The impact of Digital economy on One Belt One Road initiative

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Table of Contents

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Preface

EDITORS

The scientific monography provides an in-depth, interdisciplinary exploration of important viewpoints and issues related the digital economy and the One Belt and One Road Initiative (BRI). As one of the most ambitious and globally influential development strategies of the 21st century, the BRI continues to reshape trade, investment, and cooperation patterns across continents. At the same time, rapid digitalization is transforming traditional economic structures, enabling new forms of innovation, competitiveness, and interconnectivity. The convergence of these two powerful forces—BRI and digital transformation—raises important questions about the direction of global economic development, particularly in emerging markets and developing economies.

The central objective of this volume is to examine how digital technologies are redefining the framework and outcomes of the BRI. By focusing on digital infrastructure, smart technologies, e-government, service trade, and innovation performance, the book offers a multi-faceted perspective on how countries participating in the BRI can leverage digitalization to advance economic growth, improve governance, and foster sustainable development. It also addresses the strategic implications of digital transformation for China's outward foreign direct investment (OFDI), its role in global value chains, and the structure of cross-border cooperation in the digital age.

Chapters in this book address several critical themes. First, they analyze the digital maturity levels of countries and regions involved in the BRI. Maturity models—such as those applied to e-government and smart cities—help to understand the readiness and capability of institutions to absorb and implement digital technologies effectively. The contributions examine the stages of digital development, identify key enablers and barriers, and propose pathways toward higher integration, resilience, and strategic alignment. These analyses are supported by national and international research projects, such as the Slovenian Research Agency's core research funding project P5–0023, Entrepreneurship for an Innovative Society, as well as bilateral cooperation projects BI-ME/23-24-010 and BI-CN/20-22-015, which focus on the maturity of e-government and smart city initiatives within the broader BRI framework.

Second, the book explores the application of digital solutions across various sectors, highlighting how technological innovation can enhance efficiency, transparency, and connectivity. Key areas of analysis include developing digital payment systems and fintech solutions that support cross-border trade, implementing blockchain technology to ensure product traceability and supply chain integrity, and integrating artificial intelligence in logistics, governance, and service delivery. These case studies are particularly relevant for BRIaewa, where rapid urbanization, growing digital markets, and strong trade ties with China present opportunities and challenges for sustainable digital integration.

Third, the authors reflect on the importance of digital infrastructure in bridging gaps between developed and developing economies within the BRI. Infrastructure development—both physical and digital—remains a core pillar of the initiative. By examining investment patterns, digital public services, cloud computing platforms, and regional connectivity initiatives, the book assesses the role of public-private partnerships, regulatory frameworks, and multilateral cooperation in advancing digital inclusion and narrowing the digital divide. As an extension of the BRI, the digital Silk Road serves as a strategic lens through which these infrastructure dynamics are discussed.

Moreover, the book emphasizes the importance of sustainable and green development in the context of digitalization. While digital transformation offers unprecedented benefits, it also presents environmental challenges, including rising energy consumption and electronic waste. The scientific monography advocates for digital solutions that align with sustainability, circular economy, and responsible innovation. Topics such as smart energy grids, digital monitoring of environmental indicators, and policy instruments for sustainable ICT development are addressed to highlight the intersection between green technology and digital strategy.

Another crucial dimension of the book is the examination of institutional and policy implications. The digital transformation of public administration, particularly through e-government platforms and data-driven policymaking, significantly affects transparency, citizen engagement, and service quality. The authors assess the conditions under which digital governance models can be effectively implemented, considering BRI countries' political, cultural, and administrative diversity. Lessons learned from pilot projects and comparative analyses provide practical guidance for governments aiming to modernize their institutional frameworks.

Throughout the volume, special attention is paid to the role of innovation ecosystems. The development of smart cities and regions is explored from a technological standpoint and through the lens of collaboration among stakeholders, including universities, businesses, civil society, and local governments. Creating innovation hubs, Living Labs, and experimental testbeds contributes to knowledge diffusion, user-driven innovation, and socio-economic resilience.

This book brings together various perspectives from scholars, policymakers, and practitioners actively engaged in the digital transformation of BRI-related regions and sectors. By combining theoretical insights with empirical evidence, the volume contributes to a nuanced understanding of how digitalization can shape the future of global economic integration. It highlights both the opportunities and challenges associated with digital development and calls for coordinated, inclusive, and forward-looking strategies that place digital technologies at the service of people, communities, and the environment.

As such, this book will interest a broad audience, including researchers in international economics, public administration, and information systems; policymakers working on regional development and digital governance; and business leaders seeking to navigate the evolving digital trade and investment landscape. It provides a valuable reference point for future studies and initiatives aiming to harness the potential of digital technologies within the Belt and Road Initiative and beyond.

I. THE IMPACT OF DIGITAL ECONOMY DEVELOPMENT IN BRI COUNTRIES ON CHINA'S OFDI

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With the development of the digital economy, the country's production and operation have undergone earth-shaking changes. The digital economy is promoting the transformation of traditional manufacturing to digital and intelligent, giving birth to new industries and models, reducing production costs, improving efficiency in all aspects, and promoting the economic development of the country. In addition, with the implementation of the "Belt and Road" Initiative, the cooperation between China and the "Belt and Road" has become increasingly close, and the development degree of the digital economy has also been included in the consideration of OFDI. Therefore, the research on the development status of the digital economy in the "Belt and Road" and its impact on China's OFDI has important reference value for enterprises to formulate OFDI strategies and promote China's opening up reference value.

Keywords:
digital economy,
Belt and Road Initiative,
outward foreign direct investment (OFDI),
economic development,
China

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1 Introduction

In September and October 2013, the Chinese president introduced the initiative to build the Silk Road Economic Belt and the 21st Century Maritime Silk Road (the Belt and Road). Based on the central cities and important ports along the Belt and Road, this initiative has established efficient transport corridors for international economic cooperation. It has promoted infrastructure investment and trade development, thereby fostering global economic growth (Deng, He, & Jiang, 2019).

However, due to varying levels of economic development among countries, China faces challenges in expanding its Outward Foreign Direct Investment (OFDI) to countries along the Belt and Road. This limitation hinders the scale of development. The Digital Silk Road integrates digital technology into the Belt and Road framework, enhancing enterprises' focus on the digital economy, forming new growth drivers, and creating favourable conditions for Chinese enterprises to invest overseas (Deng, Ma, & Wang, 2019).

In the current world, topics like the integration of the digital economy with various industries have become prominent concerns for Chinese scholars. Some researchers have analyzed the development of the digital economy in countries along the "Belt and Road," but few studies have delved into the internal relationship between this development and China's Outward Foreign Direct Investment (OFDI) (Xia & Dong, 2022). With the rapid development of the digital economy, if our country aims to enhance the quality and efficiency of overseas investments, it is essential to analyze the level of digitization in the host country. Therefore, this paper analyzes the internal mechanism of the digital economy development level of countries along the route to China's Outward Foreign Direct Investment (OFDI) by constructing an index system of the digital economy development level. From a theoretical perspective, this paper enhances the framework for understanding the influencing factors of China's Outward Foreign Direct Investment (OFDI) to some extent.

Today, digital technology has become a key factor in global economic integration. Many countries around the world are actively seizing the opportunity to drive the development of their own countries and regions through the digital economy. China's economic development is also inseparable from the support of digital technology. Therefore, Chinese enterprises should closely grasp this trend and adjust their investment concepts accordingly. To optimize their investment model, individuals must accurately select their position to seize the initiative in global competition and align with the current development trends. Based on the rapid development of digital technology, this paper examines the current status of the digital economy in countries along the route. It aims to uncover the mechanism through which the digital economy impacts China's Outward Foreign Direct Investment (OFDI) and offers a scientific basis for the optimal allocation of OFDI for Chinese enterprises (Buckley, Clegg, & Cross, 2007). This study takes the digital economy as a new starting point for the outward foreign direct investment (OFDI) of Chinese enterprises. This approach is beneficial for enterprises in formulating OFDI strategies.

2 Analysis of factors affecting OFDI

2.1 Home-country perspective

From the perspective of a country's economic development, the higher the degree of economic development in a country, the more Outward Foreign Direct Investment (OFDI) it attracts (Dunning, 1988). There is a close relationship between OFDI, a country's GDP, and its growth rate. Secondly, by analyzing a country's Gross National Product (GNP) and its growth rate, we can observe that the level of economic development of a country significantly influences the promotion of Outward Foreign Direct Investment (OFDI). The higher the level of economic development of the home country, the more effectively it can facilitate Chinese enterprises in expanding globally and making overseas investments.

From the perspective of institutional factors, the macro-adjustment ability and government intervention of the home country have a direct impact on the outward foreign direct investment (OFDI) of the company, and the company should leverage the institutional advantages of the home country (Du et al., 2023). Meanwhile, from the perspective of enterprises and industries, the smaller the institutional distance between the home country and the host country, the more encouraged enterprises will be to change their traditional investment mode and accelerate the process of OFDI.

From the perspective of bilateral relations, fostering a robust relationship between the host country and the home country can effectively mitigate risks, safeguard investments, and boost Foreign Direct Investment (FDI) in developing countries (Desbordes & Vicard, 2009). Secondly, through data analysis at the company level, we have found that effective bilateral cooperation can increase the company's overseas investment scale, diversify its investment strategies, and consequently enhance the success rate of its investments (Neumayer & Spess, 2005).

2.2 Host-country perspective

In terms of market size, larger markets are more likely to generate economies of scale and aggregation, thus reducing investment costs and promoting overseas investments by enterprises (Lewis, 2013). Secondly, the host country of Chinese overseas investment has a large market, and companies are more willing to invest overseas.

In terms of resource endowment, China still has a significant gap in resources. To acquire more resources, we must explore the foreign market. Additionally, based on China's international investment data from 2002 to 2011, countries with abundant resources are more likely to attract higher levels of foreign direct investment (Yang, Liu, & Zhang, 2016.

