaningfulness of the work they perform. It represents a transformation from human-operated to human-overseen processes, where the strategic input of human resources becomes more critical than ever.

5.3 Enhancing Compliance and Client Confidence

With evolving regulatory environments, especially in the digital age, compliance is increasingly complex and critical. Orux ensures that the firm remains agile, able to adapt to regulatory changes swiftly and efficiently. This agility reinforces client confidence as they become assured

of the firm's capabilities to handle their financial matters in keeping up with the government regulations and remain compliant.

5.4 Market Positioning and Competitive Advantage

Orux has not only streamlined operations but also significantly improved the firm's market positioning. The ability to process high volumes of documents accurately and swiftly provides a competitive edge, attracting clients who are increasingly seeking efficient and innovative accounting solutions. This edge is crucial in a competitive market where firms are continuously striving for differentiation.

5.5 Future Implications and Sustainability

Moving forward, the integration of Orux positions the firm well for future technological advancements. The ongoing evolution from Robotic Process Automation (RPA) to AI-driven solutions suggests a future where data-driven insights and decision-making will become predominant. The firm's early adoption and integration of AI not only prepares it for this future but also set a standard in the industry, promoting a culture of innovation and continuous improvement.

5.6 Challenges and Considerations

Despite these advantages, the adoption of Orux is not without challenges. The initial investment, both in financial and human capital terms, is significant. Moreover, the cultural shift towards automation requires extensive training and change management to ensure all stakeholders are aligned and proficient in utilizing the new system. The resistance to change is often underscored by concerns over job security. However, the firm's approach, reallocating rather than displacing staff, serves as a model for how automation can enhance rather than replace human capabilities.

5.7 Concluding Thoughts

In conclusion, Orux has catalyzed a profound transformation within the accounting firm, marked by enhanced efficiency, reduced errors, and strategic resource utilization. These changes not only promote the firm's competitive edge but also enhance its sustainability by preparing it for future advancements. The journey of Orux within this firm exemplifies a successful integration of technology and strategy, providing valuable insights for similar implementations in the industry. This case study not only highlights the benefits but also tries to address the necessary considerations to ensure such transitions are beneficial and sustainable, paving the way for future innovations in the field of accounting. The lessons drawn from the firm's experience are applicable beyond the borders of Paraguay, offering a blueprint for integration of AI in accounting that balances technology with strategic foresight. As we move forward, it is clear that the intersection of technology and traditional practices will increasingly define the landscape of industries, making adaptations such as these not just beneficial but essential for maintaining relevance and excellence in service delivery.

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Cloud Computing Security in the Banking Industry: A Case Study from Singapore

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Abstract

Cloud computing stands as a game-changer in the banking sector, promising businesses scalability, flexibility, and cost-efficiency. Its adoption in the banking sector has the potential to revolutionize operations, enhancing operational efficiency, improving customer service, and accelerating digital transformation. However, the sensitive nature of financial data and operations remains significant security challenges. This study aims to delve into the challenges and security considerations of cloud computing in the banking industry, focusing specifically on Singapore. Through the collection of survey questions from professionals working in cloud IT departments of banks in Singapore, the study seeks to identify key challenges and security practices. A mixed-methods approach will be employed, combining quantitative data from surveys with qualitative insights from interviews and case studies. The survey will focus on areas such as security measures currently in place, perceived threats, compliance with regulatory frameworks, and the impact of cloud computing on banking operations. The study's findings are expected to provide valuable insights for banks in Singapore and other regions considering cloud adoption. By understanding the challenges and effective security measures, banks can enhance their security posture in the cloud, ensuring the safe and reliable operation of their services.

KEYWORDS: Cloud Computing, Banking Industry, Security Challenges, Regulatory Framework

1 INTRODUCTION

In an era of rapid digital transformation, cloud computing has emerged as a pivotal technology reshaping the banking industry. IBM defines that cloud computing as the process of accessing computing resources such as physical or virtual servers, data storage, networking capabilities, application development tools, software, and AI-powered analytics tools over the internet (IBM, 2024)). Cloud computing can change the way business is conducted, offering scalability, flexibility, and cost-effectiveness that surpass the banking industry's vast amounts of sensitive data and complex operations. By leveraging cloud services, banks can increase operational efficiency, improve customer service, and accelerate digital transformation. Gartner states that IT spending on public cloud services continues to rise unabated. In 2024, worldwide end-user spending on public cloud services is forecast to total \$679 billion and projected to exceed \$1 trillion in 2027. By 2028, cloud computing will be a necessity not just for business competitiveness but also for business survival (Gartner, 2023). However, the adoption of cloud computing in the banking industry comes with significant security challenges due

to the sensitive nature of financial data and operations (Jebaraj, 2023). The banking sector in Singapore is a leader in cloud technology adoption, driven by the country's reputation for a strong regulatory framework, advanced technology infrastructure, and commitment to innovation (Global, 2023). Despite the many benefits, the adoption of cloud computing in the banking sector raises important security considerations, and banks must ensure that their cloud environment is secure, compliant with regulatory requirements, and resilient to cyber threats (Kvartalnyi, 2023). Key security challenges include data protection, identity and access management, compliance with regulatory standards such as Monetary XXX-2 Authority of Singapore (MAS) guidelines, and the ability to respond to emerging cyber threats (MAS, 2024). This study aims to explore the challenges and security of cloud computing in the banking industry, focusing on Singapore. By gathering survey responses from professionals employed in the cloud IT departments of Singaporean banks, the study will pinpoint critical challenges and prevailing security practices. The results of this study are expected to provide valuable insights for banks in Singapore and other regions looking to improve security measures on the cloud.

2 LITERATURE REVIEW

The evolving technologies like blockchain, cloud computing, data analytics, and artificial intelligence (AI) are enabling innovative financial solutions, fostering financial inclusion, and enhancing customer-centric services (Adedoyin Oyewole, 2023). The integration of AI with cloud computing has significantly improved application security in the fintech sector, providing tangible benefits in protecting sensitive financial data and ensuring the integrity of fintech applications (Kunduru, 2023). These technologies will shape the future of fintech globally, emphasizing the importance of strategic implementation for effective use. Moreover the integration of AI with cloud technology is a crucial development in enhancing security in fintech applications, with AI's role expected to expand as the fintech landscape evolves (Kunduru, 2023). Cloud computing is increasingly used worldwide for its efficiency and cost-effectiveness. In Africa, cloud computing in archives and records management is still in the early stages. While cloud-based services offer significant benefits, such as improved efficiency in business operations and records management, there are substantial obstacles. Challenges include records storage, jurisdictional issues, privacy, security concerns, and the digital divide, all of which hinder the full realization of cloud-based records management's potential. The continent is not yet fully prepared to embrace these technologies and leverage their advantages, making cloud-based records management services a potential weakness (Tshepho Mosweu, 2019). Conversely, financial institutions in the US and EU have leveraged cloud services extensively for various functions, ranging from basic tasks like email management to critical operations such as payment processing and data storage. The benefits of cloud adoption in this sector are substantial, including accelerated innovation, enhanced security, and improved operational resilience. However, the regulatory frameworks governing cloud usage in these regions vary, with common themes and differences between jurisdictions that impact standard-setting and regulatory bodies. (Hal S. Scott, 2019). Although cloud computing adoption can get numerous benefits, including cost-effectiveness, scalability, and accessibility anywhere with any device, it is subject to security threats, vulnerabilities, and attacks in the other hand. For

financial institutions, keeping data secure is the most important part, especially for banking information. IBM found that the average data breach cost a company \$145 to \$154 for each compromised account. Since banking information is even more sensitive and valuable, it could be even more than that. (Cost of a Data Breach Report 2023). Despite various studies, there is still a need for further examination of the security challenges and strategies associated with cloud computing for the banking sector.

3 METHODOLOGY

3.1 Research Methodology

This study will employ a mixed methods approach to examine the challenges and security considerations of cloud computing in Singapore's banking sector. Mixed methods research combines aspects of quantitative and qualitative to address research questions. It can help the study to gain a more complete picture than a standalone quantitative or qualitative study, as it combines the strengths of both methods (George, 2023). The research will begin with a quantitative and qualitative survey distributed to specific experts working in cloud security in 5 different banks in Singapore. This survey will focus on gathering data regarding current security measures, perceived threats, regulatory compliance, and the impact of cloud computing on banking operations. Additionally, qualitative case studies will be conducted, including indepth interviews with selected survey participants and analysis of relevant documents. These case studies will provide deeper insights into specific security practices and challenges faced by banks in Singapore. By combining quantitative and qualitative approaches, this study aims to provide a comprehensive understanding of cloud computing security in the banking industry in Singapore.

3.2 Population and Sample

The population for this study comprises professionals working in cloud IT departments across the banking sector in Singapore. This includes individuals who are directly involved in managing, implementing, and securing cloud computing technologies within their respective banks. The target population encompasses a wide range of roles, including IT managers, cloud security specialists, system administrators, and compliance officers. The sample for this study consists of 15 experts working in cloud security from five different banks in Singapore. Additionally, 76 responses were gathered from general cloud engineers working in these banks. These individuals were selected based on their specialized knowledge and experience in cloud computing security within the banking industry. The selection criteria ensured that the sample represents a diverse range of perspectives and practices, providing a comprehensive view of the current state of cloud computing security in Singapore's banking sector.

4 FINDING FROM A SURVEY

The survey responses reveal a generally positive perception of cloud security practices among experts of the Bank's IT department, with most respondents expressing moderate to high satisfaction levels. For the transparency and visibility into their bank's cloud security practices,

4.1 Impact of Cloud Computing Security in Singapore's Bank



As per the results of the research, the adoption of cloud computing technology has significantly enhanced Singapore's banks' ability to manage identity and access control. The sentiment analysis of the responses revealed that 80% of the comments highlighted positive aspects of cloud computing adoption, such as enhanced security and scalability, while 20% pointed out challenges related to integration and adoption. Centralized identity management emerged as a key benefit, simplifying administration, ensuring consistency across the organization, and streamlining processes. Enhanced security controls, including advanced features like multi-factor authentication (MFA) and single sign-on (SSO), have been instrumental in securing access to sensitive data and applications. Cloud-based identity and access management (IAM) solutions offer high scalability and flexibility, enabling banks to efficiently add or remove users, adjust access levels, and adapt to changing business needs. Improved user experience and monitoring capabilities further contribute to the effective management of identity and access control. However, the integration and adoption of cloud-native IAM tools present challenges, as these solutions often require significant integration

efforts and time to meet organizational requirements. Despite these challenges, the overall sentiment is positive, with cloud computing technology providing substantial improvements in identity and access control management for Singapore's banks. Please see the word cloud below for a visual representation of the key themes identified in the research:

4.2 Security Challenges and Resilience in Cloud Computing Adoption

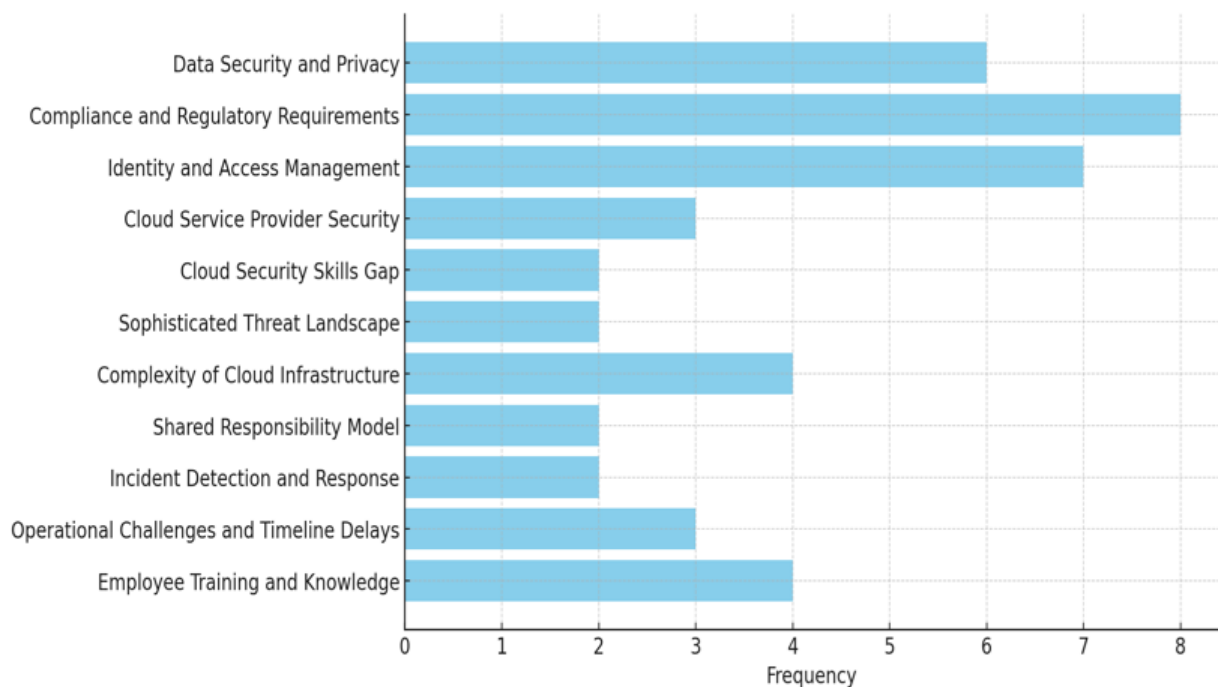


Figure 4.2: Frequency Of Key Security Challenges in Cloud Computing Adoption.

The survey responses reveal several critical security challenges faced by banks in adopting cloud computing technologies. The most frequently mentioned issues include compliance and regulatory requirements, identity and access management (IAM), and data security and privacy. These challenges are essential for banks as they navigate stringent regulatory frameworks and ensure the confidentiality, integrity, and availability of sensitive data stored in the cloud. Effective IAM is crucial for managing access controls and permissions without impacting time-to-market (TTM). Other significant concerns include the complexity of cloud infrastructure, which involves managing diverse components such as virtual machines, containers, and multi-cloud environments. Employee training and knowledge enhancement are also highlighted, indicating the need for continuous upskilling to handle cloud security issues effectively. Operational challenges and timeline delays underscore the impact of strict security protocols on delivery times and customer satisfaction. Timeline delays and downtime occur more than expected as responding to security incidents and conducting forensic investigations in a cloud environment can be more complex than in traditional on-premises environments. It requires specialized tools and processes tailored to cloud platforms to quickly identify, contain, and remediate security incidents.