In terms of the institutional environment, a favourable host country system can establish a stable setting for companies to invest overseas. This can effectively mitigate investment risks stemming from political instability and fluctuations in the business environment, thereby reducing risks associated with conducting business abroad (Cheng & Ruan, 2004). Secondly, the government should formulate preferential policies to reduce or eliminate tariffs and lower market access standards. This will help reduce the investment costs of enterprises and increase their enthusiasm to invest in China. In addition, some relevant studies have also conducted empirical research on the overseas investment behaviour of Chinese enterprises within the institutional environment of 47 countries along the "Belt and Road". The results indicate that Chinese enterprises tend to favour countries with good governance, particularly those with robust regulatory frameworks and political stability (Zhao et al., 2020).

3 Digital economy concept and development research

3.1 Conceptualization of the digital economy

Within the scope of the digital economy, some scholars refer to the concept of digital economy as e-commerce. Some believe that the digital economy encompasses not only digital products created through digital technology but also the services it enables. This includes three levels: the outermost layer and the middle layer, which involve economic activities and business models operating with digital technology, while the core layer is associated with information and communication-related industries (Kolk & Pinkse, 2017). The China Communications Academy has proposed that the digital economy can be categorized into two types. The first is digital industrialization, which pertains to information and communication industries and other related sectors that are distinct from traditional industries. The second type aims to enhance the output of traditional industries through digital technology (Qiu & Wang, 2008).

3.2 The impact of the development of digital economy on economic change

The changes brought about by the digital economy involve not only the transformation of traditional industries but also the advancement of new industries and further technological innovation. From the perspective of the digital economy driving the development of emerging industries, the China Academy of Information and Communications Technology proposed a new industrial development model based on the digital economy (Qiu & Wang, 2008). This model can not only promote the development of traditional industries but also lead to the creation of new products and services, resulting in additional economic benefits. In addition, some scholars believe that the digital economy is not restricted by distance, which can lead to economies of scale and the development of new industries.

From the perspective of promoting technological innovation through the digital economy, utilizing Internet-based mass innovation platforms can significantly reduce the cycle and cost of technological innovation (Lin, Chen, & Qin, 2012). This, in turn, can facilitate the further development of technology by enterprises. Some scholars believe that the development of the digital economy plays a crucial coordinating role in the process of enterprise innovation. It enhances the degree of innovation coordination, facilitates enterprises in better digesting and absorbing technology, and ultimately boosts enterprises' innovation ability (Dunning, 1988).

4 Current status of China’s investment in countries along the Belt and Road

4.1 Investment profile

As depicted in Figure 1, both the flow and stock of China's Outward Foreign Direct Investment (OFDI) to countries along the Belt and Road have been steadily increasing from 2009 to 2021 (Deng, He, & Jiang, 2019). The proportion of China's total OFDI remains relatively stable despite some fluctuations.

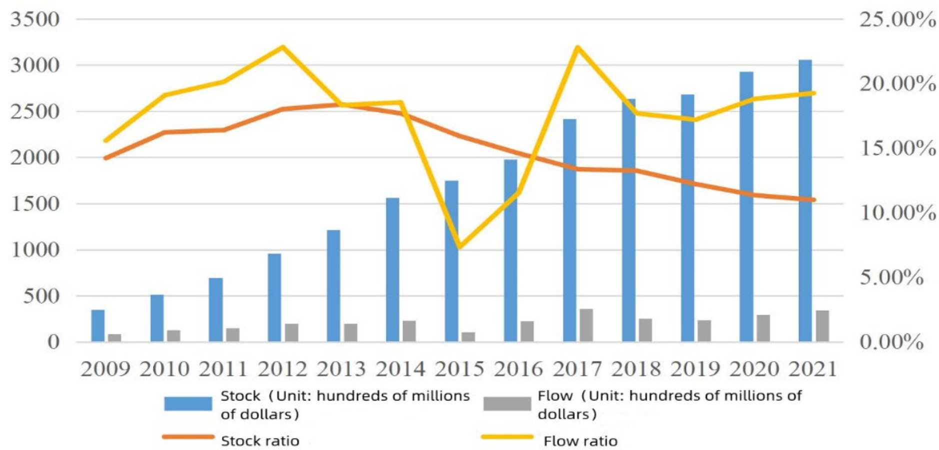

Figure 1: China's foreign direct investment in countries along the "Belt and Road" and its proportion in China's total foreign direct investment

Data Source: China's OFDI Statistical Bulletin and China's Belt and Road Network.

From 2009 to 2021, China's Outward Foreign Direct Investment (OFDI) flow to countries along the routes increased from 8.81 billion US dollars to 34.42 billion US dollars. This marks an almost threefold increase, with the proportion of China's total outbound direct investment flow rising from 5.6% to 19.3%. The total investment flow to countries along the routes reached 281.80 billion US dollars over the 13-year period. From the specific year observation, China's outbound foreign direct investment (OFDI) to countries along the route significantly increased its total proportion from 2009 to 2012, reaching 22.8% in 2012, which marked the highest level in history. However, since 2013, the proportion of China's Outward Foreign Direct Investment (OFDI) to countries along the routes has fluctuated greatly and fell to the lowest point in 2015, accounting for only 7.3%. In this year, the outbound investment flow to countries along the routes decreased by 53.1% compared to last year. Except for a few years, China's outbound investment flows to countries along the Belt and Road have maintained a steady increase. With the promotion of the "Belt and Road" strategy, China's foreign direct investment (FDI) inflow is increasing significantly. The sectors involved are expanding, particularly in manufacturing, wholesale, retail, and other fields. The investment growth rate in these sectors is noticeable, and Chinese enterprises are increasingly investing in countries along the route. Covering 11,000 economic system levels.

From the perspective of Outward Foreign Direct Investment (OFDI) stock, in 2009, China's total OFDI to countries along the route reached 34.94 billion US dollars. In the following year, its scale increased significantly to 306.03 billion US dollars, marking an 8.8-fold increase over the past 13 years. This demonstrates a substantial improvement overall. The proportion of Outward Foreign Direct Investment (OFDI) in China's total OFDI has not changed significantly, fluctuating between 11.0% and 18.4%. From 2009 to 2013, the proportion of China's foreign direct investment (FDI) in countries along the Belt and Road continued to rise. Although it declined in 2014, it still accounted for more than 10% of the total FDI. On the whole, China's Outward Foreign Direct Investment (OFDI) reserves for countries along the route are still substantial, and the prospects for the construction of the "Belt and Road" initiative remain promising.

4.2 Region of investment distribution

As depicted in Figure 2, China's investment in countries along the Belt and Road is projected to reach 66.9% in Asian countries in 2021. In East Asia and Southeast Asia, the investment is expected to reach 50.0%. This is primarily due to Chinese enterprises focusing their investments in infrastructure construction, energy, and other related sectors in this region. These areas can not only meet the investment needs of Chinese enterprises but also promote local economic development and enhance China's international competitiveness. Chinese companies ranked second in terms of overseas investment in Europe, with 14.6% of Chinese investments directed towards European countries. Luxembourg and the Russian Federation accounted for 64.5% of the total Chinese investment in Europe. Although China has more investment in Africa, with about a third of the countries on the Belt and Road located in Africa, only 14% of foreign investment comes from Africa (Deng, Ma, & Wang, 2019).

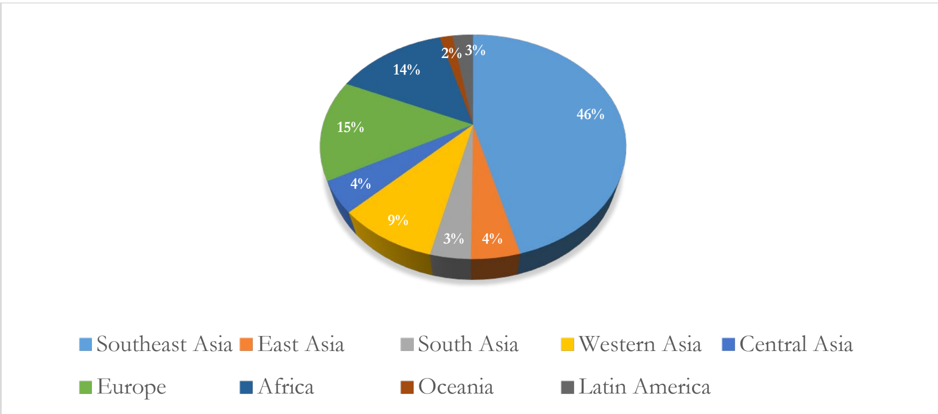

Figure 2: Regional distribution of China's direct investment in countries along the Belt and Road in 2021

Data Source: China's Foreign Direct Investment Statistical Bulletin.

China's investment in the "Belt and Road" initiative primarily focuses on Asia and Europe, with Southeast Asia standing out as the most prominent region. In terms of China's outbound investment flow, the investment stock in Singapore amounted to 67.20 billion US dollars, with an investment flow of 8.41 billion US dollars. These figures accounted for 22.0% and 24.4% of China's total investment, respectively, ranking first. Indonesia ranked second with 6.6% and 12.7%, respectively. Vietnam and Luxembourg are also significant investors, ranking third and fourth. As shown in the figure, the high proportion of Chinese investment in Singapore can be attributed to Singapore's strategic location in the heart of Asia. Singapore is intricately linked to the global economy, has established economic and trade agreements with numerous countries, and maintains a high level of openness, offering extensive development opportunities for foreign investors.

Table 1: Top 10 countries of China's direct investment stock and flow to countries along the "Belt and Road" in 2021

Country	Stock(unit:hundreds of millions of dollars)	Country	Flow(unit:hundreds of millions of dollars)
Singapore	672.02	Singapore	84.05
Indonesia	200.80	Indonesia	43.73
Luxembourg	181.31	Vietnam	22.08
Vietnam	108.52	Luxembourg	14.99
Russia	106.44	Thailand	14.86
Malaysia	103.55	Malaysia	13.36
Laos	99.40	Laos	12.82
Thailand	99.17	Democratic Republic of the Congo	10.46
The United Arab Emirates	98.45	The United Arab Emirates	8.94
Kazakhstan	74.87	Kazakhstan	8.22

Data Source: Statistical Bulletin on China's Outward Foreign Direct Investment.

4.3 Investment industry distribution

China has close cooperation with countries participating in the Belt and Road Initiative and is a significant trading partner for many nations. China has entered a new era of high-quality development. Focusing on the "Belt and Road" initiative as an investment target is beneficial for achieving complementary industrial development between the two countries. In terms of economic strength, countries along the Belt and Road with low levels of economic development have implemented proactive policies to attract foreign investment, thereby creating more investment opportunities for Chinese enterprises.

In the context of the Belt and Road Initiative, China's investment in countries along the routes in 2021 involves a total of 18 fields. The cumulative investment of Chinese enterprises in countries along the Belt and Road is primarily focused on the manufacturing industry, showing a year-on-year increase of 22.8%, representing 39% of the total investment. This is mainly because China's manufacturing industry is undergoing transformation, industrial structural adjustment, and an increasing demand for raw materials. Therefore, we want to engage in broader and deeper cooperation with countries along the Belt and Road. Achieve complementary advantages and win-win results. In addition, Hong Kong's investment in wholesale and retail amounted to US $3.33 billion, accounting for 13.8%. Of that, $2.41 billion, or 10%, was spent on construction (Figure 3).

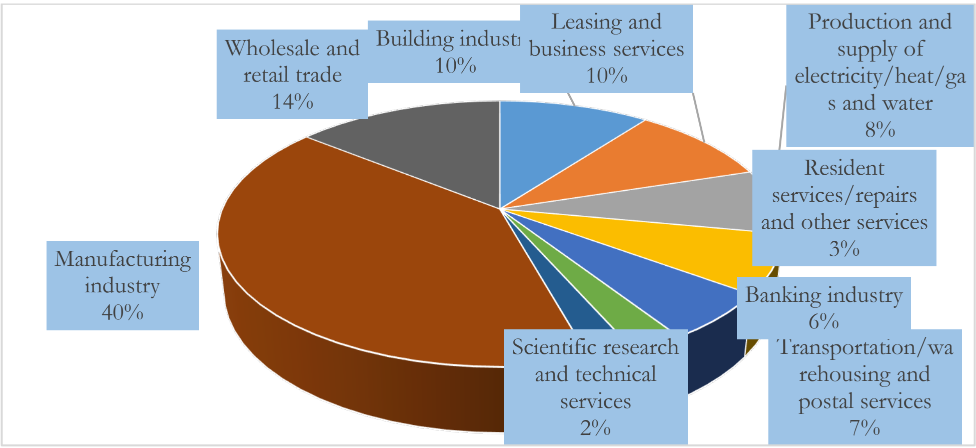

Figure 3: Industry distribution of China's direct investment in countries along the Belt and Road in 2021

Data Source: China's Foreign Direct Investment Statistical Bulletin.

5 The mechanism of the development level of digital economy on foreign direct investment

5.1 Cost-cutting effect

In the investment process, it is essential to gather information, choose partners, engage in communication and negotiation, sign contracts, fulfil payment obligations, and handle other related processes (Neumayer & Spess, 2005). The extra expenses accrued during each of these stages are considered transaction costs. Compared with traditional investment transactions, digital technology can collect information more rapidly and reduce costs through network platforms. Reduce transaction costs for investors.

First of all, with the rapid development and wide application of digital technology, traditional investment behaviour often consumes a significant amount of financial resources and energy for research and evaluation. Internet, big data, AI technology, and other digital technologies have been widely used in every aspect of economic life (Evan, Estrin, & Meyer, 2004). This enables investors to understand better the situation of the country in which they are investing. In the process of investment exchange, the two parties can also negotiate, communicate, and bargain through the Internet, whether it is to make decisions or sign contracts. It can be carried out through the corresponding information platform, which can reduce the decision-making cost of enterprises in the transaction process.

Secondly, the digital economy has transformed and upgraded the global value chain, impacting the flow and scale of global capital to some extent. China leverages its resource advantages, such as resource endowment and demographic dividend, to expedite the development of low-end industries and optimize its interests through a specialized division of labour. Through the combination of vertical outward foreign direct investment (OFDI) and international trade, Chinese multinational enterprises have restructured their production and operational modes, thereby reducing the government's regulatory costs. Therefore, by enhancing the development level of the digital economy, countries along the "Belt and Road" can effectively reduce the various costs encountered by enterprise investments, thus attracting Chinese transnational capital into the country more effectively.

5.2 Efficiency enhancing effect

In the process of cross-border operations, enterprises can obtain the information they need in real time with the help of digital technology. At the same time, companies can engage in comprehensive communication with their subsidiaries through information and communication networks. This allows for continuous exchange of information and sharing of technical results between the parent and subsidiary companies (Du et al., 2023). Consequently, this enhances their understanding of the overall situation and empowers them to make more informed decisions. It also creates favourable conditions for them to set prices and participate in market competition. With the assistance of digital technology platforms, the company can efficiently identify suitable markets and partners, conduct transactions through third-party platforms, and enhance transaction efficiency and success rates while ensuring fund security.

First of all, with the assistance of advanced digital technologies such as the Internet and big data, the costs of various complex economic activities can be effectively reduced, and the operational efficiency of enterprises can be continuously improved.

Digital technologies, such as big data and artificial intelligence, play a crucial role in enterprise business processes. They can optimize various fields including business, media, finance, telecommunications, and energy. These technologies improve product quality, reduce industrial costs, enhance production efficiency, and drive industrial development.

Secondly, when a country has a relatively high level of digital technology development, its scientific and technological advancements are typically at the forefront. Most scientific and technological achievements are formed through continuous cross-border collisions. Information exchange among researchers in different disciplines and fields fosters knowledge sharing, which facilitates the transition from individual innovations to cross-innovation and fusion innovation (Zhao et al., 2020). The popularization of intelligent mobile devices and high-speed information networks accelerates this process. It shortens the time required for knowledge innovation, reduces the time needed for knowledge value addition, and fosters the establishment of a multi-field collaborative development of science and technology innovation system.

Therefore, countries along the "Belt and Road" are promoting the development of the digital economy by utilizing data, information, and communication technology to enhance efficiency. This strategy can effectively attract transnational capital from China.

5.3 Risk reduction effect

As a new economic form, the digital economy not only enhances data privacy and intellectual property protection but also enhances existing social governance methods and government management capabilities. This provides investors with a relatively stable environment and reduces investment risks.

The development of the digital economy can expand the financing channels of enterprises, enhance their financing efficiency, and alleviate various constraints in the financing process. At the same time, technology such as blockchain and big data can be used to enhance the evaluation of the financial system, predict and manage various financial risks, ensure fund security, and offer more enterprises financing opportunities. The utilization of digital technology for continuously updating the credit evaluation system enables the financial system to promptly and effectively make a more precise assessment of the borrower's historical assets, business performance, and future development prospects. This can promote the structure of credit resources for differential allocation, improve the efficiency of resource allocation, enable more enterprises to access foreign funds and reduce the financial risks associated with foreign investments (Busse, Koniger, & Nunnenkamp, 2010).

Secondly, when conducting investments and operations, multinational enterprises often prioritize host countries with superior digital infrastructure. If the infrastructure, such as transportation and communication, is not perfect, the possibility of enterprises facing various risks in the production and operation process will increase. This can even lead to enterprises being unable to carry out normal economic activities. The higher the level of development of the digital economy, the better it can provide a conducive political and economic environment for investors. This ensures that investors can make smooth investments in the future and safeguards their legitimate interests from infringement. A favourable external environment can significantly decrease the investment risk for enterprises, enabling them to make more successful overseas investments.

Therefore, the development of the digital economy in countries along the "Belt and Road" can create a stable and orderly external environment for enterprises to invest abroad, reduce risks in the process of enterprise investment, and increase the probability of Chinese transnational capital inflows.

6 Conclusions of the study

The overall level of the digital economy of the more economically developed countries is relatively good, because they have enough capital to carry out digital economy infrastructure construction and R & D, so as to promote the combination of digital technology and traditional industries and promote industrial transformation and upgrading, and China is more willing to invest in these countries, and for the countries that are lagging behind in the development of the national digital economy, the overall level of development of the digital economy is relatively low, and there is a lack of systems and facilities matching the development of the digital economy, the efficiency of factor allocation is low, and the development of the digital economy is slow. For countries that are lagging behind in the development of the digital economy, their overall development level of the digital economy is relatively low, and they lack systems and facilities that match the development of the digital economy, the efficiency of factor allocation is low, and the development of the digital economy is slow, so China invests relatively less in these countries.

From the viewpoint of investment motivation, the improvement of the development level of the digital economy in the countries along the Belt and Road has an investment promotion effect on Chinese enterprises with market-seeking and strategic asset-seeking motivations. For market-seeking enterprises, the development of digital economy in the countries along the Belt and Road can promote the formation of economies of scale, broaden the marginal extension of the market, and carry out marketing activities through a variety of digital means, which promotes enterprises to increase their investment gradually; for strategic asset-seeking enterprises, the development of digital economy in the countries along the Belt and Road not only provides a good innovation environment but also enables enterprises to take advantage of the technological spillover to learn from their advanced technology and experience, which is more attractive to Chinese enterprises' investment. For strategic asset-seeking enterprises, the development of the digital economy in the countries along the route not only provides a favourable environment for innovation but also allows enterprises to take advantage of technological spillovers to learn from their advanced technology and experience, which is more attractive to Chinese enterprises' investment.

The digital economy in countries along the Belt and Road promotes Chinese enterprises' outbound investment by cutting costs, improving efficiency and reducing risks. The development of the digital economy in the countries along the Belt and Road helps enterprises use information platforms to quickly and accurately obtain the information they need, which reduces the time and money they spend in the investment process (Lin, Chen, & Qin, 2012). The development of a digital economy can also accelerate the efficiency of the spatial flow of resources and factors and promote enterprises to find trading objects and complete transactions quickly. and investment security.