The insights from the survey underscore the multifaceted nature of cloud security in the banking sector, highlighting the need for a comprehensive approach to address these challenges effectively. Ensuring compliance, managing identities and access, protecting data, and enhancing employee knowledge are pivotal for maintaining a robust security posture in cloud computing environments. Balancing security protocols with operational efficiency to avoid timeline delays is also critical for maintaining customer satisfaction and smooth workflows. The most notable finding is that, despite facing these challenges, the majority of respondents, about 80% reported no security incidents or data breaches occurring in their bank's cloud computing environment within their experience.

the unauthorized transfer or destruction of sensitive data, including personally identifiable information (PII). Furthermore, DLP solutions ensure compliance with regulatory requirements, such as the guidelines set forth by the Monetary Authority of Singapore (MAS). By employing advanced techniques for deep content analysis, including keyword matches, regular expressions, and internal functions, DLP systems can accurately identify sensitive information and detect potential data leaks. This enables businesses to monitor, identify, and automatically protect against the theft or exposure of confidential data (Fortinet, n.d.) In addition to DLP solutions, other important security measures identified include data encryption, tokenization, access control, API security, and the use of secure communication protocols such as TLS (Transport Layer Security). Data encryption was noted for its role in protecting data both at rest and in transit, ensuring that unauthorized parties cannot access or alter the data. Tokenization was highlighted for its ability to replace sensitive data with non-sensitive equivalents, adding an extra layer of security. Overall, the analysis underscores the critical role of DLP solutions and complementary security measures in addressing data protection challenges in the cloud, reflecting a comprehensive and multifaceted approach to cloud security in the banking industry. Here is the word cloud for a visual representation:

4.4 The influence of the regulatory framework in Singapore

For ■ Strongly Agree and ■ Agree

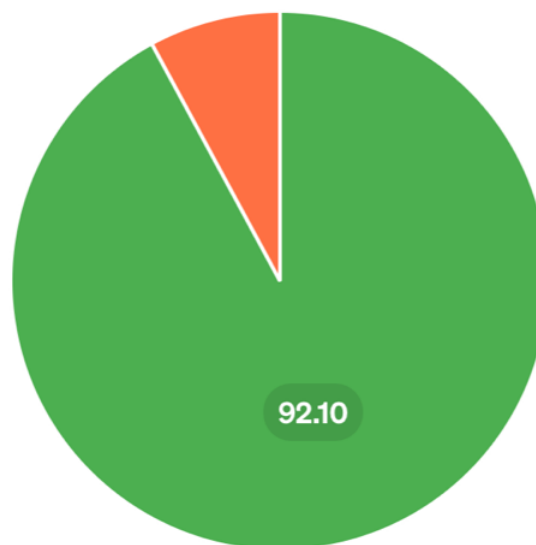


Figure 4.4: Influence Of Regulatory Framework on Security Strategies in Banks (Singapore).

The survey conducted on the influence of the regulatory framework in Singapore on the security strategies adopted by banks to mitigate cloud computing security challenges yielded significant insights. Out of respondents, a substantial majority of 92.1% strongly agreed that the regulatory framework plays a crucial role in shaping the security strategies of banks. This consensus underscores the importance of regulatory compliance in the banking sector's approach to cloud computing security. The remaining 7.9% of respondents did not strongly

agree, suggesting minimal dissent on the matter. Overall, the results highlight the critical impact of Singapore’s regulatory framework on enhancing cloud computing security measures within banks. Banks ensure compliance with regulatory requirements and industry standards for cloud security through a comprehensive approach involving continuous monitoring and reporting, selecting cloud providers with strong compliance credentials, and conducting regular risk assessments. Key strategies include implementing robust security controls, encrypting sensitive data in transit and at rest, and providing regular training to employees on security best practices. Additionally, banks manage third-party risks by evaluating and monitoring the compliance of third-party vendors and Cloud Service Providers (CSPs). They adapt to updated regulations meticulously to align their security practices with the latest requirements. These efforts underscore the complexity of maintaining regulatory adherence in a cloud environment while leveraging cloud services to safeguard data security, privacy, and financial transactions.

4.5 Key suggestion

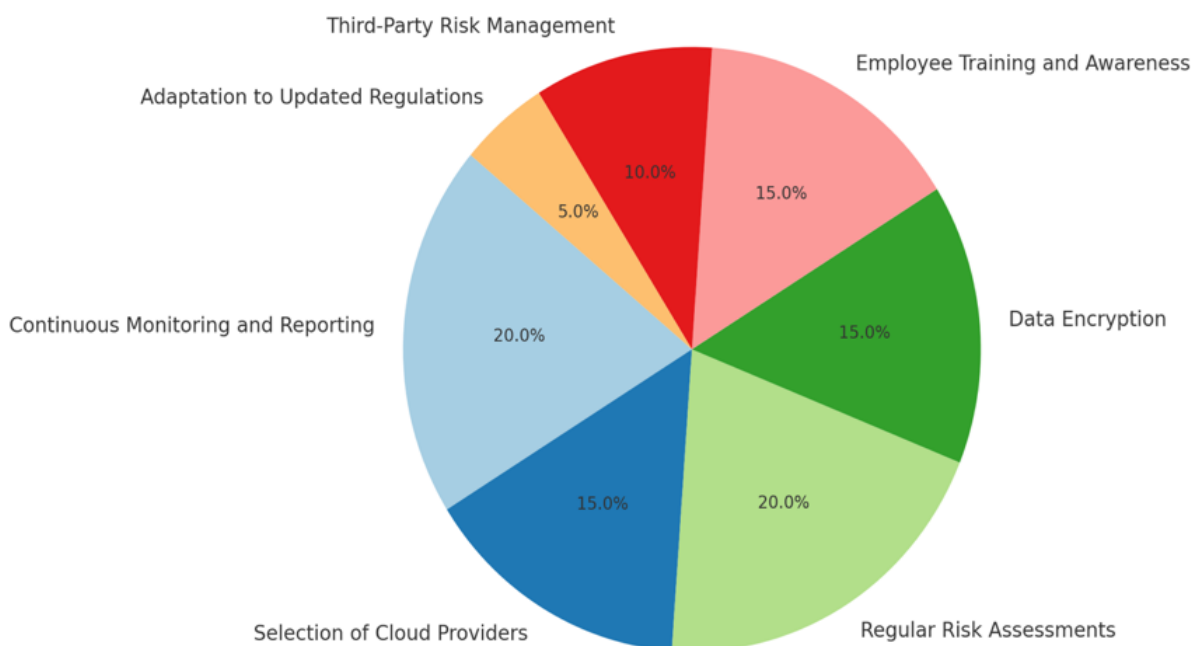


Figure 4.5: *Distribution of Key Strategies to Ensure Compliance with Regulatory Requirements.*

Key suggestions include implementing strong access controls and multi-factor authentication to boost security. Automating security responses instead of just alerting the security operations center (SOC) is also recommended. Stronger encryption for data both in transit and at rest is seen as essential, along with regular security audits and penetration testing to spot and fix vulnerabilities. Network segmentation to isolate sensitive data, using Artificial Intelligence (AI) and Machine Learning (ML) for real-time threat detection, and reconsidering the choice of cloud vendors were also mentioned. A couple of respondents admitted they had no specific ideas, but overall, the focus is on proactive and comprehensive security measures.

5 CONCLUSION

The study investigated the impact of security strategies and regulatory frameworks on cloud computing security within the banking sector in Singapore, revealing critical insights through a mixed methods approach. Key findings highlighted data security and privacy, regulatory compliance, and resilience against cyber threats as the top security challenges faced by banks adopting cloud computing. The study underscored the pivotal role of the Monetary Authority of Singapore's regulatory frameworks in shaping security strategies, which include advanced encryption, regular audits, and comprehensive employee training. These strategies have proven effective in mitigating risks and enhancing security. The study's implications stress the need for banks to continuously evolve their security measures in collaboration with regulatory authorities to develop pragmatic solutions that balance compliance and innovation. Regulatory bodies are encouraged to provide flexible frameworks that accommodate technological advancements. This study underscores the importance of robust security measures and effective regulatory frameworks in safeguarding cloud environments in Singapore's banking sector, ensuring the protection of sensitive financial data and maintaining customer trust.

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APPENDIX

Survey Questions for Cloud Computing Security in the Banking Industry: A Case Study from Singapore

1. How would you rate the overall security posture of your bank's cloud computing environment?

2. How satisfied are you with the current security measures in place for your bank's cloud environment?
3. How has your bank ensured compliance with regulatory requirements and industry standards for cloud security?
4. How satisfied are you with the level of transparency and visibility into your bank's cloud security practices?
5. What are the top three security challenges your bank has encountered in adopting cloud computing technology?
6. How has the adoption of cloud computing technology impacted your bank's ability to manage identity and access control?
7. What challenges has your bank faced in ensuring the resilience of its cloud environment against cyber threats?
8. To what extent do you agree with the statement: "The regulatory framework in Singapore significantly influences the security strategies adopted by banks in mitigating cloud computing security challenges"?
9. Can you provide an example of a security incident or breach that occurred in your bank's cloud computing environment?
10. What improvements would you suggest to enhance the security of your bank's cloud computing environment?

Survey Results for Cloud Computing Security in the Banking Industry: A Case Study from Singapore

https://docs.google.com/spreadsheets/d/1gJblSQmPArpMY_webo8pbAbXB8ll115GRyGdRoInuZI/edit?usp=sharing

The Impact of Smart Homes based on IoT Technology on the Home Furnishing Industry in China's Developed Cities

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Abstract

This study systematically analyzes the impact of Internet of Things (IoT) technology on the smart home industry in China's developed cities. Through structured surveys of over 500 residents in cities such as Beijing, Shanghai, and Shenzhen, the research reveals consumer preferences regarding smart home products, including safety, diversity, humanization, integration, and functional value. The results indicate that consumers place high importance on integrated, user-friendly, and secure smart home solutions, which drive innovation and development in the industry. Data analysis shows that as living standards improve, the demand for smart and eco-friendly home products continues to rise, creating substantial market potential for the home furnishing industry. However, the industry still faces challenges such as inconsistent technical standards and varying product quality. By using descriptive statistical methods, this study summarizes the demographic characteristics of respondents, providing a deep understanding of key trends and consumer demands in the smart home market. This research not only provides valuable insights into the smart home market for the academic community but also offers strategic guidance for home manufacturers and retailers, promoting the healthy development of China's smart home market.

KEYWORDS: Internet of Things, Smart Homes, Home Furnishing Industry, Developed Cities in China, Consumer Preferences

1 INTRODUCTION

With the rapid technological advancements of the 21st century, the Internet of Things (IoT) has been widely applied globally, particularly in China's developed cities such as Beijing, Shanghai, and Shenzhen. These cities, characterized by economic prosperity, advanced infrastructure, high levels of technological innovation, and a high standard of living, have seen smart homes quickly become an essential part of modern life. Through IoT connectivity, various household devices can achieve intelligent interaction and automation, significantly enhancing the convenience and comfort of daily living. Smart home products not only meet consumer demands for safety, product diversity, human-centered design, integration, and functional value but also drive continuous innovation in home product design and functionality. Against the backdrop of accelerated urbanization and improved living standards, the demand for smart, eco-friendly home products continues to rise, creating vast market opportunities for the home furnishing industry. However, the industry also faces numerous challenges, such

as effectively integrating IoT technology and meeting consumer requirements for safety and personalization. Addressing these issues is crucial for the sustained healthy development of the smart home market. This study conducts a comprehensive survey of over 500 residents in China's developed cities to systematically explore the multifaceted impact of IoT-based smart homes on the home furnishing industry. The results aim to reveal key considerations for consumers when purchasing smart home products, providing strategic market insights for manufacturers and retailers, and guiding future industry development. In summary, this research not only supports the academic community in understanding the application and impact of IoT technology in the smart home sector but also offers valuable practical references and recommendations for promoting the healthy development of the smart home market in China.

2 LITERATURE REVIEW

Internet of Things is a new paradigm shift in the field of IT. The term Internet of Things is abbreviated as IoT, which consists of two words, the first one is "Internet" and the second one is "Things"(Madakam,2015). The concept of Internet of Things (IoT) technology was first proposed by Ashton in 1999(Ashton,2009), when he proposed this term in a report on Radio Frequency Identification (RFID). Since then, IoT technology has developed rapidly and has had a significant impact in various fields, especially in the field of smart homes. Smart home is a home information network platform that combines home control network with multimedia information network(Ma,2019), As an important component of the Internet of Things (IoT), smart homes serve users effectively by communicating with various digital devices based on IoT. In the ideal version of a wired future, all devices in smart homes communicate with one another seamlessly. Smart home technology based on IoT has changed human life by providing connectivity to everyone regardless of time and place(Gaikwad et al., 2015, Samuel, 2016). Since the intervention of the Internet of Things, information technology, big data and cloud computing, smart homes have made significant progress. It can not only record, store and analyze users' habits and needs(De Silva,2012), interact with users in various ways such as sound, light, location and images(Junestrand,1999), but can also link external resources through information technology to provide users with healthy, Various services such as assistance, security, education and entertainment (Alaa,2017). As an emerging industry, smart homes have broad prospects. However, inconsistencies in technology and protocols among various manufacturers have resulted in diverse smart home protocols. Each smart home device has its corresponding control application, requiring users to download different software for operation. This not only occupies storage space on smartphones but also complicates user operations. The quality of smart home products on the market varies. Some merchants mislead consumers by labeling products with minor technological elements as smart home products, thus deceiving consumers and hindering the development of smart homes. Genuine smart home products should aim to "provide users with a more convenient lifestyle" through real-time information integration(Rasheed,2016), enabling interaction between people and objects, objects and objects, and objects and the environment. Smart home technology based on the Internet of Things is defined as information technology for home management; it actively assists users by promoting safety, security, comfort, convenience, and entertainment

in the living environment(Mamonov,2021). The development of smart homes has changed traditional user lifestyles. Many daily chores are replaced by smart home technologies, giving users more free time for personal activities. Implementing user-centered smart home design schemes, with products as the medium, is crucial for the healthy development of smart homes. This paper explores three aspects: humanized design concepts, green design concepts, and standardized design concepts. Humanized design is not only reflected in the product's form, function, material, etc., but also takes into account the user's physiological characteristics and psychological needs. Modern designers need to fully consider the behavioral habits and psychological needs of different groups. When designing smart home products, ergonomic principles should be applied to optimize product functions. Humanized design can improve people's quality of life(Zhuan,2023). Users of different age groups have different lifestyles and behavioral habits, and the integration of smart home systems has also become diversified. The green design concept(Ragheb,2016), also known as "sustainable architecture" or "green architecture", advocates the harmonious development of people and the environment, and requires designers to consider resource and environmental impacts in product design, optimize relevant factors, and minimize the impact on the environment. Designers should strive to extend the life cycle of smart home products, reduce energy consumption, and truly achieve sustainable development. Standardized design refers to producing products according to regulations within a certain period, ensuring product universality, and establishing unified product design standards and model. Standardized design helps ensure product quality, reduce repetitive work, speed up design processes, and promote the adoption and dissemination of new technologies. In the future, the development of smart homes will move towards protocol standardization. Various smart home devices can be controlled via applications, and standardized protocols suitable for industry production will be established. The introduction of IoT technology enables real-time collection, transmission, processing, integration, and feedback of information among various smart home devices, and predicts user behavior through cloud-based big data computation, fundamentally changing user lifestyles. The development of smart homes should be user-centered, achieving healthy development through humanized, green, and standardized design, and providing users with a more convenient and comfortable living environment.