7 Policy suggestion

7.1 Accurately grasp the development of the digital economy of countries along the "Belt and Road" and fully utilize the comparative advantages of the digital economy of countries

Currently, when Chinese companies engage in Outward Foreign Direct Investment (OFDI), the digital economy has become an important factor to consider. On the one hand, by collaborating with other countries, the government can comprehend the digital economy development policies of the countries along the route at a macro level. At the same time, it can also assist enterprises in utilizing various information platforms to analyze the current state of the digital economy in the countries along the route at a micro level. This can help achieve coordination between the government and enterprises and promote enterprises to gain a comprehensive understanding of relevant information. Minimize all types of risks encountered during the investment process. Enterprises can utilize the information they possess to adjust their investment focus, align industrial investments with the comparative advantages of different countries, employ modern technology to allocate production resources and motivate enterprises to enhance their industrial structure consistently. This will facilitate the mutual development of both countries.

7.2 We will actively cooperate with countries that have a high level of overall development in the digital economy

The digital economy has an increasing impact on economic development. It not only promotes industrial transformation and upgrading but also influences the development of global industrial and supply chains. Therefore, enterprises must fully grasp the development trends of the digital economy and enhance their technical capabilities. Through effective talent introduction policies, the government can attract high-tech professionals from around the globe, ensuring talent security for overseas investments by enterprises. By establishing connections with enterprises through government platforms and offering consulting and financing services, businesses can better understand their investment direction. Enterprises should enhance their innovation capabilities and integrate them with practicality. They should define their own development goals and directions, formulate a set of focused investment strategies, and maintain ongoing communication with local subsidiaries to make necessary adjustments. Seize the opportunity to grow and let their technology spillover effect promote the digital transformation of the company, and feedback to the economies of the countries along the route.

7.3 Actively participate in the formulation of international investment rules under the digital economy and guide enterprises with different motivations to efficiently engage in investment activities according to the rules

In the context of the digital economy, traditional industries and the original investment criteria have undergone profound changes, impacting investment cooperation between different countries. Governments can engage in communication with other countries regarding investment regulations in the digital economy through international organizations like the United Nations, various conferences, and other activities. They can offer recommendations for rulemaking while safeguarding the interests of all nations. This approach aims to establish a cohesive and secure investment environment that supports company growth and allows for a thorough examination of international regulations. Guide enterprises with various investment motivations to make informed investment decisions. Enterprises should also actively communicate with the government when investing to safeguard the legitimate rights and interests of both the enterprises and the country. They should determine the direction of investment according to the government's policy guidance and form investment strategies to achieve higher returns.

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II. Comparative Analysis of Digitalised Business Models

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Digital business models are a key component of digital transformation. Understanding these models is essential for operating successfully in the digital economy. A business model defines the value proposition, cost structure, financing sources, target audience, marketing strategy, and potential partnerships. Its primary purpose is to enable sustainable value delivery to customers. This paper uses the Business Model Canvas to analyse digitised business models, focusing on those based on recurring revenues (e.g., subscriptions, SaaS) and network effects (e.g., platforms, marketplaces). These models have fueled the growth of many digital enterprises. As emerging technologies reshape consumer expectations, companies must rethink how they create and deliver value in a constantly evolving digital environment.

Keywords:
digitalised business models,
digital transformation,
platform business model,
blockchain business model,
freemium business model,
Saas business model,
Crowdsourcing business model,
aggregator business model,
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1 Introduction

In the context of business models, all aspects related to the creation, production, and sale of a product or service are comprehensively analysed. This includes information about the target audience, product distribution channels, and company revenue streams, with a focus on monetisation mechanisms and consumer payment models (Teece, 2010). A business model can be compared to a meticulously designed plan that serves as a strategic framework for the project team, enabling systematic business strategy development (Osterwalder & Pigneur, 2010).

A business model is typically structured around the value proposition, representing a fundamental description of the offered products and/or services, emphasising their unique characteristics compared to competing market solutions (Chesbrough, 2010). Additionally, it defines the cost structure, sources of financing, target audience, marketing strategies, revenue and expense projections, competitive analysis, and potential opportunities for strategic partnerships (Osterwalder & Pigneur, 2010).

The primary objective of a business model is to enable a company to create and deliver value to consumers economically and sustainably. Due to its thorough analysis and planning before implementation, the risk of failure is significantly reduced, as the business model functions as a guiding mechanism for effective market positioning and sustainable business growth (Teece, 2010).

The landscape of business models is as diverse as the array of enterprises themselves, reflecting the varying strategies through which firms generate revenue, engage with customers, and create competitive advantages (Teece, 2010). Business models serve as structured frameworks that define how organisations deliver value and sustain profitability within dynamic market environments (Osterwalder & Pigneur, 2010). Among the most prevalent business models are (Fielt, 2013; Schmuck, 2021; Remane et al., 2022):

– Advertisement-Based Model: This model provides free content or services to end users while generating revenue through advertisements displayed on the platform. Companies like Google and Facebook leverage this approach, monetising their vast user base by offering targeted advertising services.

- Affiliate Marketing: Firms earn commissions by promoting and facilitating the sale of partner products, commonly seen in digital marketing strategies employed by platforms like Amazon Associates.

- Agency Model: Specialized firms provide non-core services, such as marketing, branding, and advertising, to other businesses in exchange for service fees.

- Aggregator Model: These companies unify multiple service providers under a single brand while earning revenue through commissions. Well-known examples include Uber and Airbnb, which act as intermediaries without owning the service assets themselves (Chesbrough, 2010).

- Blockchain-Based Model: Decentralized digital networks allow participants to engage in peer-to-peer transactions without centralised authority. This model is foundational in the cryptocurrency and fintech sectors.

- Brick-and-Mortar: Traditional businesses operate physical retail locations where consumers purchase directly.

- Bricks-and-Clicks: Hybrid models combine online and offline commerce, enabling consumers to purchase products online and collect them in-store, enhancing customer convenience.

- Crowdsourcing Model: Businesses leverage user-generated content and contributions to build services or products, exemplified by Wikipedia and open-source platforms.

- Data Licensing and Monetization: Companies collect and analyse user data, generating revenue by selling insights to advertisers and third parties.

- Distributor Model: Entities purchase goods from manufacturers and resell them to retailers or consumers, functioning as intermediaries in supply chains.

- Dropshipping: An e-commerce model where retailers do not hold inventory; third-party suppliers manage fulfilment and logistics while retailers earn commissions on sales.
- E-Commerce Model: Businesses sell products directly to consumers through online stores, with Amazon and Alibaba being prominent examples.

- Franchise Model: Entrepreneurs operate under an established brand name and business framework, paying royalties to the franchisor in exchange for branding and operational support.

- Freemium Model: Companies offer a basic version of their product for free while monetising premium features through subscription fees, as seen in platforms like Spotify and LinkedIn.

- High-Touch Model: Businesses prioritise human interaction to enhance service quality and build customer trust, commonly applied in consultancy and personalised services.

- Low-Touch Model: As exemplified by self-service stores like IKEA, firms minimise human interaction to reduce costs.

- Manufacturer Model: Companies produce goods from raw materials and sell them to distributors, wholesalers, or retailers, forming the backbone of industrial supply chains.

- Network Marketing: Also known as multi-level marketing (MLM), this structure enables individuals to sell products directly and recruit additional salespeople, earning commissions on personal sales and recruiting members' sales.

- Nickel-and-Dime Model: Businesses maintain low base product prices while charging separately for additional features or services commonly used in budget airlines and streaming services.

- Online Marketplace Model: Internet-based platforms facilitate supplier competition, generating revenue through transaction-based commissions.

Marketplaces like eBay and Etsy exemplify this approach (Osterwalder & Pigneur, 2010).

The success of modern enterprises is often linked to the strategic selection and adaptation of business models. Recurring revenue models, such as subscription-based services or Software as a Service (SaaS), have proven highly effective in ensuring financial sustainability and customer retention. Furthermore, business models that capitalise on network effects, such as online marketplaces and digital platforms, benefit from self-reinforcing growth, where increased user participation enhances overall value (Chesbrough, 2010; Appelbaum et al., 2018). The evolution of business models occurs as a response to technological advancements and shifts in consumer behaviour. Emerging technologies, such as artificial intelligence, blockchain, and the Internet of Things (IoT), compel businesses to rethink traditional operational paradigms and explore new avenues for value creation (Teece, 2010). Organisations must continuously assess how to leverage technological innovation to meet evolving consumer expectations and sustain competitive differentiation in an increasingly digital economy (Loebbecke & Picot, 2015).

2 Analysing business models with business model canvas

The Business Model Canvas (BMC) is a widely recognised strategic management tool that provides a visual framework for designing, analysing, and optimising business models. Developed by Alexander Osterwalder and Yves Pigneur (2010), it allows organisations to systematically assess how they create, deliver, and capture value. By leveraging this tool, businesses can document existing models, develop new strategies, challenge industry norms, and pivot their operational approaches in response to market dynamics.

The Business Model Canvas consists of nine interconnected building blocks, each representing a critical component of a sustainable business strategy. These elements facilitate a structured approach to business planning by ensuring that all essential aspects are accounted for in decision-making processes (Osterwalder & Pigneur, 2010).

Nine Elements of the Business Model Canvas (Osterwalder & Pigneur, 2010):

- Customer Segments – Defines the different groups of people or organisations that the business aims to serve. Understanding customer demographics, behaviours, and needs is essential for value proposition alignment.
- Value Proposition – This represents the unique value a company delivers to its customers. This includes the products and services offered and how they address customer needs better than competitors.
- Channels – Describes how a company delivers its value proposition to customers. These may include physical stores, e-commerce platforms, or digital communication channels.
- Customer Relationships – Defines a company's interaction with its customers. This can range from personalised services to automated self-service models.
- Revenue Streams – Identifies the monetisation strategies that sustain the business. Revenue may come from direct sales, subscription models, licensing fees, or freemium offerings.
- Key Resources – Lists the critical assets required for a business to function efficiently. These may include human resources, intellectual property, financial assets, and technological infrastructure.
- Key Activities – Outlines the core business operations necessary for delivering the value proposition. This includes product development, marketing, supply chain management, and strategic partnerships.
- Key Partnerships – Refers to the alliances and collaborations that strengthen business operations. Strategic partnerships can involve suppliers, distributors, technology partners, and investors.
- Cost Structure – Breaks down the financial expenses associated with running the business. This includes fixed and variable costs, operational expenses, and resource allocation.

2.1 Customer segment in business model development

Customer segmentation is pivotal in business model formulation, as consumer behaviour and purchasing patterns directly influence daily operations and strategic decision-making. By systematically categorising customers based on key attributes, businesses can tailor their value propositions, marketing strategies, and service offerings to better align with customer needs and expectations (Kotler et al., 2021). A thorough understanding of customer attributes enables businesses to implement targeted marketing campaigns, enhance customer experience through personalisation, and optimise product offerings based on consumer demand (Lemon & Verhoef, 2016). The ability to adapt to changing consumer behaviours and leverage data-driven insights ensures that businesses remain competitive in rapidly evolving markets.

2.2 Value proposition in business model development

A value proposition is a concise yet impactful statement articulating the core value a product or service delivers to its customers. In the context of the Business Model Canvas, this element defines why consumers should choose a particular offering over a competing alternative (Osterwalder & Pigneur, 2010). A compelling value proposition addresses a customer pain point, provides a unique benefit, or enhances the overall customer experience, ultimately serving as a strategic differentiator in the marketplace (Payne et al., 2017).

Beyond functional benefits, a compelling value proposition also resonates emotionally and psychologically, fostering stronger customer engagement and brand loyalty (Lemon & Verhoef, 2016). A well-crafted value proposition is the foundation of a company's marketing strategy and significantly impacts consumer perception and decision-making. Businesses that align their value propositions with evolving customer expectations and market trends gain a competitive edge and drive higher customer engagement, conversion rates, and brand advocacy (Kotler et al., 2021).

2.3 Distribution channels in business model development

Distribution channels are crucial in delivering value to customers by ensuring that products and services reach their intended audience efficiently. Osterwalder and Pigneur (2010) identified five key phases of channel development, each essential for effectively engaging customers throughout the buying journey. A well-designed distribution strategy enhances brand visibility, customer experience, and operational efficiency (Kotler et al., 2021).

Marketing and communication channels such as advertising, social media, public relations, and content marketing are pivotal in building interest and driving engagement (Lemon & Verhoef, 2016). Common evaluation channels include free trials, product demonstrations, case studies, and customer reviews, which help build credibility and provide quality evidence (Payne et al., 2017). Distribution channels vary based on the business model, including e-commerce platforms, physical retail stores, direct sales teams, and mobile applications (Chaffey & Ellis-Chadwick, 2019). Delivery channels can include home delivery, in-store pickup, subscription-based shipping, or digital downloads for software-based products (Christopher, 2016). After-sales channels include customer service hotlines, online chat support, help desks, and automated follow-up emails (Kotler et al., 2021).

Companies that leverage digital transformation, such as omnichannel retailing and AI-driven logistics solutions, can gain a competitive advantage by ensuring speed, convenience, and personalised service (Wirtz et al., 2020).

2.4 Customer relationship strategy in business model development

A customer relationship strategy defines how a business interacts with its target audience and fosters engagement throughout the customer journey. Within the Business Model Canvas framework, customer relationships shape how brands acquire, retain, and expand their customer base, significantly influencing customer satisfaction and loyalty (Osterwalder & Pigneur, 2010).

Different business models require tailored approaches to customer interaction. Osterwalder and Pigneur (2010) identified five primary types of customer relationships, each serving different strategic purposes.

Types of Customer Relationships

- Personal Assistance: This traditional, high-touch approach involves direct interaction between customers and company representatives. Luxury retail, financial advisory services, and hospitality industries rely on personal assistance to create strong emotional connections and long-term loyalty (Kotler et al., 2021).

- Self-Service: Self-service models eliminate direct brand interaction, enabling customers to independently navigate products or services through FAQs, knowledge bases, user guides, and online help centres. This cost-effective, scalable approach empowers customers to resolve issues conveniently (Chaffey & Ellis-Chadwick, 2019).
- Automated Service: Advances in artificial intelligence (AI) and machine learning have facilitated automated customer service solutions, such as chatbots, AI-powered recommendations, and virtual assistants. This interactive approach is more engaging than self-service, enabling businesses to handle routine queries, streamline transactions, and enhance operational scalability (Wirtz et al., 2020).
- Communities: Creating customer-driven communities fosters peer-to-peer interaction, shared experiences, and collaborative problem-solving. Community-based engagement enhances customer advocacy and trust (Payne et al., 2017).
- Co-Creation: Co-creation enables businesses to engage customers in product development by incorporating user-generated content, feedback, and innovation. This strategy enhances consumer involvement and strengthens brand attachment (Chesbrough, 2010).

A well-defined customer relationship strategy is critical for brand differentiation, customer retention, and long-term business sustainability. Businesses that align their relationship models with evolving consumer expectations can foster higher engagement levels, enhance customer satisfaction, and optimise service efficiency (Lemon & Verhoef, 2016).

2.5 Revenue streams in business model development

The Revenue Streams block within the Business Model Canvas identifies the financial inflows that sustain a business. Understanding revenue generation is critical, as companies must align their monetisation strategies with customer preferences to maximise profitability (Osterwalder & Pigneur, 2010). By considering the buyer persona, companies can determine what their target audience will pay for and tailor their pricing models accordingly (Kotler et al., 2021).

Various monetisation methods exist, each suited to different business models, industries, and customer expectations. The most prevalent revenue streams include:

- Direct Sales: This traditional model involves selling products or services directly to customers for a fee. Direct sales provide a straightforward and immediate source of revenue, allowing companies to scale based on product demand (Chesbrough, 2010).
- Advertising Revenue: Businesses such as blogging platforms, media outlets, and IT-driven platforms generate income by selling advertising space to brands that want to engage their audience. The effectiveness of this model depends on audience reach, engagement, and data-driven ad targeting (Wirtz et al., 2020).
- Freemium Model: Popular in digital and software industries, the freemium model offers essential services for free while monetising through premium features, enhanced functionalities, or exclusive content. This approach attracts a large user base and converts a fraction of free users into paying customers (Payne et al., 2017).
- Subscription Model: Subscription-based revenue streams provide ongoing access to a product or service in exchange for a recurring fee. This model ensures predictable and stable revenue, making it particularly valuable for businesses in Software-as-a-Service (SaaS), streaming platforms, and membership-based businesses (Chaffey & Ellis-Chadwick, 2019).

- Businesses may also adopt hybrid models, combining multiple revenue streams (Lemon & Verhoef, 2016) —such as advertising + subscriptions (YouTube Premium), direct sales + freemium (mobile apps), or SaaS with add-on services (Salesforce, Adobe Creative Cloud)—to maximise profitability and market adaptability.

2.6 Key resources in business model development

In the Business Model Canvas, key resources represent the essential assets that a company requires to deliver its value proposition, reach customer segments, and sustain operations (Osterwalder & Pigneur, 2010).

Key resources can be classified into four primary types:

- Tangible Resources: These include physical assets such as real estate, machinery, equipment, production facilities, and inventory. Businesses that rely on manufacturing, retail, logistics, and infrastructure depend heavily on tangible resources to produce and deliver goods efficiently (Barney, 1991).
- Intangible Resources: Intellectual property (IP), patents, trademarks, copyrights, proprietary knowledge, and brand reputation fall under this category. Innovation-driven businesses, such as those in technology, pharmaceuticals, and creative industries, leverage intangible resources to maintain market differentiation and protect their competitive position (Teece, 2010).
- Human Resources: Employees are vital in executing business strategies. A highly skilled and motivated workforce enhances productivity, drives innovation, and supports business growth (Wright et al., 2001).
- Financial Resources: Financial resources encompass monetary assets, investment capital, credit facilities, and funding sources such as bank loans, venture capital, grants, and retained earnings. Strong financial management ensures stability, scalability, and strategic expansion (Chesbrough, 2010).

Effective management of key resources is essential for sustaining long-term success and resilience (Barney, 1991).

2.7 Key activities in business model development

In the Business Model Canvas, key activities refer to a business's core operations and processes to deliver its value proposition, reach target customers, and sustain profitability (Osterwalder & Pigneur, 2010). These industry-specific activities directly impact operational efficiency, market positioning, and customer satisfaction.

Key activities can be classified into three primary types:

1. Production Activities: These involve the creation and development of products or services, ensuring that offerings meet market demands and quality standards (Teece, 2010

2. Problem-Solving Activities: Businesses specialising in solving customer challenges engage in problem-solving activities (Barney, 1991).
3. Platform/Network Activities: Companies that function as intermediaries, aggregators, or digital platforms focus on managing and optimising networks (Wirtz et al., 2020).

Key activities form the backbone of a company's business model (Chesbrough, 2010).

2.8 Key partners in business model development

Key partnerships ensure a business's efficient operation, scalability, and sustainability. Within the Business Model Canvas, key partners provide resources, capabilities, and strategic advantages that enhance a company's ability to deliver its value proposition effectively (Osterwalder & Pigneur, 2010).