3 RESEARCH DESIGNS, SCOPE AND METHODS

This study adopts a quantitative research design to explore the impact of smart homes based on IoT technology on the home furnishing industry in developed cities in China. The research design includes multiple stages such as data collection, data analysis, and reliability and validity testing. The scope of this study includes: Geographic scope: The study focuses on developed cities in China, especially Beijing, Shanghai and Shenzhen. These cities are at the forefront of technology adoption and urban development, making them an ideal place to study the impact of IoT smart homes. Technology Scope: The study covers various IoT-based smart home products and analyzes their impact on the home industry. Population scope: The research subjects are residents of developed cities in China, covering different age, gender, education levels and income groups.

4 METHODS AND ANALYZE

Items	Categories	N	Percent (%)
Gender	female	252	48.18
	male	271	51.82
Age	18-25	146	27.92
	26-35	173	33.08
	36-45	51	9.75
	46-55	43	8.22
	Over 55 years old	110	21.03
	First tier cities	351	67.11
Residential location	New first-tier cities	135	25.81
	Second-tier cities and below	37	7.07
Educational level	College degree	71	13.58
	Graduate degree or above	110	21.03
	High school and below	38	7.27
	Undergraduate	304	58.13
Income	3000-5000	80	15.3
	5001-7000	183	34.99
	7001-9000	151	28.87
	Above 9000	89	17.02
	Below 3000	20	3.82
Acceptance of technology products	Higher	256	48.95
	Lower	65	12.43
	Neutral	31	5.93
	Very high	162	30.98
	Very low	9	1.72
Types of housing	High end apartments	46	8.8
	Self-built houses in rural areas	143	27.34
	Townhouse/Townhouse	307	58.7
	Types of housing	27	5.16
Total		523	100

Table 1: Overview of Respondents' Data Distribution

This study collected data through a structured questionnaire, which was distributed to more than 500 residents in developed cities in China to ensure that the final sample size was no less than 500 people. Developed cities here refer to cities with prosperous economies, well-developed infrastructure, active technological innovation, and high living standards of residents, such as Beijing, Shanghai, and Shenzhen. These cities are at the forefront of technology adoption and urban development, providing an ideal background for studying the impact of IoT smart homes. The questionnaire covers measurement items in multiple dimensions, such as security, diversity, humanization, integration and standardization, perceived functional value, perceived emotional value, and purchase intention. Through descriptive analysis, the demographic characteristics of the respondents were summarized, including gender, age, place of residence, education level, income, acceptance of technology products, housing type, and purchase intention. As shown in Table 1, first of all, from the perspective of gender distribution, the number of females and males is 252 and 271 respectively, accounting for 48.18% and 51.82% respectively, and the number of females and males is not much different. From the perspective of age distribution, 18-25 years old accounted for 27.92%,

Items	N	Mean	Std.	Skewness	kurtosis
Security	523	3.656	0.879	-0.854	0.652
Diversification	523	3.491	0.92	-0.63	0.445
Humanization	523	3.422	0.87	-0.364	-0.149
Integration and standardization	523	3.246	0.735	0.012	-0.378
Perceive the value of function	523	3.607	0.851	-0.707	0.227
Perceive emotional value	523	3.533	0.819	-0.442	-0.197
Purchase intention	523	3.656	0.768	-0.608	0.568

Table 2: *Descriptive Analysis of Different Dimensions*

26-35 years old accounted for 33.08%, 36-45 years old accounted for 9.75%, 46-55 years old accounted for 8.22%, and 55 years old and above accounted for 21.03%. It can be seen that in terms of gender: the ratio of men and women is relatively balanced, with slightly more men than women. In terms of age, it is mainly concentrated in the youth group (18-35 years old) and the elderly group (over 55 years old), and there are fewer respondents in the middle-aged group (36-55 years old). This distribution may reflect the market characteristics of smart home products. Young people and the elderly are more interested in smart home products, while the participation of middle-aged people in the survey is relatively low. In terms of residence, the respondents are divided into first-tier cities, new first-tier cities, and second-tier and lower cities. Among them, respondents living in first-tier cities account for the majority of the sample, accounting for 67.11%, respondents living in new first-tier cities account for 25.81%, and respondents living in second-tier and lower cities account for a relatively small proportion, accounting for 7.07%. China's developed cities include the above-mentioned first-tier cities and new first-tier cities. From these data, it can be seen that the respondents are mainly concentrated in first-tier and new first-tier cities with developed economies and complete infrastructure, which is consistent with the market positioning and demand characteristics of smart home products. In terms of the respondents' acceptance of technology products, they are divided into five categories: very high, high, general, low and very low. 48.95% of the respondents said that they have a high acceptance of technology products, 30.98% of the respondents said that they have a very high acceptance of technology products, 5.93% of the respondents have a general attitude towards technology products, 12.43% of the respondents said that they have a low acceptance of technology products, and only 1.72% of the respondents said that they have a very low acceptance of technology products. The majority of respondents have a high and very high acceptance: the proportion of respondents with a high and very high acceptance reached 79.93%, indicating that most respondents have a positive attitude towards technology products and are willing to accept and use new technologies and smart home products. The acceptance is neutral: Only 5.93% of the respondents are neutral in their acceptance of technology products. This group of people may be potential users, and they only need more information and experience accumulation to become active acceptors. A small number of people with low and very low acceptance: The proportion of respondents with low and very low acceptance is 14.15%. This group of people has a low acceptance of technology products, and more education and promotion may be needed to change their attitudes. From these data, we can see that most respondents have a positive attitude towards technology products, especially in cities with developed economy and technology, which is consistent with the market positioning and demand characteristics of smart home products. Smart home

companies can conduct marketing promotions for people with high acceptance, and at the same time, gradually increase the interest and recognition of neutral and low acceptance groups through education, experience activities and other means.

This study uses a five-point Likert scale (Johns, 2010) with a maximum value of 5, a minimum value of 1, and an average value between 3 and 4, indicating that the consistency level of the items and the survey population varies greatly. Secondly, skewness and kurtosis are important statistics for describing the data distribution pattern. By analyzing the skewness direction and tail characteristics of the data, we can have a more comprehensive understanding of the distribution characteristics of the data, and then make more accurate statistical inferences and decisions. Skewness reveals the symmetry of the data distribution, and kurtosis reveals the steepness of the crest of the data distribution and the thickness of the tail. The combination of the two can provide rich distribution information and help to deeply understand the intrinsic characteristics of the data. As shown in Table 2, N represents the sample, Mean represents the five-component Likert value, Std. represents the standard deviation, Skewness represents the skewness value, and Kurtosis represents the kurtosis value.

From the descriptive analysis of different dimensions, the average values of Security, Diversification, Humanization, Integration and standardization, Perceived functional value, Perceived emotional value, and Purchase intention are 3.656, 3.491, 3.422, 3.246, 3.607, 3.533, respectively. 3.656, with the mean value between 3 and 4 respectively, indicating that participants highly recognize the safety, diversification, humanization, integration, standardization and other characteristics of smart homes, and also have a high willingness to purchase. Secondly, judging from the skewness and kurtosis values, both are less than 1, indicating that the data distribution conforms to the normal distribution.

5 CONCLUSION AND OUTLOOK

This study systematically analyzed the impact of IoT-based smart homes on the home furnishing industry in developed cities in China. Through an in-depth survey of over 500 residents in cities such as Beijing, Shanghai, and Shenzhen, significant consumer preferences for smart home products were revealed, particularly in terms of safety, diversity, user-friendliness, integration, and functional value. The findings indicate that consumers highly value the integration and security of smart home solutions, which promotes continuous innovation within the industry and enhances market acceptance of these products. As urbanization progresses and living standards rise, there is an increasing demand for smart, eco-friendly home products, creating substantial market potential for the home furnishing industry. However, challenges such as the lack of unified technical standards and variations in product quality remain prevalent, hindering further development of the smart home market. Addressing these issues through technological standardization, quality control, and enhanced user experiences is crucial for the sustainable growth of the market. This study not only provides valuable insights into the smart home market for academia but also offers practical market strategy recommendations for manufacturers and retailers. Through data analysis, manufacturers can better understand consumer behaviors and preferences, enabling more precise decision-making in product design, functionality development, and marketing strategies. Furthermore, the study emphasizes the importance of incorporating human-centered, green, and standardized approaches in

product design to meet consumer demands for personalization and sustainability. Looking ahead, the application of IoT technology in the smart home sector holds immense potential. As technology continues to evolve, smart homes will further achieve seamless connectivity and intelligent interaction between devices, offering users a more convenient and comfortable living experience. Continuous research and development will be critical in ensuring that the industry remains competitive in a rapidly changing market. Through ongoing innovation and optimization, the smart home industry in China is poised to improve residents' quality of life while driving economic growth, maintaining a strong growth trajectory.

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Investigating the Effects of Digital Innovation on Instructional Strategies and the Roles of Teachers

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Abstract

This study examines the effects of digital innovations on education specifically focusing on the efficacy of online learning tools in Chinese universities. While the findings provide valuable insights, the cultural and educational context of China may limit their generalizability. Future research should explore these effects in diverse cultural and educational settings. A quantitative methodology was employed, analyzing responses from 500 questionnaires distributed among students and faculty at Chinese universities. The findings reveal that online learning tools positively influence student engagement, knowledge acquisition, and academic performance. However, the study also identifies several challenges, such as technical difficulties and issues with maintaining student engagement over time. Furthermore, these tools enhance learning motivation and strategies and improve the quality of teacher-student interactions. The adoption of digital tools has also led to significant improvements in teaching efficiency and necessitated adjustments in teaching strategies. The majority of students and teachers have reported favorable perceptions towards these tools, particularly after participating in training sessions. Notably, 85% of students reported increased confidence in using online tools, while 78% of teachers observed enhanced integration of digital tools into their teaching practices after professional development. These results underscore the importance of continuous training and support for educators and learners to maximize the benefits of educational technology. The study highlights the need for well-structured training programs that not only improve technical skills but also foster positive attitudes towards the use of digital innovations in education.

KEYWORDS:Digital Education Tools, Online Learning Impact, Student Engagement, Teaching Practices, E-learning Effectiveness, Educational Technology, Learning Outcomes, Teacher and Student Perceptions

1 INTRODUCTION

This study investigates the application and significance of digital innovation in education, focusing on online learning tools. With rapid advancements in information technology, education is undergoing unprecedented changes. Online learning tools, such as virtual classrooms, interactive simulations, and educational software, have the potential to expand the boundaries of education, improve accessibility, and offer flexibility. These tools allow students to learn at their own pace, support personalized learning paths, and accommodate diverse teaching methods. Despite their increasing popularity, significant uncertainties remain regarding their

actual impact on student learning outcomes, engagement, and teaching practices. Additionally, online learning tools can present challenges such as technical difficulties, reduced face-to-face interaction, and increased distraction. While online learning tools have the potential to support knowledge acquisition, improve academic performance, and enhance learning motivation, the evidence supporting these claims is not yet comprehensive. Previous research indicates that online learning tools can improve knowledge acquisition and academic performance (Broadbent & Poon, 2015; Jose & Jose, 2022), but more robust evidence is needed due to methodological limitations. Studies by Nortvig, Petersen, and Balle (2018), and Kumar and Todd (2022) suggest that online learning tools can enhance student engagement and satisfaction, but the specific factors contributing to these positive outcomes require further exploration. Additionally, while online learning tools are believed to improve teaching efficiency and innovate teaching strategies (Zekaj, 2023), a systematic understanding of teachers' acceptance of these tools and the practical challenges encountered is still lacking. This study focuses on Chinese universities, which may limit its generalizability to other cultural or educational contexts. Discussing the cultural and background factors that may influence the results and proposing methods to adapt the findings to different environments will enhance the content of this paper. Future research should consider factors in different cultural and educational environments, exploring how these factors influence the effectiveness of online learning tools and proposing strategies to adapt findings to different contexts. This study aims to fill these research gaps by comprehensively evaluating the effects of online learning tools on education. Future research should focus on the long-term impact of online learning tools and evaluate their lasting impact on student learning outcomes and teachers' teaching practices through long-term follow-up surveys to provide a more comprehensive understanding.

2 LITERATURE REVIEW

First, the impact of online educational tools on student learning outcomes. Broadbent and Poon (2015) believe that online learning tools can effectively support students' knowledge acquisition, improve academic performance and enhance learning motivation. Kumar and Todd (2022) found that these tools can increase student engagement, improve learning satisfaction, and overall learning experience. However, there are also studies pointing to potential disadvantages such as digital fatigue, technology issues and the need for students to have strong self-discipline. Secondly, online tools can stimulate students' learning motivation by providing an interactive learning environment and instant feedback, and optimize teachers' teaching practices by enhancing teacher-student interaction. Zekaj (2023) pointed out that online learning tools not only improve teaching efficiency, but also promote the change of teachers' roles, allowing teachers to play more guidance and support roles, thereby promoting innovation in teaching strategies. Additionally, teacher and student acceptance and perceptions of these tools are explored. Broadbent and Poon (2015) and Jose and Jose (2022) argue that appropriate training and support are key to the effective use of these tools. These findings highlight the importance of understanding and assessing the multifaceted impacts of educational technology to advance educational practice and policy. In summary, this article not only demonstrates the practical application of online learning tools in education, but also highlights the importance of continued research and development of these tools to meet future educational needs.