Key partnerships can be classified into four primary types:

1. Suppliers: Suppliers provide the raw materials, components, or finished goods necessary for manufacturing and production. A reliable supply chain ensures quality consistency, cost efficiency, and reduced production delays (Christopher, 2016).
2. Non-Competitor Partnerships: These partnerships involve collaborations between businesses that complement each other but do not compete directly. Such relationships help firms share resources, expand service offerings, and enhance operational efficiency (Barney, 1991).
3. Joint Ventures: A joint venture is a formal agreement between two or more companies to develop new markets, technologies, or customer segments. Joint ventures allow businesses to combine expertise, share risks, and accelerate market penetration (Gulati, 1998
4. Coopetition (Competitive Collaboration): Coopetition refers to strategic collaboration between direct competitors. This approach allows businesses to co-develop technologies, enter new markets, or tackle industry-wide challenges while maintaining competitive differentiation (Nalebuff & Brandenburger, 1996).

2.9 Cost structure in business model development

The Cost Structure block of the Business Model Canvas represents all expenses associated with executing a business model. Understanding and managing costs is critical for businesses to set realistic revenue targets, ensure financial sustainability, and optimise profitability (Osterwalder & Pigneur, 2010). Start-ups and established enterprises must carefully assess cost components to balance investment, operational efficiency, and long-term growth.

Key Components of Cost Structure

1. Fixed Costs: Fixed costs remain constant regardless of production levels
2. Variable Costs: Variable costs fluctuate based on production volume and business activity.
3. Economies of Scale: As businesses grow, they often experience lower per-unit costs due to bulk purchasing, process optimisations, and operational efficiency. This allows companies to spread fixed costs over a larger output and increase profitability (Ghemawat, 2016).
4. Economies of Scope: Businesses can also reduce overall costs by diversifying their product or service offerings. Shared resources, expertise, and infrastructure across multiple revenue streams help optimise cost efficiency (Chesbrough, 2010).

The cost structure is a fundamental aspect of business model sustainability. Companies that strategically balance fixed and variable costs, leverage economies of scale, and manage industry-specific expenses can enhance efficiency, profitability, and long-term competitiveness.

3 Subscription business model

The subscription-based business model has emerged as a powerful tool for business expansion, offering a predictable and recurring revenue stream. This model benefits both businesses and consumers by ensuring financial stability for companies while providing convenience and continuous value to customers (Teece, 2010). Unlike traditional one-time sales models, the subscription model fosters long-term customer relationships, making customer retention a critical success factor.

A subscription business model allows companies to provide ongoing access to a product or service in exchange for recurring monthly or annual payments. Customers must continue paying the fee to maintain access to the product or service (Osterwalder & Pigneur, 2010). This model has become increasingly prevalent across various industries, from digital streaming services to subscription boxes and SaaS (Software as a Service) platforms (Wirtz et al., 2020).

The subscription business model serves as a sustainable growth strategy, offering several key advantages:

- Predictable Revenue Streams: The recurring nature of subscription payments ensures financial stability and facilitates long-term financial planning (Ghaziani et al., 2017).
- Enhanced Customer Lifetime Value (CLV): The longer customers remain subscribed, the more significant their value contribution to the business (Lemon & Verhoef, 2016).
- Stronger Customer Relationships: The model prioritises continuous engagement, fostering brand loyalty and reducing dependency on one-time purchases.
- Scalability and Innovation: Businesses can regularly update their offerings, ensuring continuous improvement and maintaining customer interest.

Despite its advantages, the subscription model presents unique challenges that businesses must navigate:

- Customer Retention and Churn Management: Since revenue depends on customer retention, businesses must minimise churn by ensuring customer satisfaction and delivering consistent value (Kotler et al., 2021).
- Customer Acquisition Costs (CAC): Acquiring subscribers can be costly, and businesses must carefully manage marketing expenditures to ensure long-term profitability.
- Pricing Strategies: Subscription fees must be affordable yet profitable, balancing customer willingness to pay with operational sustainability.

Subscription businesses employ distinctive marketing strategies to attract and retain customers:

- Freemium Model: Many digital platforms, such as Spotify and LinkedIn Premium, offer a free tier to attract users, later converting them to paid subscribers (Pujol, 2010).
- Customer-Centric Pricing: Subscription fees are typically set at a low monthly price to encourage long-term commitment while reducing the financial burden on the user.
- Personalization and Engagement: Subscription businesses rely on data-driven insights to tailor offerings, improve user experiences, and maximise retention (Wirtz et al., 2020).

The subscription business model represents a transformative approach to revenue generation, fostering customer retention, financial predictability, and business scalability. However, success requires meticulous planning, including cost management, retention strategies, and value delivery. If executed effectively, the subscription model offers substantial growth potential, positioning businesses for long-term market relevance and success.

4 Multi-sided platform business model

The multi-sided platform (MSP) business model has become dominant in the digital economy, and it has been adopted by some of the world's most valuable start-ups, such as PayPal, Uber, Alibaba, eBay, and Facebook. Enabled by internet connectivity and digital technologies, MSPs serve as intermediaries that connect two or more distinct participant groups, facilitating interactions and transactions between them (Parker et al., 2016). This model has gained traction among start-ups, young firms, and established brands, making it an attractive choice for entrepreneurs seeking scalable business models (Gawer & Cusumano, 2014).

At its core, a multi-sided platform creates value by facilitating connections between different participant groups. Unlike traditional businesses that produce goods or services, MSPs do not generate content or manufacture products directly; their value proposition lies in their ability to enable interactions (Rochet & Tirole, 2003) efficiently.

Most MSPs operate as two-sided platforms, where they link:

- Buyers and sellers (e.g., eBay, Alibaba)
- Drivers and passengers (e.g., Uber, Lyft)
- Owners and renters (e.g., Airbnb, Turo)
- Merchants and consumers (e.g., Amazon, Shopify)

Some platforms, like Facebook and Google, operate as multi-sided ecosystems, facilitating interactions among users, advertisers, and content developers (Eisenmann et al., 2006).

The success of MSPs largely depends on network effects, which influence the platform's value based on the number of users participating.

1. Direct Network Effects (Same-Side Effects): The platform's value increases when more users on the same side join (e.g., more Facebook users make the platform more attractive to other users).
2. Indirect Network Effects (Cross-Side Effects): The value of the platform increases when more users join the opposite side (e.g., more sellers on eBay attract more buyers, and vice versa) (Parker et al., 2016).

A strong network effect enables rapid growth and scalability, while a weak network effect can lead to platform failure due to low engagement and lack of perceived value.

MSPs generate revenue through various monetisation strategies, with the most common being:

- Transaction Fees: Charging a fixed fee or commission on participant transactions.
- Subscription Fees: Charging users a recurring membership or premium access fee.

- Advertising Revenue: Generating income through targeted advertising.
- Freemium Model: Offering essential services for free while monetising premium features.

While many multi-sided platforms have achieved remarkable success, failure is common among new market entrants due to challenges in acquiring and retaining users (Evans & Schmalensee, 2016).

Despite its scalability, the MSP model presents unique challenges, including:

- Customer Acquisition & Retention: Platforms must attract and retain a critical mass of users to sustain engagement and ensure continuous transactions.
- Balancing Supply and Demand: Successful MSPs optimise both sides of the platform to avoid mismatches (e.g., ensuring enough drivers are available for passengers).
- Trust & Security: Building trust between participants is crucial, particularly in peer-to-peer marketplaces (Gawer, 2021).
- Regulatory & Competition Issues: MSPs often face antitrust concerns, data privacy challenges, and regulatory scrutiny, especially in financial technology and ride-sharing (Eisenmann et al., 2006).

The multi-sided platform business model has reshaped entire industries by leveraging network effects, digital technology, and user-driven value creation. While offering substantial growth potential, its success relies on effective participant engagement, trust-building mechanisms, and strategic market positioning. Future research and innovation in this space will likely continue shaping the evolution of digital ecosystems and platform-based economies.

5 Aggregator business model

The aggregator business model has revolutionised numerous industries by consolidating fragmented markets under a single brand, enhancing efficiency, convenience, and user experience. This model has been successfully adopted in transportation, hospitality, travel, food delivery, and e-commerce (Parker et al., 2016). Unlike traditional intermediaries, aggregators control user experience significantly, ensuring quality, consistency, and brand recognition across their service offerings (Evans & Schmalensee, 2016).

The aggregator model operates as a network-based e-commerce model, where the aggregator partners with multiple independent providers to offer services under a unified brand. The providers retain ownership and operational independence but adhere to standards, pricing structures, and contractual agreements set by the aggregator (Gawer, 2021).

Unlike marketplaces, where buyers and sellers interact directly, aggregators maintain strict control over the transaction process, ensuring standardised service quality and consistent customer experiences. This model leverages economies of scale to drive network effects, where more users attract more service providers, reinforcing a self-sustaining growth cycle (Rochet & Tirole, 2003).

Aggregators primarily generate revenue through the following:

- Commission-Based Fees: Service providers pay a percentage of their earnings to the aggregator for customer access.
- Subscription Fees: Some aggregators charge monthly or annual fees for premium access or enhanced services.
- Advertising Revenue: Platforms monetise through sponsored listings or targeted advertising.
- Lead Generation Fees: Some aggregators sell customer leads to service providers.

Aggregators curate and standardise the service experience, whereas marketplaces are neutral platforms facilitating buyer-seller transactions (Parker et al., 2016).

Aggregators can be categorised based on content type and industry focus:

- Content Aggregators: Aggregate news, articles, or blog content.
- Job Aggregators: Consolidate job postings from multiple sources.
- Poll Aggregators: Compile and analyse public opinion data
- Real Estate Aggregators: Collect and list property details from various agencies-

- Review Aggregators: Aggregate user reviews for products, movies, or businesses.
- Search Aggregators: Provide meta-search functionality, pulling results from multiple search engines.
- Social Network Aggregators: Aggregate content from various social media platforms.
- Shopping Aggregators: Compare product prices across different retailers.
- Video Aggregators: Aggregate videos from multiple sources into curated lists.

Although commonly associated with the digital revolution, aggregation predates the internet—traditional businesses such as record labels (music industry aggregators) and travel agencies operated under similar principles. However, digital technology has accelerated scalability, enabling aggregators to optimise processes, reduce costs, and reach global audiences (Evans & Schmalensee, 2016).

The aggregator business model continues to evolve, with innovations in artificial intelligence (AI), big data analytics, and blockchain enhancing operational efficiency. Future trends may include automation, decentralised aggregation models, and enhanced data-driven decision-making (Gawer, 2021).

The aggregator business model has fundamentally reshaped consumer behaviour, market competition, and industry dynamics. By leveraging network effects, economies of scale, and digital technology, aggregators streamline fragmented industries, enhance customer experience, and drive business efficiency. Despite customer acquisition, trust, and competition challenges, the model remains a robust and scalable framework for modern businesses.

6 Freemium business model

The freemium business model has become a dominant strategy in the digital economy, particularly for software, cloud services, and online platforms. This model provides a free, limited version of a product or service while offering a premium version with enhanced features for a fee (Pujol, 2010). Due to its low customer acquisition costs and scalability, companies such as Spotify, LinkedIn, Skype, and Dropbox have widely adopted the freemium model.

Unlike traditional free trials, where access to premium features is temporarily granted, the freemium model permanently offers a free basic version. This ensures continuous user engagement, allowing businesses to convert free users into paying customers over time (Nason, 2010).

The effectiveness of the freemium model depends on several critical factors:

1. Clear Value Differentiation: The premium version must provide significant advantages over the free version to entice users to upgrade (Kumar, 2014).
2. User Engagement & Retention: Customers are unlikely to upgrade immediately; therefore, retention strategies such as loyalty programs, feature updates, and targeted promotions are crucial (Lemon & Verhoef, 2016).
3. Optimized Free-to-Premium Ratio: While free users drive brand awareness, only a small percentage (typically 1-5%) convert to paid plans. Businesses must ensure premium revenue offsets operational costs (Pujol, 2010).
4. Viral & Network Effects: A large user base enhances brand credibility and encourages word-of-mouth marketing, reducing reliance on traditional advertising (Parker et al., 2016).

Despite its advantages, the freemium model presents several challenges:

1. High User Volume Requirement: The model depends on large-scale adoption; a small user base may not generate sufficient premium conversions (Chesbrough, 2010).
2. Long-Term Monetization: Revenue generation takes time, requiring businesses to carefully balance cost structures (Osterwalder & Pigneur, 2010).
3. Risk of Cannibalization: If the free version is too feature-rich, users may never upgrade, diminishing profitability (Kumar, 2014).

The freemium business model remains a robust growth strategy for digital and internet-based companies. Businesses can scale effectively and drive long-term profitability by combining low acquisition costs, viral effects, and strategic premium differentiation. However, success depends on balancing free and premium offerings, optimising conversion rates, and ensuring financial sustainability.

7 Blockchain business model

Since Satoshi Nakamoto's groundbreaking paper, Bitcoin: A Peer-to-Peer Electronic Cash System (2008), blockchain technology has rapidly permeated various business sectors. As an immutable, decentralised, and transparent system, blockchain has redefined transaction security, data integrity, and peer-to-peer interactions (Tapscott & Tapscott, 2016). The increasing adoption of blockchain-based business models across industries reflects its potential to disrupt traditional business frameworks and eliminate intermediaries (Iansiti & Lakhani, 2017).

Blockchain technology is founded on three core principles:

1. Decentralization – Unlike traditional databases controlled by a central authority, blockchain distributes data across a network of nodes, ensuring resilience and eliminating single points of failure (Nakamoto, 2008).
2. Immutability – Data stored on the blockchain is cryptographically secured and tamper-proof, ensuring data integrity and cybersecurity (Yli-Huumo et al., 2016).
3. Transparency – While user identities remain encrypted, all transactions are publicly recorded, fostering trust and accountability in digital ecosystems (Casino et al., 2019).

These features enable blockchain to redefine traditional business models, particularly those reliant on transaction processing, record-keeping, and security mechanisms (Pilkington, 2016).

Several blockchain business models have emerged, leveraging its peer-to-peer architecture, decentralised governance, and token-based economies:

1. Peer-to-Peer (P2P) Blockchain Business Model

This model leverages blockchain's decentralised nature to facilitate direct user interactions without intermediaries. Businesses profit through:

- Transaction fees (e.g., Bitcoin, Ethereum).
- Storage and data-sharing platforms (e.g., Filecoin, IPFS).

- Decentralized marketplaces (e.g., OpenSea for NFTs).

By removing intermediaries, P2P blockchain platforms reduce costs, enhance security, and give users greater control over their data (Swan, 2015).

2. Blockchain-as-a-Service (BaaS) Business Model

BaaS companies offer blockchain infrastructure and services to enterprises, enabling them to integrate blockchain without complex backend development (Zhang et al., 2020). Services include:

- Smart contract deployment (e.g., Ethereum, Hyperledger).
- Cloud storage solutions (e.g., Amazon Managed Blockchain, Microsoft Azure Blockchain).
- Identity management and authentication services (e.g., Civic, Sovrin).

BaaS allows businesses to focus on front-end applications while outsourcing blockchain architecture, reducing development costs and accelerating adoption.

3. Token Economy: Utility Token Business Model

Blockchain utility tokens are digital assets that facilitate network activities and transactions within blockchain ecosystems. Companies issue tokens to:

- Incentivize network participation (e.g., Basic Attention Token rewards users for viewing ads).
- Enable decentralised applications (DApps) (e.g., Ethereum ERC-20 tokens).
- Facilitate microtransactions and cross-border payments (e.g., Ripple XRP).

Utility tokens are widely used in decentralised finance (DeFi), gaming, and digital content monetisation, allowing businesses to engage users through token-based incentives (Davidson et al., 2018).

Despite its disruptive potential, blockchain faces several challenges:

- Scalability Issues – High transaction loads may slow network performance (e.g., Bitcoin's transaction limitations).
- Regulatory Uncertainty – Governments worldwide are still developing blockchain regulations (Zohar, 2015).
- Energy Consumption – Proof-of-Work (PoW) consensus mechanisms consume substantial energy, raising environmental concerns.

The blockchain business model is a transformative approach to secure, decentralised, and efficient transactions. By leveraging peer-to-peer networks, token economies, and blockchain services, businesses can reduce costs, enhance transparency, and build trust-driven digital ecosystems. While challenges remain, the continued evolution of blockchain applications ensures its long-term viability and impact across industries.

8 SaaS business model

The Software-as-a-Service (SaaS) business model has become one of the most influential developments in the digital economy, transforming how software is developed, delivered, and monetised. Introduced by John Koenig in 2005 at the *SDForum Software as a Service Conference*, SaaS has experienced exponential growth, driven by advancements in cloud computing, scalable infrastructure, and subscription-based monetisation (Koenig, 2005; Cusumano, 2010).

SaaS is a subscription-based model where software is centrally hosted in the cloud and provided to users on-demand. This shift from product ownership to service access has disrupted software industries across B2B and B2C markets, fostering customer retention, cost-efficiency, and global scalability (Choudhary, 2007).

The SaaS model is distinctly different from traditional software businesses, offering:

1. Recurring Revenue Streams

- SaaS companies rely on subscriptions rather than one-time purchases.
- Initial development costs are high, but revenue accumulates over time, ensuring predictable income (Cusumano, 2010).

2. Customer Retention & Engagement

- Long-term success depends on reducing churn rates and maximising customer lifetime value (CLV).
- Frequent customer interactions through personalised services and continuous updates help sustain subscription renewals (Lemon & Verhoef, 2016).

3. Continuous Software Updates & Enhancements

- Unlike traditional software, where updates occur through new releases, SaaS platforms allow real-time feature enhancements.
- Providers manage security patches, bug fixes, and software optimisations without user intervention.

Despite its advantages, SaaS companies face several challenges:

- High Customer Acquisition Costs (CAC) – Marketing, lead generation, and sales require significant upfront investments.
- Churn Management – Retaining customers is critical, as losing subscribers reduces lifetime value (LTV).
- Infrastructure Costs – Hosting, security, and data storage expenses increase with scale (Krishnan et al., 2007).
- Competitive Market – The SaaS sector is highly saturated, requiring strong differentiation and customer-centric innovations.

Successful SaaS businesses focus on three core performance indicators (Reinartz & Kumar, 2003):

1. Customer Acquisition Cost (CAC) – The expense of acquiring a new subscriber.
2. Customer Lifetime Value (CLV) – The total revenue from a single customer over their subscription period.

3. Churn Rate – The percentage of customers cancelling subscriptions, affecting long-term profitability.

Balancing CAC and CLV is essential to creating a self-sustaining, profitable SaaS company (Bessemer Venture Partners, 2016).

The SaaS model is prevalent across various industries: CRM and sales (Salesforce, HubSpot, Pipedrive), ERP and accounting (NetSuite, QuickBooks, Xero), Project Management (Asana, Trello, Basecamp), E-commerce and web hosting (AWS, Shopify, Google Cloud), and HR & Recruitment (BambooHR, Workday, WebHR). These companies leverage AI, automation, and integrations to enhance SaaS offerings and drive business innovation.

The SaaS business model has revolutionised software distribution and monetisation, enabling scalable, customer-centric solutions. While subscription-based revenue ensures financial stability, customer acquisition costs, retention strategies, and ongoing updates remain key challenges. The future of SaaS lies in AI-driven automation, enhanced cybersecurity, and hyper-personalization, ensuring continuous industry evolution.

9 Crowdsourcing business model

The crowdsourcing business model is a digital-era innovation that utilises the collective knowledge, skills, and contributions of a large group—or ‘crowd’—to enhance business operations. Businesses outsource tasks, gather data, and engage users through multi-sided platforms, fostering cost efficiency, scalability, and rapid problem-solving (Howe, 2006).

Crowdsourcing involves obtaining work, ideas, opinions, or funding from a large, decentralised group via the Internet, mobile apps, and social media. Participants may contribute:

– Voluntarily (e.g., Wikipedia, Waze).
– For monetary compensation (e.g., Upwork, Amazon Mechanical Turk).