3 RESEARCH DESIGNS, SCOPE AND METHODS

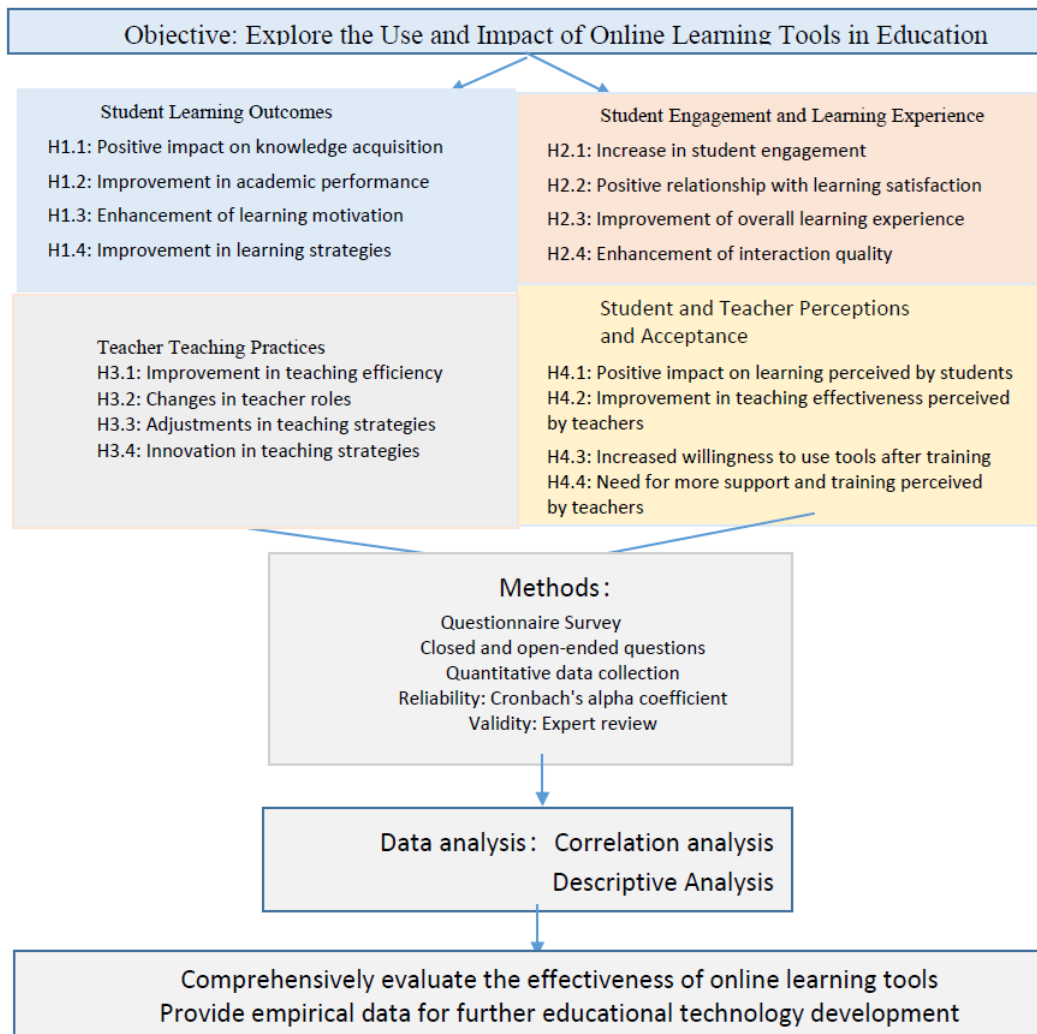


Figure 3.1: *Research framework*

This research framework explores the use and impact of online learning tools in Chinese universities, aiming to enhance the generalizability of findings by suggesting future research in diverse cultural and educational contexts. The model examines student learning outcomes, engagement, teaching practices, and perceptions of both students and teachers. To achieve these goals, a questionnaire survey method with closed questions was used, ensuring reliability and validity through Cronbach's alpha and expert review. However, potential biases from self-reported data, such as social desirability or recall bias, are acknowledged. Incorporating objective measures like exam scores and course participation records would improve validity, providing comprehensive data for evaluating the effectiveness of online learning tools and contributing to further educational technology development.

4 DATA ANALYSIS AND RESULTS

4.1 Reliability Analysis

Section Category	Representative Cronbach's Alpha
Knowledge Acquisition	0.88
Academic Performance	0.88
Learning Motivation	0.84
Learning Strategies	0.84
Student Engagement	0.85
Learning Satisfaction	0.87
Overall Learning Experience	0.89
Quality of Interaction	0.88
Positive Impact Belief	0.9
Willingness to Use Tools After Training	0.88
Teaching Efficiency	0.87
Changes in Teachers' Roles	0.85
Adjustments in Teaching Strategies	0.85
Innovation in Teaching Strategies	0.82
Improvement in Teaching Effectiveness	0.75
Need for More Support and Training	0.88

Table 1: *Summary of Reliability by Section Category*

The reliability of the study was assessed using Cronbach's alpha coefficient. This statistical measure was used to determine the internal consistency of the survey instruments used in the research. Cronbach's alpha values for the various sections of the survey ranged from 0.72 to 0.89, indicating acceptable to excellent reliability. Specifically, a Cronbach's alpha of 0.89 was recorded for the section on the impact of online learning tools on knowledge acquisition, suggesting that the items within this section are highly consistent in measuring the intended construct.

4.2 Validity

The study's validity was ensured through expert review, where experts in educational technology and digital learning reviewed the survey instruments and research methodology. Their feedback refined the questions, ensuring the instruments accurately measured the intended variables. This process confirmed the relevance, clarity, and coverage of the constructs, ensuring content validity. These measures of reliability and validity support the robustness and credibility of the findings, providing confidence that the results accurately reflect the impact of

digital innovation on instructional strategies and teachers' roles.

4.3 Descriptive Analysis

Category	Students	Teachers
Sample Size	350	150
Age Distribution		
15-24 years	350 (100%)	0 (0%)
25-34 years	0 (0%)	37 (24.67%)
35-44 years	0 (0%)	43 (28.67%)
45-54 years	0 (0%)	38 (25.33%)
55-64 years	0 (0%)	29 (19.33%)
Over 64 years	0 (0%)	3 (2%)
Level of Study/Education		
Bachelor	164 (46.86%)	91 (60.67%)
Master	186 (53.14%)	59 (39.33%)
Previous Online Learning Experience		
Have	261 (74.57%)	101 (67.33%)
No Have	89 (25.43%)	49 (32.67%)

Table 2: Descriptive Analysis Summary (Students and Teachers)

The descriptive analysis of students and teachers shows that all 350 students are within the 15-24 age range, with 46.86% pursuing a Bachelor's degree and 53.14% pursuing a Master's degree. Among them, 74.57% have prior experience with online learning. In contrast, the 150 teachers are more varied in age, with the majority between 25-54 years old. Of these teachers, 60.67% hold a Bachelor's degree and 39.33% hold a Master's degree, with 67.33% having previous online learning experience.

4.4 Correlation Analysis

The correlation analysis shows significant positive relationships between the use of online learning tools and various educational aspects. For knowledge acquisition (H1.1), understanding depth correlates with memorizing new information ($r=0.597$, $p<0.01$). In academic performance (H1.2), test scores correlate with coursework participation ($r=0.630$, $p<0.01$). Learning motivation (H1.3) correlates with a sense of accomplishment ($r=0.617$, $p<0.01$), and planning study time correlates with monitoring progress (H1.4, $r=0.631$, $p<0.01$). Student engagement (H2.1) correlates with group discussion participation ($r=0.608$, $p<0.01$). Learning satisfaction (H2.2)

correlates with achieving learning goals ($r=0.661$, $p<0.01$), and overall learning experience (H2.3) correlates with recommendations ($r=0.580$, $p<0.01$). Communication quality (H2.4) correlates with in-depth discussions ($r=0.615$, $p<0.01$). Students' belief in online tools (H4.1) correlates with learning flexibility ($r=0.631$, $p<0.01$), and tool use frequency after training (H4.3) correlates with improved usage ability ($r=0.660$, $p<0.01$). Teaching efficiency (H3.1) correlates with classroom management effectiveness ($r=0.55$, $p<0.01$). The changing role of teachers (H3.2) correlates with promoting independent learning ($r=0.699$, $p<0.01$), and adjustments in teaching strategies (H3.3) correlate with interactive methods ($r=0.615$, $p<0.01$). Innovation in teaching strategies (H3.4) correlates with new teaching concepts ($r=0.652$, $p<0.01$). Improvement in teaching effectiveness (H4.2) correlates with content diversity ($r=0.615$, $p<0.01$), and the need for more support and training (H4.4) correlates with technical challenges ($r=0.613$, $p<0.01$). These correlations indicate that online learning tools positively impact student and teacher experiences, reinforcing their efficacy in educational settings.

5 CONCLUSIONS AND DISCUSSIONS

This study analyzes the impact of online learning tools on educational outcomes in Chinese universities. Future research should use longitudinal studies and explore these tools in diverse contexts to verify their generalizability. Findings indicate significant enhancements in student knowledge acquisition, academic performance, motivation, and engagement. Online tools improve understanding of course material, test scores, class participation, group discussions, and communication with instructors. The study highlights that online learning tools enhance teaching effectiveness and transform teachers' roles. Both students and teachers find these tools beneficial, especially with adequate training and support. Training programs should cover basic skills, advanced techniques, and practical applications of digital tools.

Structure of Training Programs: Modular Approach: Divide the training into modules, each focusing on a specific aspect of digital tool usage. This allows participants to progress at their own pace and revisit modules as needed.

Hands-On Practice: Incorporate interactive workshops and practice sessions where participants can apply what they have learned in real or simulated classroom settings.

Feedback and Assessment: Regular feedback sessions and assessments to track progress, address challenges, and reinforce learning outcomes.

Implementation Strategies: Continuous Professional Development: Schedule regular follow-up sessions and refresher courses to ensure that educators remain updated with the latest advancements and best practices.

Peer Support Networks: Establish support groups or communities of practice where educators can share experiences, tips, and resources.

Resource Availability: Provide access to comprehensive online resources, including tutorials, guides, and troubleshooting helpdesks.

Cultivating Positive Attitudes: Showcasing Benefits: Highlight the benefits of digital tools through case studies and success stories from other educators and institutions.

Encouraging a Growth Mindset: Foster a culture of continuous learning and adaptation, encouraging educators to embrace new technologies and innovative teaching strategies. These recommendations aim to ensure that training programs are effective in enhancing technical skills and fostering positive attitudes towards the use of digital innovations in education. Implementing well-structured training programs will maximize the benefits of educational technology and support educators and learners in adapting to digital advancements. Despite

Category	Variable 1	Variable 2	R	P	M	SD
H1.1	Understand depth	Memorize new information and concepts	0.597	<0.01	3.32	1.154
H1.2	Learner test and examination scores	Frequency of coursework and project participation	0.63	<0.01	3.25	1.207
H1.3:	Interestingness of the learning process	Sense of accomplishment	0.617	<0.01	3.29	1.143
H1.4	Planning study time and resources	Monitoring of learning progress and effectiveness	0.631	<0.01	3.35	1.175
H2.1	Increased classroom participation and interaction	Active participation in group discussions and projects	0.608	<0.01	3.29	1.178
H2.2	Satisfaction with learning outcomes	Achieve learning goals	0.661	<0.01	3.23	1.218
H2.3	Improvement of the overall learning experience	Recommendation or endorsement	0.58	<0.01	3.35	1.179
H2.4	Improved quality of communication among classmates	In-depth and helpful discussions on the platform	0.615	<0.01	3.33	1.179
H4.1	Improvement of learning effect	Flexibility and convenience of learning	0.631	<0.01	3.29	1.195
H4.3	Increased frequency of use	Improved ability to use tools effectively	0.66	<0.01	3.23	1.214
H3.1	Classroom and student management effectiveness	Simplification of the teaching preparation process	0.55	<0.01	3.43	1.166
H3.2	The changing role of teachers	Promote students' independent learning	0.699	<0.01	3.52	1.186
H3.3	Promote more interactive and participatory teaching methods	Achieve differentiated teaching	0.615	<0.01	3.31	1.142
H3.4:	New opportunities for teaching innovation	Introduce new teaching concepts and practices	0.652	<0.01	3.31	1.194
H4.2	Improvement of teaching quality and efficiency	Richness and diversity of teaching content	0.615	<0.01	3.39	1.198
H4.4	Need for more professional training	Facing technical and operational challenges	0.613	<0.01	3.59	1.154

Table 3: Key Variables Correlation Analysis Summary (Students and Teachers)

the many positive impacts of online learning tools, this study also identified several challenges. These include technical difficulties, issues with maintaining student engagement over time, and the need for continuous updates and improvements. Additionally, some students and teachers reported experiencing digital fatigue and feeling overwhelmed by the constant need to adapt to new technologies. Addressing these challenges requires ongoing support, training, and further research into effective solutions. Addressing these challenges requires ongoing support, training, and further research into effective solutions. Future research should focus on longitudinal studies to assess the long-term impact of online learning tools. A longitudinal perspective involves studying the same participants over an extended period, allowing for the observation of changes and developments over time. This is crucial for understanding the sustained effects of digital innovations on educational outcomes, such as student performance,

engagement, and teachers' instructional practices. For example, longitudinal studies can track how students' familiarity and proficiency with online tools evolve, how their learning outcomes change over multiple academic years, and how teachers adapt their teaching strategies to integrate new technologies effectively. These insights are essential for identifying enduring benefits or potential drawbacks that might not be apparent in short-term studies. Additionally, future research should explore the impact of online learning tools in different educational contexts and investigate the influence of emerging technologies and cultural factors. These efforts will help optimize the use of online learning tools in education and enhance outcomes and experiences for both students and teachers. **Significance:** This study not only provides empirical data on the effectiveness of online learning tools in education, but also reveals the potential of these tools to improve student learning outcomes, engagement, and teachers' teaching practices. These findings have important guiding significance for the development of educational practice, educational policy and educational technology. **Educational Practice:** By evaluating the effectiveness of online learning tools in different teaching and learning environments, this study provides educators with practical recommendations on how to effectively utilize these tools to enhance student learning experiences and learning outcomes. **Education Policy:** The findings provide key insights for policymakers to develop or adapt education policies to promote appropriate use of online learning tools and ensure education quality and equity. **Educational Technology Development:** By identifying the strengths and limitations of online learning tools, this research helps drive innovation and improvements in educational technology solutions to meet changing teaching and learning needs. **Enhancing student and faculty acceptance:** Understanding student and faculty perceptions and acceptance of online learning tools is critical to promoting the effective integration of these tools. The findings from this study will inform how training programs can be designed and implemented to improve the skills and confidence of educators and learners. Future research should assess the long-term impact of online learning tools, explore their effects in diverse educational contexts, and investigate emerging technologies and cultural factors.

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Using Artificial Intelligence Technology to Improve the University Education in China

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Abstract

In recent years, the integration of Artificial Intelligence (AI) technology into various fields has garnered significant attention due to its transformative potential. This article explores the advantages and significance of incorporating AI into China's university education system, summarizing key areas where AI can advance higher education. Through research and analysis of 250 collected questionnaires, the study examines attitudes and perceptions across different educational backgrounds and age groups regarding AI's benefits in university education. Data analysis reveals that personalized learning methods are considered the most important advantage of AI, accounting for 30.8%. Exposure to AI tools varies by educational background: individuals with college degrees are more familiar with AI homework tutoring and language learning applications (64.37%), undergraduates are most often exposed to ChatGPT (64.43%), and graduate students frequently use AI homework tutoring (71.43%). Feedback indicates that college degree holders believe AI enriches educational resources (57.47%), bachelor's degree holders see a similar enrichment (59.06%), and those with graduate degrees highly value the timely feedback and rich resources provided by AI (71.43%). Despite slight differences in experiences regarding personalized learning, adaptability, access to educational resources, and equitable distribution of resources, the consensus is that AI significantly benefits university education. These advantages highlight the potential for AI to enhance higher education in China, meriting further development and improvement.

KEYWORDS: Artificial Intelligence, University Education, Artificial Intelligence Tools and Applications, Advancement of University Education in China

1 INTRODUCTION

Artificial intelligence (AI) is currently known as one of the world's three cutting-edge technologies. AI refers to big data, parallel computing, deep learning as the drive, through the study of human intelligence, so that the machine can simulate, extend, expand human intelligent behavior, to construct an artificial system with certain intelligent ability, can complete the work that usually requires human intelligence to be competent (Ashby, 1960). With the rapid development of technology, AI has gradually attracted people's attention. In the era of AI, many fields have collided with AI to create a different spark, and the field of education is no exception. Through the views of scholars, according to the direction of the content of the viewpoint, the meaning of Artificial Intelligence Education (AIE): The first category: AIE is AI empowerment education, which mainly points to the application level of AI, also known as AI

and education, AIE, AIE application, education Artificial intelligence, etc. Based on intelligent perception, teaching algorithms and data decision-making technologies, it uses intelligent tools to automatically analyze all elements of the education system, implement precise intervention, support large-scale teaching and personalized learning, accelerate talent training models, and reform teaching methods (Peng Shaodong, 2021). The second category, AIE, that is, AI course teaching, mainly points to the level of AI learning, also known as AI special education, AI special education, AI subject education, etc. It refers to the pandisciplinary education that uses AI as the learning content education to improve the individual's AI literacy, including AI knowledge education, applied ability education and affective education (Chinese Education Society, 2021). This study delves into the implications and benefits of integrating artificial intelligence within China's university education system. It sheds light on the pivotal role of artificial intelligence in enhancing higher education and explores the specific areas where its implementation drives progress. Additionally, it delves into the varied perspectives and viewpoints across different educational backgrounds and age brackets regarding the advantages of artificial intelligence in university education. The research further delves into assessing the significance of diverse benefits offered by artificial intelligence in education and the level of engagement with AI tools among individuals from varying educational backgrounds.

2 LITERATURE REVIEW

Based on the research and discussion of AI in the field of education, corresponding views have been proposed. Kemal Gohan Nalbant represent that the contribution of AI to education is relatively high in every field (military, medicine, psychology, sociology, neurology, linguistics). AI holds great hope and a future for education. Wherever it is, it is used to support both formal teaching and lifelong learning. Flexible, inclusive, personalized, exciting, and effective educational tools in AI make learning more accessible and more enjoyable. In this context, considering the benefits of AI applications in education, it is recommended that schools switch to AI-supported education. Considering the benefits that AI brings to education, schools have made learning more efficient by using AI-supported applications (Tao B, 2019). Valentyna Yuskovych-Zhukovska et al. conducted a study that Application of AI in Education. Problems and Opportunities for Sustainable Development. The study found that AI has a key role in implementing the idea of personalized learning - the adaptation of learning, its content and pace to the pacific needs of each student. It provides the ability to obtain data from a variety of sources, verify this data and analyze it using analytics and machine learning. In this way, the powerful potential of AI in education can be revealed, and its use can act as a catalyst for the transformation of the education system for all stakeholders, from individual learners to local governments, which will promote and ensure sustainable development. AI technologies can change any industry, but their possibilities are not limitless. The main limitation of AI is that learning is possible only based on data, otherwise it is impossible. This means that any errors in the data will be reflected in such training results (Nalbant, 2021). Partita Biswas et al. also found that professionally valuable ideas, skills, and perspectives are increasingly being conceived, transmitted, and realized in the context of the shift to a new digital world. Along with this shift is the increasing significance of communities in the physical and digital worlds. This kind of reform's primary objective is to personalize each student's

learning experience. As a result, some students should be able to improve their academic performance, while other children should learn more and faster than their peers. One strategy for making value systems more systematic and implementing them is to keep a professional digital portfolio updated throughout one's career. Together, these two developments can reshape social and political ties and enable better allocation of educational system resources per predetermined criteria for various individuals and groups (Yuskovych-Zhukovska, 2022). While the advantages of AI in the field of education are gradually being paid attention to, some researchers have shown that some of the drawbacks are also worth serious consideration. Such as while there are many benefits to incorporating AI in education, there are also several challenges and concerns that need to be addressed. Institutions must carefully consider the costs and benefits of implementing AI systems in their classrooms and ensure that they are taking appropriate measures to protect students' privacy and prevent bias. By balancing the benefits and challenges of AI in education, we can create a more personalized, efficient, and effective learning experience for all students (partita Biswas, 2023).

3 RESEARCH DESIGNS, SCOPE, AND METHODS

Item	Option	Frequency	Percentage (%)	Cumulative Percentage (%)
Gender	Male	152	60.8	54.00
	Female	98	39.2	100.00
Age group	18~24	117	46.8	46.8
	25~29	84	33.6	80.4
	Over 30	49	19.6	100.00
Educational Qualifications	College	87	34.8	34.8
	Undergraduate	149	59.6	94.4
	Graduate students and above	14	5.6	100.00
Total		100	100.0	100.0

Table 1: Frequency analysis results of gender, age group and educational qualifications

This article employs a questionnaire survey method, distributing surveys online to universities across various regions in China. A total of 250 questionnaires were collected, with the sample consisting of 152 males (60.8%) and 98 females (39.2%). Participants ranged in age from 18 to over 30, with the largest group being 18-24 years old (117 participants, 46.8%). Educational backgrounds included college associate degrees, undergraduate degrees, and graduate degrees and above, with undergraduates forming the largest group (149 participants, 59.6% of the total). Frequency analysis was conducted on the variables of gender, age, and education of the respondents. The sample distribution data results are presented in Table 1.

4 DATA ANALYSIS AND RESULTS

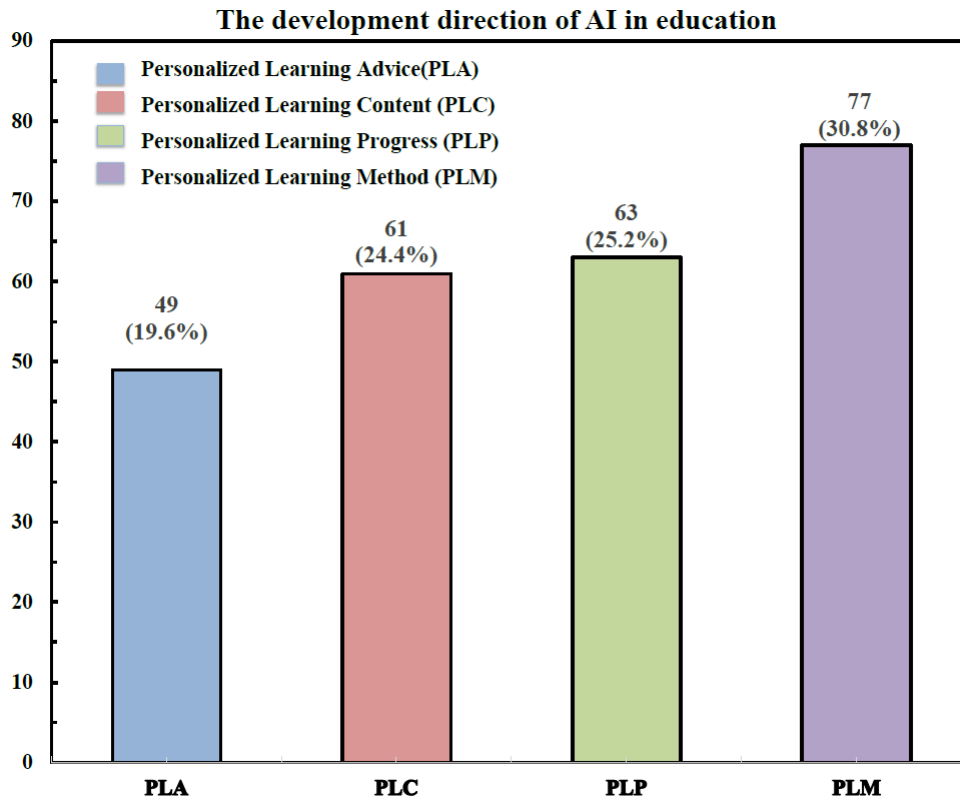


Figure 4.1: Projects to strengthen and develop AI technology in university education in China.

Personalized learning in AIE involves tailoring educational content, methods, suggestions, and progress tracking to the individual needs, preferences, and learning styles of each learner. Personalized learning content (PLC) involves providing educational materials that are specifically curated to meet the unique needs and interests of individual learners (Hua Chen, 2024). Personalized learning Method (PLM) involve adapting teaching techniques and approaches to align with the preferred learning styles, pace, and cognitive abilities of individual learners (Zhija Mou, 2017). Personalized learning advice (PLA) entail providing tailored recommendations and guidance to learners to help them navigate their learning journey more effectively (Fenghua Xu, 2023). Personalized learning progress (PLP) involves continuously monitoring and assessing each learner's progress, understanding their strengths and weaknesses, and providing feedback and support to facilitate their ongoing development (YongPeng Xie, 2024). In response to the above content, a questionnaire survey was used to collect a histogram on "Which aspect of AI technology should be more focused on strengthening and developing in Chinese university education?" is shown in Figure 4.1. Judging from the data distribution in the figure, the highest emphasis on personalized learning methods accounts for 30.8%. Learning methods in university education are the most considered. In addition, the proportions of personalized learning content and personalized learning process are 24.4% and 25.2% respectively. There is not much difference between the two. The emphasis on these two aspects

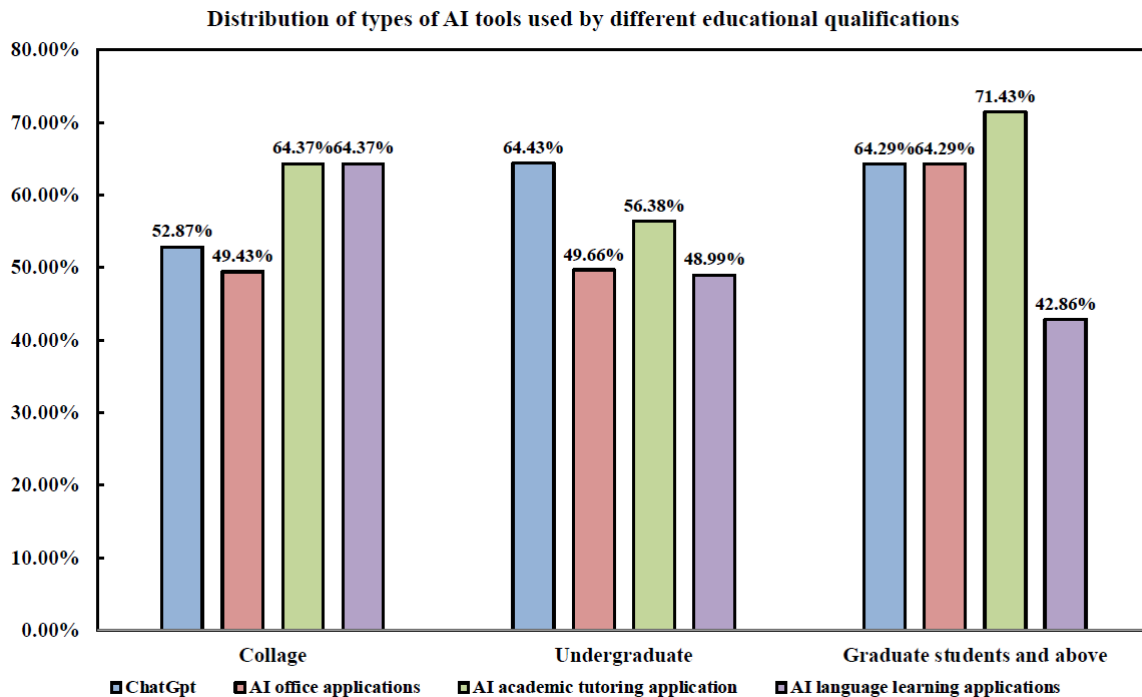


Figure 4.2: Distribution of AI tools that people with different educational qualifications have been exposed to in China.

is almost the same.

AI tools are increasingly being integrated into university education to enhance teaching, learning, and administrative processes. Among them, ChatGPT is an application that has been highly discussed recently. It is an AI-driven conversational agent that allows students to participate in real-time conversations, answer questions, provide explanations, and provide personalized support. Universities can deploy ChatGPT as a virtual assistant on their website or learning management system to help students inquire about information related to course registration, academic advising, campus resources, and general information (Stephen Wolfram, 2023). In addition, AI office applications are AI-driven office applications that use natural language processing (NLP) and machine learning algorithms to automate management tasks, streamline work processes, and improve productivity. Universities can use AI office applications to perform tasks such as automated document processing, scheduling, email management, and data analysis (Xiao Linqiao, 2021). For example, AI tools like Grammarly or Hemingway Editor can help students improve their writing skills by providing real-time feedback on grammar, style, and clarity. The AI homework tutoring application uses adaptive learning algorithms and personalized feedback mechanisms to provide on-demand help and support for students to complete homework and understand course materials (Sri Setyanings, 2011). Platforms like Chegg Study or Wolfram Alpha offer AI tutoring services that help students solve complex problems, understand difficult concepts, and get step-by-step guidance on assignments in various subjects such as math, science, and computer programming. AI language learning applications use speech recognition, natural language understanding, and personalized learning algorithms to promote language acquisition and proficiency development.

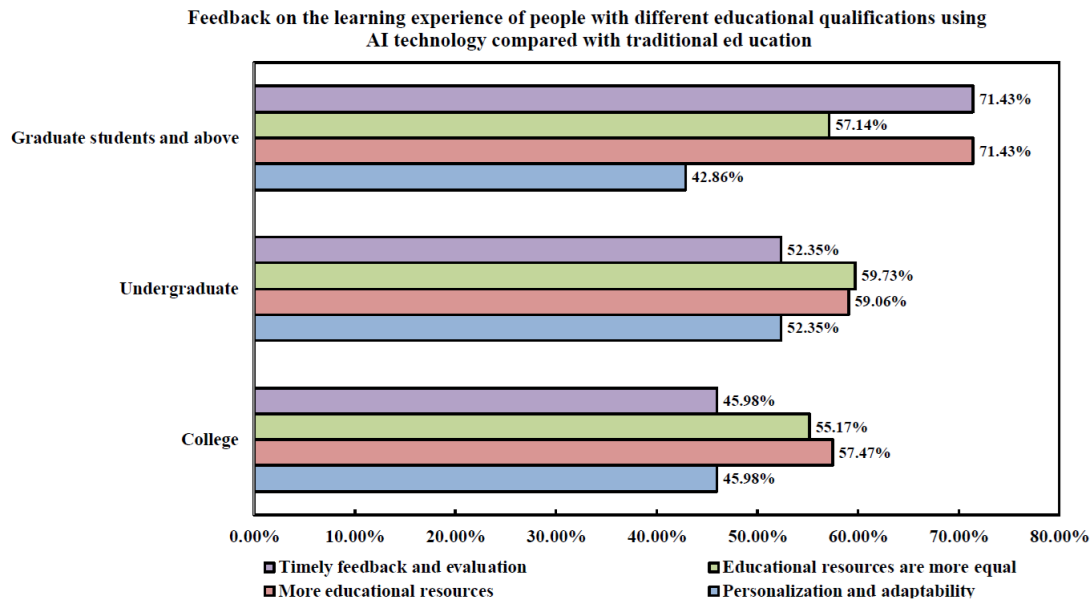


Figure 4.3: Feedback from people with different educational qualifications on the learning experience of using AI technology in university education in China.

(Zhang Linjie, 2024). Language learning platforms like Duolingo or Rosetta Stone integrate AI technology to provide interactive lessons, personalized exercises, and adaptive feedback based on each learner's proficiency level, learning progress, and areas for improvement. Figure 4.2 shows the distribution of AI tools that people with different educational backgrounds have been exposed to (multiple choices). Among them, the proportion of college graduates who have been exposed to AI homework tutoring applications and AI language learning applications is the same 64.37% followed by ChatGPT accounting for 52.87%, and finally AI office applications accounting for 49.43%. Students with college degrees are more exposure to academic tutoring and language learning. For those with a bachelor's degree, ChatGPT accounts for the most exposure, accounting for 64.43%; followed by AI homework tutoring applications, accounting for 56.38%; AI office applications and AI language learning applications account for similar proportions, 49.66% and 48.99% respectively; People with a graduate degree or above are most exposed to AI homework tutoring applications, accounting for 71.43%; ChatGPT and AI office applications account for the same 64.29%, and AI language learning applications are relatively less exposed, accounting for 42.86%.

Compared with traditional teaching methods, the use of AI technology in Chinese university education provides a more personalized and adaptable learning experience. AI tailors the learning experience based on each student's progress, preferences, and learning styles, dynamically adjusting content and activities accordingly. Traditional methods, however, typically follow standardized curricula and teaching methods, limiting their ability to adapt to diverse learning needs (Yao Peng, 2020). AI-driven platforms offer a wealth of educational resources, including multimedia materials, online courses, and interactive simulations, enriching the learning experience, and catering to various learning preferences (Li Huimeng, 2021). In contrast, traditional teaching resources are often limited to textbooks, lectures, and supplement-

tary materials, which may not meet the diverse needs of students. AI technology also helps bridge gaps in access to educational resources, providing equitable learning materials and opportunities for all students, regardless of geographic location or socioeconomic background, thereby promoting inclusivity and ensuring every student has the chance to succeed (Zhang Deshuai, 2018). For feedback on teaching outcomes, AI systems offer instant feedback and performance assessments, allowing students to track their progress in real time and identify areas for improvement (Yang Haidong, 2024). Adaptive feedback mechanisms provide personalized guidance and support. In contrast, traditional methods often feature delayed, subjective, or inconsistent feedback, with assessments typically conducted at fixed intervals, offering limited timely insights for improvement (Zhang Saiyu, 2023). Figure 4.3 illustrates the feedback from individuals with different educational backgrounds on their learning experience using AI technology in Chinese university education (multiple choices). Among those with a college degree, 57.47% believe that AI technology has enriched educational resources, while 55.17% think it has made educational resources more equitable. The proportions for timely feedback and evaluation, personalization, and adaptability are all 45.98%. Those with a bachelor's degree believe AI technology enhances the equality of educational resources (57.93%), with a slightly higher proportion (59.06) indicating it enriches educational resources. The proportions for timely feedback and evaluation, personalization, and adaptability are all 52.35%. Individuals with graduate degrees or higher prioritize timely feedback and evaluation, as well as the enrichment of educational resources, both at 71.43%. They also recognize the role of AI in making educational resources more equitable (57.14%), while personalization and adaptability are considered less significant (42.86%).

5 CONCLUSIONS AND OUTLOOK

The integration of AI technology in Chinese university education offers significant advantages over traditional teaching methods by providing a more personalized and adaptable learning experience (Sun Yan, 2020). AI tailors' educational content and activities to individual student needs, enhancing learning outcomes. It offers a vast array of educational resources, including multimedia materials and interactive simulations, which cater to diverse learning preferences and help bridge gaps in access to education (Pingren Zhong, 2023). AI systems also provide instant feedback and performance assessments, enabling real-time progress tracking and personalized support, unlike the often delayed and inconsistent feedback in traditional methods (Hao Zhijun, 2022). The integration of AI into university education in China has many advantages, including personalized learning experience, optimized resource allocation and enhanced feedback mechanisms. By leveraging AIE technology, universities can meet the diverse needs of students, improve operational efficiency, and enhance outcomes. However, there are also many problems and challenges. Since AI requires high professional skills and equipment and is costly, it requires more professional technicians and the support of regional governments to fully realize its value. Going forward, continued investment in AI infrastructure and professional development will be critical to maximizing the benefits of AI in higher education in China.

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Research on the Sales Model of Chinese Tea E-commerce in the Digital Wave

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Abstract

With the continuous progress of digital technology, e-commerce has become an important force driving the sales of Chinese tea. This study takes the Pu-er tea sales on the Pin-duo duo platform as a case study, aiming to explore and analyze customer behavior in purchasing tea on e-commerce platforms, and how these behaviors affect the sales model of e-commerce platforms. Through an online questionnaire survey, this study collected consumer experience data on purchasing Pu-er tea on Pin-duo duo, including smoothness evaluations in search, browsing, selection, payment, and after-sales service. The study adopts quantitative analysis methods to conduct statistical analysis on the collected data, in order to identify key factors that affect consumer purchasing decisions. The results indicate that the friendliness of the user interface, transparency of product information, convenience of the payment process, and responsiveness of after-sales service are the main factors affecting the consumer purchasing experience. In addition, this study also found that personalized recommendations and community interaction have a significant effect on improving customer loyalty and increasing repurchase rates. Based on the research results, this article proposes a series of optimization suggestions aimed at improving the sales model of e-commerce platforms and enhancing the smoothness of consumer purchases of Pu-er tea. These suggestions include enhancing user interface design, providing detailed product information, simplifying payment processes, strengthening after-sales service, and utilizing big data and artificial intelligence technology for personalized marketing. This study not only provides strategies for improving user experience and sales efficiency for e-commerce platforms, but also provides theoretical support and practical guidance for tea producers and sellers on how to better utilize e-commerce platforms in the digital wave.

KEYWORDS:E-commerce Sales Model, Pu-er Tea, Pin-duo Duo E-commerce Platform, Consumer Behavior, Shopping Fluency

1 INTRODUCTION

Driven by the digital wave, e-commerce has become an important component of modern commerce, and this trend is particularly significant in the Chinese tea market. Chinese tea, as a traditional agricultural commodity with profound cultural heritage and health benefits, has also expanded its market in the diversified consumption channels of e-commerce platforms in recent years. As a leading social ecommerce platform in China, Pin-duo duo has opened up new sales channels and customer groups for tea e-commerce with its Split group-buying model and discount strategy.

With the growth of the user base and the diversification of consumer demand on e-commerce platforms, how to improve shopping fluency and the low price strategy is also the reason why Pin-duo duo, a rising social e-commerce platform, can expand the market in a very short period of time. Shopping fluency not only indicates the completion of the transaction, but also reflects the purchase intention, behavior and satisfaction of consumers. The strategy to achieve trading must also include analyzing the market needs from the perspective of the customer, thus promoting a healthy trading cycle, so that the buying and selling can flow, price is one of the core factors affecting trading decisions, and the emergence of various platforms has made consumers increasingly sensitive to price. This study focuses on the purchasing process of Pu-er tea on the Pin-duo duo platform, aiming to explore the key factors that affect shopping fluency. Pu-er tea, as an important branch of Chinese tea, has been favored by many consumers due to its unique fermentation process and aging potential. On Pin-duo duo, a platform characterized by price advantages and social elements, studying the shopping smoothness of Pu-er tea is of great significance for improving user experience and enhancing customer loyalty. Exploring the key factors that affect shopping fluency in China's tea e-commerce sales model, especially on the Pin-duo duo platform, in the context of the digital wave. The research will focus on analyzing search functions, payment processes, logistics tracking, and how these processes affect consumer shopping experience and purchase intention. The social e-commerce sales model also poses a challenge to the traditional e-commerce model, especially in terms of price. The importance of customer purchase fluency, that is, the degree of seamlessness, smoothness and pleasure experienced by consumers when shopping on e-commerce platforms, has become a key indicator to measure the success of e-commerce. From product search, selection comparison, payment process to logistics tracking, the fluency of each step directly affects consumers' satisfaction and willingness to buy. On the Pin-duo duo platform, the purchase fluency of Pu-er tea is not only related to consumers' satisfaction with the single shopping experience, but also to the long-term competitiveness and market position of the platform.

2 LITERATURE REVIEW

Although e-commerce for agricultural products, including tea, has ushered in a good era of development, some scholars still point out that compared to traditional sales and other commodity categories of e-commerce, there is still significant room for improvement in the total agricultural product e-commerce market (Guo, J.2022). The rise of Pin-duo duo, a group buying shopping app, has had a significant impact on the sale of tea in China. Leveraging a model of heavy markdowns and group-buying, Pin-duo duo has become a juggernaut in the sale of beverages, including tea (Profitable Transformation– Chin Africa, 2023). The development of computer network technology has made search costs negligible. Due to the vast variety of products sold online, consumers will try their best to purchase products that meet their maximum needs rather than popular ones. This is also one of the important conditions for niche products to exist in the market. As consumer personalized needs continue to increase, many companies are turning to niche the market strategies (Franzolini, B). Customer sales fluency is directly related to consumers shopping experience, such as mobile payment integration, In China's mobile-first environment, seamless transactions are crucial. Integrate

popular mobile payment methods such as we chat Pay and Ali pay. Make sure your online checkout process is efficient and secure while shopping on e-commerce platforms, minimizing friction in the purchase process. And consumer satisfaction and loyalty often have a direct impact on sales and market share. Through in-depth research on customer sales fluency, we are able to better understand consumer needs and preferences to optimize the sales process, enhance the user experience, and enhance consumer purchase intentions and loyalty.

The Chinese tea transformation of transaction models from physical chain stores to various ecommerce platforms primarily based on online platforms. Facing the era of consumer sovereignty characterized by the individual needs of consumers and the competitive pressure of the global buyer market (Franzolini, B.2020). With the increasing diversification of consumer demands and the intensification of market competition, the timely delivery of diversified products has become the key to attaining competitive advantage (Zhu et. al., 2021). Product information pertains to detailed information about product features, consumer recommendations, evaluation reports. and service information pertains to FAQs(Frequently Asked Questions), promotional notifications, membership information, orders and delivery information, etc. (Tzeng et al., 2020).

3 RESEARCH DESIGN

Shopping fluency include the smoothness that consumers experience during the shopping process, usually related to the convenience of shopping and the simplicity of the payment process. Through a questionnaire survey, this study will collect shopping experience data from consumer purchase Pu-er tea of the Pin-duo duo platform. The survey targets users who purchase Pu -er tea using Pin-duo duo . Based on the target audience of Pu-er tea, my survey targets customers aged 30 and above 30 years old. Expected the number of questionnaires 200 through online survey.

4 METHODS

4.1 Questionnaire survey design

The first part is a customer purchase decision questionnaire, which includes preset factors that users are involved in during the purchase process, and these social e-commerce factors will affect their purchase decisions: 1.search and compare browsing of Pu-er tea products, 2.evaluation and feedback from other buyers, 3.whether this order can be initiated or participated in the consolidation, 4.whether to choose the "use before payment" or "confidential payment" method, 5.whether to view logistics information, 6. customer service provides high-quality consultation and answers. The second part focuses on the platform's biggest feature of "consolidation+low price", which involves factors related to customer purchases: 1.success rate of consolidation, 2. speed of consolidation completion, 3.discounted prices for consolidation. The third part is a comparison: does the consolidation model affect the speed at which customers decide to purchase and complete transactions compared to traditional e-commerce transaction models.

4.2 Data result analysis

This paper collected 205 questionnaires from customers over 30 years old in Harbin through online questionnaire survey.

Feature Classification	Option	Frequency	Percentage
Gender	Male	107	52.20%
	Female	98	47.80%
Age group	30-39	47	22.90%
	40-49	52	25.40%
	50-59	45	21.90%
	Over 60	61	29.80%
Monthly income (¥)	Under 3k	20	9.80%
	3k-5k	74	36.10%
	5k-8k	67	32.70%
	8k-12k	20	9.80%
	Over 12k	24	11.70%
Occupation	Enterprise Employee	49	23.90%
	Manager	51	24.90%
	Educator	44	21.50%
	Retiree	61	29.80%

Table 1: The basic information of the interviewees

Gender distribution of customers: Male 52.2%, female 47.8%. Age distribution: Mainly concentrated in 40-49 years old, over 60 years old respondents accounted for a relatively high proportion. The purchase frequency is mainly weekly (30.24%) and monthly (30.73%), indicating that Pu-er tea has a high frequency of consumption in this group of people. Over 60 years old fewer customers choose to buy it quarterly or annually, indicating that Pu-er tea may be a daily consumer product.

The check ability of logistics information: 38.05% of customers believe that being able to view logistics information is an important factor when buying Pu-er tea. This shows that consumers want to maintain the transparency of information throughout the shopping process and keep abreast of the order status.

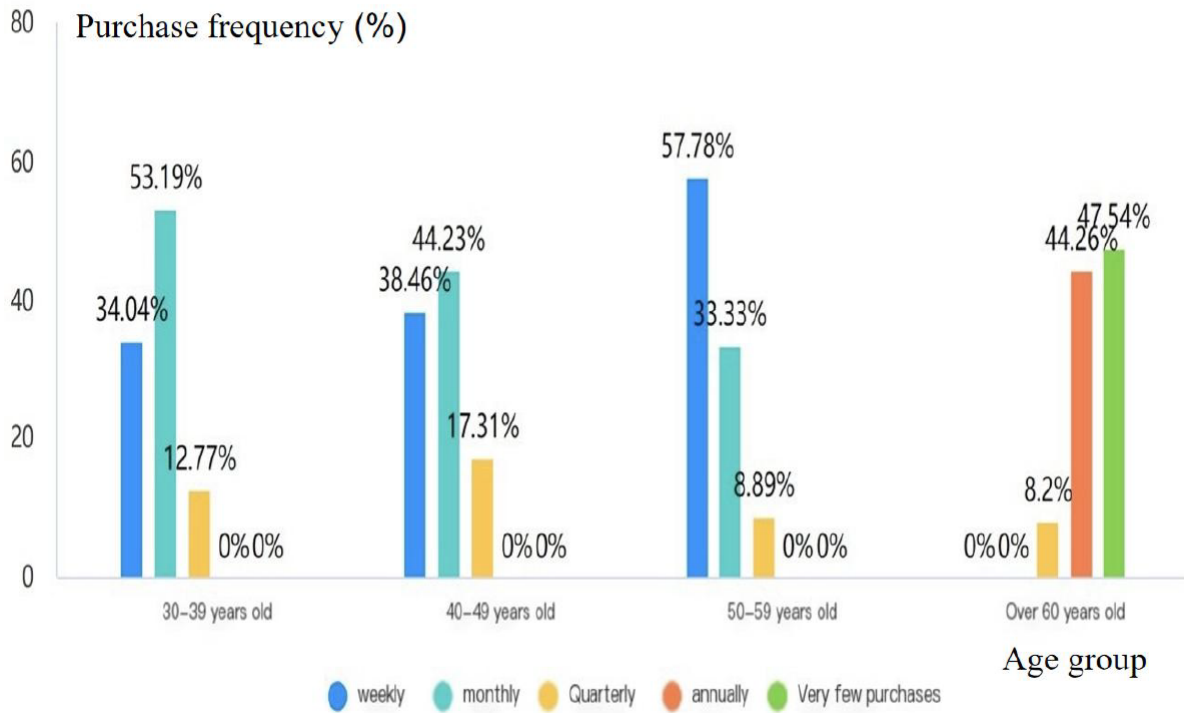


Figure 4.1: Differences in customer age groups and purchase frequency

The convenience of payment methods : 45.85% of customers believe that whether they can choose "use first and pay later" or password-free payment has an impact on whether they buy Pu-er tea in an order. This reflects that convenient and fast payment methods can improve the smoothness of shopping and reduce the friction of payment links.

The speed of the shopping process: the speed of order matching is very important to customers, and 80% of customers believe that this is one of the most important factors in the order matching process. The fast order matching process can reduce the waiting time of customers and improve the shopping experience. The success rate of the shopping process: 50.24% of customers believe that the success rate of order sharing is very important. Ordering with a high success rate can enhance consumer confidence and reduce the negative emotions caused by failure. Quality and response speed of customer service: although only 9.76% of customers believe that providing high-quality consultation and answers by customer service is an influencing factor, this does not mean that customer service is not important. On the contrary, it may show that there is room for improvement in self-service and information transparency. Logistics speed: a total of 61.98% of customers believe that the logistics speed has a great impact on their willingness to buy. Fast logistics can reduce customers' waiting anxiety and increase shopping satisfaction. The attractiveness of payment methods: 60.48% of customers believe that the "use first, pay later" option has an important impact on their purchase decisions. This payment method may lower the psychological threshold for purchase and make the decision-making process smoother. Compared to traditional e-commerce trading



Figure 4.2: Which step in the order consolidation process of Pin-duo duo platform affects the purchase decision.

models, 34.63% of users feel that the low price effect of consolidation slightly accelerates their decision-making speed when making purchases.

The Likert scale is used to quantify the respondents' views on different questions, which contains five options, representing different degrees from 'very disagree' to 'very agree'. The positive percentage of page load speed is higher than 60%, so there is a significant positive impact on the note. Page loading speed, time limited preferential activities, the recommendation mechanism, price transparency and the instant presentation of user evaluation. These factors have a significant positive impact on shopping decisions.

5 CONCLUSION

In the context of digital transformation, this study makes an analysis of China's tea e-commerce sales model, especially the purchase fluency of Pu-er tea on the Pin-duo duo platform. Through the discussion of key factors such as search convenience, payment process, and logistics tracking, this study reveals their impact on consumers' shopping experience and willingness to buy. These data show that Pin-duo duo has successfully attracted customers of the target age group and effectively promoted their purchasing behavior through its unique business model and user experience design. Strengthen the recommendation mechanism, price transparency and logistics after-sales service to further enhance the user experience. Customize more precise marketing strategies and services according to the needs of different age and income groups. Continue to pay attention to user feedback, continuously improve and innovate, and enhance user satisfaction and loyalty. Develop effective sales strategies for different customer groups. The impact of different platforms and purchasing mechanisms on the smoothness of customer shopping is also different. On the Pin-duo duo e-commerce platform, the Splicing orders model allows consumers to purchase products at low prices through group buying, which indirectly improves the smoothness of transactions. The simplification of the payment process is also crucial to improving the smoothness of shopping. A safe, convenient and transparent payment system can not only reduce consumers' payment anxiety, but also speed up the transaction process and improve consumers' purchase conversion rate. In addition,

Influencing factors	Positive impact ratio	Neutral attitude ratio	Negative impact ratio	Remarks
Page loading speed	62.44%	12.20%	25.36%	Significant positive impact
Limited-time promotional activities	59.51%	18.54%	21.95%	Positive impact
Recommendation mechanism	58.53%	16.10%	25.37%	Positive impact
Price transparency and evaluation	59.03%	16.10%	24.88%	Positive impact

Table 2: *The impact of Pin-duo duo sales model on customers' shopping decisions.*

the transparency of logistics tracking is also the focus of consumers' attention. Timely and updated logistics information can enhance consumers' trust in e-commerce platforms and reduce uncertainty and anxiety in the waiting process. However there are also some limitations in this study. For example, the research samples are mainly concentrated on the Pin-duo duo platform, which may not fully represent all China's tea ecommerce sales models. This study mainly focuses on the smooth purchase process of shopping, while the relevant technical and cultural factors and socio-economic background are relatively limited. Future studies further expand the sample scope to include more e-commerce platforms and consumer groups, while considering the influence of cultural differences and socioeconomic factors on shopping fluency. Optimize the order matching mechanism: E-commerce platforms should continue to improve the speed and success rate of order matching to ensure that consumers can complete shopping quickly and smoothly. Strengthen the convenience of payment: promote more convenient payment methods, such as "use first and pay later". This study explore valuable insights for e-commerce platforms, policymakers and industry practitioners. E-commerce platforms should pay attention to the optimization of shopping fluency and continuously improve search algorithms, payment systems and logistics tracking services. Policymakers should encourage technological innovation and improve service quality, and support the healthy development of the e-commerce industry. Industry practitioners should pay attention to changes in consumer demand and constantly explore new service models and marketing strategies.

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The Impact of The Development of the Digital Economy on China's Export Competitiveness

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Abstract

Global economic turbulence, characterised by trade friction, protectionism, and unilateralism, has created challenges for China's export sector. The advent of digital technology as part of a new information revolution has transformed the landscape of international competition, with data resources assuming a pivotal role. The digital economy, with its distinctive and sustainable growth trajectory, has emerged as a pivotal driver of China's economic growth, conferring benefits to both the digital industry and traditional enterprises. This paper examines the impact of the digital economy on China's export competitiveness, reviewing relevant literature and analysing current developments in both the digital economy and exports. The study employs panel data from 31 provinces and cities between 2012 and 2022 to empirically examine this relationship. It introduces a novel approach by measuring export competitiveness through the ECI index. The findings indicate that the majority of Chinese regions have not yet achieved export levels commensurate with their economic size, with notable regional imbalances in export competitiveness. The results indicate that the digital economy significantly enhances regional export competitiveness. In particular, the digital information industry exerts a pronounced impact, while internet development also enhances export competitiveness. In particular, the development of the digital information industry exerts a more pronounced influence on export competitiveness, while the level of the Internet also contributes to the enhancement of export competitiveness to a certain extent. It is imperative that China prioritizes the digital economy, cultivates digital advantages, and enhances export competitiveness through digital means.

KEYWORDS:Digital Economy, Export Competitiveness, ECI Index, China's Export

1 INTRODUCTION

1.1 Statement of the problem

The advent of the information technology revolution has witnessed a rapid development of the digital economy, which has now evolved into a novel form of economy. The total value of a country's exports is largely contingent upon the advancement of that country's manufacturing industry. In contrast, the development of the global manufacturing industry has undergone a significant shift, exhibiting a pronounced inclination towards high-end and intelligent trends. In conjunction with the ascent of labor factor costs, China's low-cost labor production advantage is gradually receding, and the constraints on China's manufacturing

industry have been further intensified. A series of challenges, including the gradual decline of China's population and changes in the resource environment, have prompted the country to rethink its traditional manufacturing industry, which has long been a cornerstone of the Chinese economy. As a result, China is facing one of the most urgent needs for transforming its manufacturing industry. The integration and development of manufacturing and the digital economy constituted a significant challenge for China. As a large industrialized country, China is well-positioned to reduce production costs and improve efficiency, as well as to promote the upgrading of its manufacturing industry and enhance its export competitiveness by utilizing the digital economy to develop its manufacturing industry. China is confronted with a number of challenges in this process, including the enhancement of independent research and development capabilities in core technologies, the expansion of the scale of integrated service providers, the cultivation of core technical talents, and the clarification of data management norms.

1.2 Objective of the study

The current discourse on the impact of the digital economy on export trade is largely confined to a discussion of its general direction and a lack of analysis of the mechanism by which the digital economy affects export trade. This is despite the fact that the digital economy's own development is characterized by a lack of uniformity, and that the impact of the digital economy on different economic environments is therefore likely to vary. In order to gain a more nuanced understanding of this impact, it is necessary to combine insights from other scholars on the relevant theoretical basis of international trade with an analysis of the mechanism by which the digital economy affects the channels of export trade. This will enable us to explore the direct and indirect effects of the digital economy on trade and the indirect impact of the digital economy on trade. The theoretical analysis serves as the foundation for the construction of an econometric model, which is then utilized to empirically analyse the impact of the digital economy on export trade. The econometric model is employed to test the role of the mechanism in question. In the context of the global digital revolution, it is evident that the digital economy will exert a significant influence on the competitiveness of China's export trade. Consequently, it is of theoretical importance to investigate the interaction between this influence and the potential for enhancing export competitiveness. This investigation can inform the development of strategies to promote the growth of China's digital economy and export trade.

1.3 Definitions

Digital Economy The connotation of the digital economy can be traced back to the research of Tapscott (1996). According to Tapscott, in the new economy, information is presented in the form of data, and this digitized economic model can be regarded as a knowledge-based economic model based on the dissemination of knowledge and information. He analyzes the characteristics of the digital economy from three aspects the digital economy and its elements, business and governance in the context of the development of the Internet, and adapting to transformation and change. The U.S. Department of Commerce (1998) announced the Digital Economy Act, yet there persists a lack of consensus regarding its definition, with

scholars offering disparate interpretations. Brent Moulton (1999) observed that the connotation of the digital economy is uncertain, but it is primarily constituted by information technology and Internet trade. He posited that the digital economy encompasses both information technology and e-commerce, and that it is the primary driver of the bullish stock market and the productivity recovery. The G20 countries (2016) defined the digital economy as a series of economic activities that utilize digitized knowledge and information as key production factors, modern information networks as important carriers, and ICT as a driving force. This definition underscores the significance of the digital economy, namely The concept of the digital economy is based on the integration of advanced science and technology, data, and the modern Internet as the main platform for network information technology, which is used to enhance efficiency, promote economic and social structural transformation, and ultimately achieve the goal of economic growth. The China Academy of Information and Communications Technology (CAICT) (2018) defines the digital economy in a more expansive manner, encompassing not only information technology but also the digital characteristics of traditional enterprises and the digital governance of society. As the definition of the digital economy has been refined by CAICT, the scope of Internet technology has been broadened to encompass a wider range of digital technology and the digital characteristics of the Internet and the governance of society. This has led to a more comprehensive development of the digital economy. Export competitiveness The World Economic Forum (1985) defines export competitiveness as the ability of enterprises to provide goods and services at home and abroad at more advantageous prices and qualities within the context of their economic and social environments. The Forum's core view is that

competitiveness is based on the differentiation advantage of quality and price. Lall (1998) defines export competitiveness as the advantage of a country's products over those of other countries in terms of research and development, production, sales, and service, among other factors. He notes that export competitiveness can be expressed as the proportion of exports of a given commodity in the total exports in the international market. The higher this proportion, the stronger the export competitiveness. Lu Xiaodong (2014) demonstrates that the productivity improvement of export enterprises effectively contributes to the change of technological complexity of China's exports. This suggests that improving enterprise productivity is the key to realizing product upgrading as well as maintaining the sustainability of China's export competitiveness.

2 DATA & METHODOLOGY

2.1 Data

2.2 Propositional hypothesis

The empirical analysis of the relationship between the digital economy and export competitiveness is mainly carried out through the establishment of a model, the first step is to select the indicators of export competitiveness, based on the panel data at the regional level, so the ECI meter is chosen as the measure of export competitiveness index, and the next step is to measure the digital economy from four aspects: information business, telecommunication business, Internet development, and industrial digitization. The panel data of 30 China provinces and

Data sources	Website
National Bureau of Statistics of China	https://www.stats.gov.cn/english/
China Knowledge Network-China Economic and Social Big Data Research Platform	https://data.cnki.net/index/
China Economic Network Statistics Database	https://db.cei.cn/jsps/Home
World Bank database	https://data.worldbank.org/indicator
International Monetary Fund (IMF)	https://www.imf.org/en/data
OECD database	https://data.oecd.org/
China Family Tracking Survey (CFPS)	https://opendata.pku.edu.cn/dataverse/CSDA

Table 1: Data sources and Web sites

cities from 2012 to 2022 are selected from the regional level for econometric analysis, so as to conclude the correlation between digital economy and export competitiveness.

2.3 Method

The comparative analysis method was employed to assess the export competitiveness of China's provinces. The ECI index was utilized to gauge the export competitiveness at the regional level, with a focus on identifying and comparing the disparities between different regions and between different years. The ECI index offers a straightforward means of quantifying the extent to which a region's local economy contributes to exports. The empirical analysis method involved the construction of a regression model to analyse the export competitiveness index as the dependent variable, based on the description of the development of the digital economy. The relevant data on China's digital economy development and export competitiveness are collected and organized. Thereafter, empirical tests are carried out using Stata software, and in-depth analysis is carried out based on the empirical results.

2.4 Equations

Selection and measurement of export competitiveness indicators The empirical analysis of the relationship between the digital economy and export competitiveness is mainly carried out through the establishment of a model, the first step is to select the indicators of export competitiveness, based on the panel data at the regional level, so the ECI meter is chosen as the measure of export competitiveness index, and the next step is to measure the digital economy from four aspects: information business, telecommunication business, Internet development, and industrial digitization. The panel data of 30 China provinces and cities from 2012 to 2022 are selected from the regional level for econometric analysis, so as to conclude the correlation between digital economy and export competitiveness. The export competitiveness index ECI is constructed as follows:

$$ECI_i = \frac{export_i / \sum_{i=1}^n export_i}{GDP_i / \sum_{i=1}^n GDP_i}.$$

$export_i$ represents the total export of region i , GDP_i denotes the domestic signifies the export competitiveness index of region i . The magnitude of the index reflects the ratio of the proportion of the region's export to the national level and the proportion of the region's GDP to the national level. It is evident that if the ECI index is greater than 1, it signifies that the export development of the region is superior to the economic development, and the export competitive advantage is more pronounced. Conversely, if the index is less than 1, it indicates a relative disadvantage, and the level of export development is not yet commensurate with the economic level. This paper presents a measurement of the ECI index for 31 provinces and cities in China from 2012 to 2022, as shown in the table 2 and 3.

The ECI indices of 31 provinces and cities in China for 2012-2022 are measured as shown in the table below. The results show that, compared with the overall national trend, the ECI index of different provinces fluctuates widely, reflecting inter-regional differences and the combined influence of various factors. Overall, different regions are affected by different policies and show different development trends in export competitiveness, but most regions show the trend of export trade growth and competitiveness. The regions with ECI indexes greater than 1 are marked in the table, in particular, Shanghai has a higher ECI index between 2012 and 2014, indicating that its export competitiveness is stronger. Provinces such as Shanxi, Ningxia and Gansu have relatively low ECI indices, indicating that their export competitiveness is relatively weak. This may be due to factors such as relatively homogeneous regional industrial structure and insufficient market demand.

Econometric Modelling and empirical studies Based on the empirical analysis of panel data of 31 provinces and cities from 2012 to 2022, this paper constructs the following basic econometric model:

$$ECI_{it} = SI_{it} + ICTP_{it} + TV_{it} + MBB_{it} + AP_{it} + CN_{it} + EC_{it} + FDI_{it} + \mu_i + \mu_t + \varepsilon_{it}.$$

The first topic to be addressed is descriptive statistics. As evidenced by the data presented in the table 4, the average value of China's export competitiveness index (ECI) is 0.697, which is considerably below the level of 1. This indicates that the overall export competitiveness of China's regions has not yet reach a level commensurate with the size of the economy. Furthermore, there is a significant disparity between the maximum and minimum values, suggesting that export competitiveness is unevenly developed across various regions.

The table 5 presents the pairwise correlations. The preceding empirical results demonstrate the correlations among the indicators. Specifically, the following observations can be made: The Export Competitiveness Index (ECI) is positively correlated with all other indicators, with correlation coefficients generally being high. This indicates a significant positive correlation between export competitiveness and variables.

This paper assesses the degree of multicollinearity through the use of VIF (Variance Inflation Factor) analysis. This analysis measures the correlation between each independent variable and the other independent variables. If the VIF value is high, it may indicate a problem with multicollinearity. The results indicate that the average VIF value is 5.77, which suggests that the model has passed the multicollinearity test. In general, a VIF value exceeding 10 may be indicative of a significant degree of multicollinearity. The table 6 pertains to the examination of multicollinearity. In this study, the degree of multicollinearity is evaluated through the use of

VIF (Variance Inflation Factor) analysis, which shows the correlation between each independent variable and the other independent variables. In the event that the VIF value is elevated, it may indicate the presence of a multicollinearity issue. The results indicate that the average VIF value is 5.77, which suggests that the model has passed the multicollinearity test. In general, a VIF value exceeding 10 may be indicative of a significant degree of multicollinearity. The results indicate a significant and positive correlation between (SI) and the Export Competitiveness Index (ECI) at the 1% level in the OLS model. The software industry is typically characterised by a high level of innovation and technological intensity. Technological innovation improves the quality and competitiveness of products and services, thereby contributing to the growth of exports. In all four models, ICT industry fixed asset investment (ICTP) is significantly and negatively correlated with the export competitiveness index (ECI) at the 5% level. A higher level of ICT industry fixed asset investment may be indicative of a region's greater degree of development within the ICT sector. However, a comparatively low level of ICT technology within the region may constrain the international competitiveness of its products and services, thereby reducing export competitiveness.

Given the considerable variation in the economic development of different regions in China, the export competitiveness also exhibits notable disparities. Consequently, this paper estimates the results for the eastern, central, and western regions separately. The findings indicate that, with the exception of the western region, the share of software industry revenue in GDP (SI) exhibits a significant positive correlation with the Export Competitiveness Index (ECI) at the 10% level. Moreover, the regression coefficient for the central region is considerably larger than that of the eastern region. This may be attributed to the fact that the regression coefficient of the central region is considerably larger than that of the eastern region. This may be due to the economic structure of the central region being more dependent on the software industry, or the development level of the software industry in the central region being relatively high, which contributes more significantly to the export competitiveness.

3 CONCLUSION

This paper describes the development of the digital economy in 31 provinces and municipalities in China from 2012 to 2022 in terms of the information industry, telecommunication business, Internet business, and industrial digitization. At the same time, we analyze China's export competitiveness at the regional level by drawing on existing literature on export competitiveness and find that China's overall export competitiveness has not reached a level commensurate with the development of its economic scale. It is evident that China's overall export competitiveness has not reached a level commensurate with the development of its economic scale. The following conclusions are drawn from the statistical and empirical analyses conducted.

1. The development of digital information industry will promote export competitiveness.
2. The improvement of Internet business level will promote export competitiveness.
3. The development of export competitiveness is unbalanced among regions in China.
4. The impact of digital economy on export competitiveness is most significant in the eastern part of China.

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ECI calculation results

provinces	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Shanghai	2.52	1.70	2.64	2.48	1.82	2.45	2.02	1.50	1.74	1.54	2.04
Yunnan	0.26	1.00	0.58	0.41	0.29	0.58	0.23	1.00	0.33	0.32	0.57
Inner Mongolia	0.07	0.06	0.12	0.23	0.09	0.25	0.12	0.18	0.08	0.12	0.30
Beijing	0.86	0.92	1.00	0.76	0.35	0.85	0.77	1.03	0.65	0.74	0.71
Jilin	0.17	0.09	0.13	0.24	0.09	0.23	0.13	0.13	0.13	1.00	0.19
Sichuan	0.41	0.44	1.21	1.03	0.29	0.98	0.46	0.68	0.48	0.54	1.11
Tianjin	1.08	0.97	0.86	1.81	0.93	1.82	0.84	0.91	1.12	1.21	1.19
Ningxia	0.22	0.12	0.44	0.96	0.21	1.00	0.31	0.26	0.08	0.15	0.25
Anhui	0.46	0.38	0.43	0.52	0.44	0.40	0.47	0.49	0.42	0.44	1.12
Shandong	0.75	0.73	0.71	0.77	0.46	1.46	0.72	1.23	0.82	0.90	1.15
Shanxi	0.16	0.19	1.00	0.23	0.19	0.24	0.26	0.31	0.24	0.26	0.25
Guangdong	2.29	1.16	2.48	2.51	1.05	2.75	2.24	2.23	1.00	1.59	1.98
Guangxi	0.45	0.19	0.42	1.18	0.46	0.54	0.53	1.00	0.66	0.53	0.69
Xinjiang	0.65	0.32	0.68	1.36	0.61	1.29	0.51	0.78	0.24	0.33	0.93
Jiangsu	1.61	1.58	1.35	1.42	1.51	1.45	1.00	1.77	1.34	1.14	1.39
Jiangxi	0.45	0.55	0.54	0.62	0.56	1.05	0.65	0.73	0.62	0.51	1.00
Hebei	0.31	0.22	0.47	0.83	0.29	0.39	0.42	0.53	0.30	0.35	0.40
Henan	0.44	0.34	0.41	0.36	0.39	0.40	0.42	0.39	0.34	0.41	0.46
Zhejiang	1.64	1.92	2.05	2.03	2.07	2.03	2.15	2.55	1.56	1.73	2.17
Hainan	0.30	0.15	0.36	0.82	1.00	0.40	0.33	0.55	0.25	0.23	0.74

Table 2: China's Export Competitiveness Index by Region, 2012-2022

ECI calculation results

provinces	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hunan	0.15	0.12	0.25	0.53	0.17	0.28	0.35	0.46	0.30	0.45	0.59
Gansu	0.17	0.18	0.24	0.26	0.13	0.09	0.12	0.12	0.05	0.04	0.10
Fujian	1.00	0.77	1.65	2.52	1.30	1.18	1.12	1.25	1.00	1.23	1.14
Tibet	1.35	1.07	0.84	0.19	0.15	0.34	0.10	0.16	0.04	0.06	0.14
Guizhou	0.20	0.19	0.27	0.31	0.16	0.35	0.15	0.14	0.13	0.11	0.11
Liaoning	0.57	0.75	1.28	0.58	0.74	0.68	0.68	0.92	0.59	0.63	0.72
Chongqing	0.87	1.05	1.31	2.43	0.59	1.72	0.87	1.16	0.93	0.82	0.96
Shaanxi	0.22	0.20	0.29	0.26	0.30	0.87	0.57	0.61	0.38	0.45	0.45
Qinghai	0.10	0.06	0.31	1.00	0.08	0.13	0.05	0.06	0.02	0.03	0.03
Heilongjiang	0.29	0.30	0.30	0.17	0.09	0.31	0.13	0.18	0.07	0.13	0.19

Table 3: China's Export Competitiveness Index by Region, 2012-2022

Variable	Obs	Mean	Std. Dev.	Min	Max
ECI	3 41	0.697	0.607	0.022	2.749
SI	3 41	0.048	0.069	0.000	0.541
ICTP	3 41	0.029	0.027	0.008	0.207
Tv	3 41	6.552	1.146	3.495	9.617
MBB	3 41	120.76 0	27.949	71.700	228.09 0
AP	3 41	7.416	1.021	3.715	9.341
CN	3 41	3.687	1.551	-0.734	6.783
EC	3 41	7.480	1.538	1.920	10.767
FDI	3 41	8.699	1.598	4.240	12.852

Table 4: Descriptive Statistics

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ECI	(1)	1.								
SI	(2)	0.000	1.							
ICTP	(3)	0.440***	0.000	1.						
Tv	(4)	0.328***	0.918***	0.000	1.					
MBB	(5)	0.281***	0.252***	0.195***	0.000	1.				
AP	(6)	0.493***	0.764***	0.783***	0.248***	0.000	1.			
CN	(7)	0.405***	0.322***	0.262***	0.769***	0.299***	0.000	1.		
EC	(8)	0.466***	0.524***	0.454***	0.755***	0.445***	0.849***	0.000	1.	
FDI	(9)	0.543***	0.585***	0.521***	0.652***	0.499***	0.845***	0.856***	0.000	1.
		0.558***	0.559***	0.489***	0.614***	0.532***	0.817***	0.826***	0.872***	0.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5: Pairwise correlations

Variable	VIF	1/VIF
SI	7.57	0.132130
ICTP	7.27	0.137469
AP	7.00	0.142828
EC	6.98	0.143285
CN	6.11	0.163641
FDI	5.49	0.182289
MBB	2.89	0.345655
Tv	2.86	0.349046
Mean VIF	5.77	

Table 6: Multi-collinearity check

	OLS	FE	FE RE	(1)	(2)	(3)	(4)
				ECI	ECI	ECI	ECI
SI				3.749*** (0.988)	1.704* (0.964)	1.603* (0.868)	1.831** (0.848)
ICTP				-15.241*** (2.449)	-7.786*** (2.737)	-6.202** (2.716)	-5.148** (2.332)
Tv				-0.060 (0.036)	-0.019 (0.025)	0.086 (0.137)	0.104 (0.118)
MBB				0.009*** (0.002)	-0.000 (0.002)	0.003 (0.002)	0.005*** (0.002)
AP				-0.109* (0.064)	-0.216** (0.090)	-0.312** (0.134)	-0.156 (0.111)
CN				0.020 (0.039)	0.031 (0.037)	-0.018 (0.038)	-0.008 (0.036)
EC				0.157*** (0.042)	0.129*** (0.040)	0.081** (0.041)	0.118*** (0.037)
FDI				0.097*** (0.036)	0.038 (0.037)	0.085** (0.036)	0.110*** (0.034)
_cons				-1.052*** (0.300)	1.175*** (0.328)	0.941 (1.042)	-0.964** (0.452)
Individual				uncontrolled	containment	containment	uncontrolled
fixation							
Year fixed				uncontrolled	uncontrolled	containment	containment
N				341	341	341	341
r2				0.451	0.799	0.845	0.538

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Benchmark regression results

	Eastern Region	Central Region	Western Region
	(1)	(2)	(3)
	ECI	ECI	ECI
SI	2.341** (1.136)	8.770* (4.916)	-0.956 (3.498)
ICTP	-10.468** (4.199)	-9.156 (7.241)	11.069 (6.916)
Tv	0.116 (0.355)	0.293 (0.264)	0.120 (0.204)
MBB	-0.002 (0.004)	-0.003 (0.006)	0.006 (0.005)
AP	-0.055 (0.278)	-0.197 (0.301)	-0.353 (0.249)
CN	-0.140* (0.076)	0.009 (0.052)	0.137* (0.077)
EC	0.171 (0.130)	-0.013 (0.055)	0.178*** (0.061)
FDI	0.063 (0.062)	0.114 (0.074)	0.109 (0.075)
_cons	-0.111 (2.704)	-0.611 (2.197)	-1.008 (2.211)
Individual fixation	containment	containment	containment
Year fixed	containment	containment	containment
N	121	99	121
r2	0.845	0.614	0.705

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Heterogeneous results