– In exchange for social recognition or community engagement (e.g., Open-source software development).

The ability to mobilise collective intelligence makes crowdsourcing a powerful tool for data collection, innovation, and problem-solving (Surowiecki, 2004).

The term "crowdsourcing" was first coined by Jeff Howe (2006), describing how businesses leverage a distributed workforce to complete projects. The rise of internet connectivity, social media, and cloud computing has accelerated crowdsourcing adoption across industries, from market research and customer engagement to software development and funding campaigns (Brabham, 2013).

Several crowdsourcing models cater to distinct business objectives:

1. Crowdsourced Data & Intelligence. Platforms leverage user-generated content to aggregate real-time data. Examples: *Waze* collects traffic reports from drivers, offering real-time navigation; *Google Local Guides* crowdsources reviews and photos for Google Maps.
2. Open-Source Software Development. Decentralised developers collaborate to create and improve software, often for free. Examples: *Linux* and *Mozilla Firefox* are maintained by global volunteer programmers; *GitHub* enables developers to share and enhance code collaboratively.
3. Crowdfunding Platforms. Businesses raise funds by soliciting small contributions from a large number of backers. Examples: Kickstarter and Indiegogo provide platforms for entrepreneurs to fund projects. For Example, GoFundMe enables charitable donations and personal fundraising.

The crowdsourcing model aligns with Osterwalder & Pigneur's (2010) Business Model Canvas:

1. Value Propositions:

– Access to data, expertise, funding, or services from a global crowd.

- Users gain incentives, including monetary rewards, recognition, or community engagement.

2. Customer Segments:

- Supply Side: The crowd (freelancers, contributors, or backers).
- Demand Side: Businesses, organisations, or individuals seeking input or funding.

3. Channels:

- Digital platforms (websites, mobile apps) facilitate participation and data collection.
- Social media and word-of-mouth play a crucial role in engagement.

4. Customer Relationships:

- Self-service participation through platform interfaces.
- A strong sense of community, fostering loyalty and recurring engagement.

5. Revenue Streams:

- Transaction fees (e.g., commissions on crowdfunding campaigns).
- Advertising revenue (e.g., Google Local Guides monetising data for businesses).
- Premium services and subscriptions (e.g., LinkedIn crowdsourcing user data for paid insights).

6. Key Resources:

- Crowdsourced data is the core asset.
- A scalable digital platform to process contributions.

7. Key Activities:

- Platform development and maintenance.
- Marketing and community engagement.
- Moderation and quality control.

8. Key Partners:

- Third-party applications, businesses, and platform integrators.

9. Cost Structure:

- Lower overhead than traditional businesses, but requires investment in platform infrastructure, moderation, and marketing.

Despite its advantages, crowdsourcing presents several challenges, which are Quality Control Issues – Ensuring reliable contributions from an open community requires moderation (Howe, 2008); User Motivation and retention – Encouraging long-term participation without direct financial incentives (Estellés-Arolas & González-Ladrón-de-Guevara, 2012) and Data Security & Privacy – Handling sensitive user-generated data ethically and securely.

10 Peer-to-Peer (P2P) Business Model

The peer-to-peer (P2P) business model has transformed traditional industries by enabling direct individual transactions and reducing the need for corporate intermediaries. Initially popularised by Napster (1999), a file-sharing system that disrupted the music industry, P2P has since evolved into a fundamental business model underpinning ridesharing (Uber, Lyft), accommodation (Airbnb), and financial services (DeFi, peer-to-peer lending platforms) (Botsman & Rogers, 2010).

The P2P economy facilitates direct exchanges of goods, services, or data between individuals without requiring a centralised corporation to manage production or distribution (Eisenmann et al., 2006). Instead, digital platforms act as intermediaries, ensuring secure transactions and minimising risks.

Despite its name, accurate peer-to-peer transactions without an intermediary are rare, as platforms provide essential services such as trust mechanisms, payment processing, and dispute resolution (Evans & Schmalensee, 2016).

Core Characteristics of the P2P Model are:

- Decentralized Transactions: Buyers and sellers interact directly without centralised corporate ownership.
- Digital Intermediation: Platforms facilitate trust, payment security, and user verification.
- Lower Costs & Accessibility: Reduces overhead costs, making services affordable and scalable.
- Network Effects: The more users a platform has, the more valuable it becomes (Metcalfe's Law).

The P2P business model generally follows this operational structure:

1. A digital platform connects individuals offering products or services.
2. Users list and browse offerings (e.g., an apartment for rent on Airbnb, a ride on Uber).
3. A transaction occurs, facilitated by the platform's payment and security systems.
4. The platform earns revenue through transaction fees, advertising, or premium services.

The peer-to-peer (P2P) business model offers several key advantages contributing to its widespread adoption and success. One of the most significant benefits is cost reduction, as individuals can monetise their assets or services without relying on traditional corporate structures, leading to lower operational expenses for providers and consumers. Additionally, increased consumer choice is another critical advantage, as buyers can access diverse products and services at competitive prices. The flexibility and scalability of P2P platforms also allow businesses to expand without the need for significant infrastructure investments, as they do not own the assets being exchanged. Furthermore, trust and community engagement play a vital role in sustaining the P2P economy, as user ratings, reviews, and feedback mechanisms help foster reliability and accountability among participants. These advantages collectively make the P2P model a disruptive force in various industries, enabling efficient and cost-effective individual transactions.

The peer-to-peer business model has revolutionised traditional industries, empowering individuals to transact directly and leveraging digital platforms for efficiency and security. While regulatory uncertainty, fraud prevention, and market saturation persist, the continued evolution of technology and decentralisation ensures P2P's long-term viability as a disruptive business model.

11 Conclusion

The evolution of digital technologies has facilitated the emergence of innovative business models, reshaping traditional industries and creating new economic opportunities. Among these, peer-to-peer (P2P), multi-sided platforms, aggregator, freemium, subscription, SaaS, crowdsourcing, and blockchain-based models have demonstrated their ability to disrupt established markets by leveraging decentralisation, scalability, and digital connectivity. These models enable businesses to optimise resource allocation, reduce costs, and enhance customer engagement while fostering more flexible and user-centric ecosystems.

Each of these business models presents distinct advantages and challenges. The subscription and SaaS models provide businesses with predictable revenue streams and long-term customer relationships yet require continuous innovation and high initial investment. The freemium model, widely used in digital services and software, lowers customer acquisition costs but demands careful balancing between free and premium offerings to ensure profitability. The aggregator model consolidates service providers under a single brand and relies on network effects and stringent quality control. Meanwhile, blockchain-based and decentralised business models have introduced trustless transactions yet face scalability, regulation, and adoption challenges.

The P2P business model has emerged as one of the most transformative, enabling individuals to transact directly without corporate intermediaries. Crowdsourcing has also proven to be a valuable mechanism for companies seeking to leverage collective intelligence, whether for data collection, open-source innovation, or funding purposes.

Despite their success, these business models face several limitations that businesses must address for long-term sustainability. Regulatory challenges persist, particularly for platform-based and blockchain-driven models, as governments struggle to establish appropriate policies for taxation, labour rights, and liability. Consumer trust and security remain critical, especially in decentralised and P2P environments, where fraud, privacy breaches, and misinformation can undermine platform credibility. Furthermore, competition in digital markets is fierce, requiring businesses to continuously innovate to retain customers and differentiate themselves.

While this research comprehensively analyses digital business models, several limitations must be acknowledged. One major constraint is industry-specific variability, as the success and applicability of these business models differ across industries. For instance, while the subscription model thrives in SaaS and streaming services, it may not be as effective in physical product-based industries. Future studies could explore how these models function in niche markets and assess their long-term sustainability in various sectors.

Another limitation is the regulatory and legal barriers associated with platform-based and decentralised business models. The study identifies regulatory concerns but does not provide an in-depth legal analysis of how different jurisdictions govern digital platforms, blockchain-based businesses, and P2P services. Future research could conduct comparative studies on global regulatory frameworks, examining how policies impact the scalability and compliance of digital businesses.

Moreover, technological advancements are rapidly reshaping digital business models. Innovations such as artificial intelligence (AI), machine learning, and blockchain technology may alter the effectiveness of freemium, SaaS, and P2P models. This study is limited in its ability to predict long-term technological disruptions, highlighting the need for continuous research into how businesses can adapt to emerging digital trends.

Finally, consumer behaviour and adoption dynamics are pivotal in the success of subscription, freemium, and crowdsourcing models. While the study discusses customer retention strategies, it does not delve into the psychological and behavioural factors influencing consumer decision-making. Further research could examine user motivations, willingness to pay for premium features, and trust mechanisms in decentralised platforms, providing a deeper understanding of how digital businesses can enhance user engagement and loyalty.

Given the evolving landscape of digital business models, several areas warrant further exploration. One key direction is the role of AI and automation in optimising business operations, customer personalisation, and fraud detection. AI-driven insights could help companies enhance P2P platforms, SaaS services, and subscription-based offerings, making them more efficient and responsive to consumer needs.

Another critical area for future research is regulatory frameworks for emerging business models. Governments worldwide are grappling with how to regulate platform economies, blockchain businesses, and decentralised finance (DeFi). A comparative analysis of regulatory best practices could provide valuable insights into policy development and compliance challenges, helping companies to navigate legal complexities while fostering innovation.

The sustainability and ethical implications of digital business models also deserve further investigation. While these models optimise efficiency and scalability, their environmental and social impacts remain underexplored. Research could assess how SaaS, crowdsourcing, and blockchain-based businesses contribute to sustainable practices, ethical labour use, and responsible data management.

Additionally, the future of hybrid business models is an emerging area of interest. Companies increasingly combine subscription, freemium, and blockchain elements to create diversified revenue streams and enhance customer experience. Future studies could examine successful hybrid models, identifying key factors contributing to their adaptability and profitability.

Finally, consumer trust and digital security are becoming pressing concerns, especially in P2P, decentralised finance, and data-driven business models. Given the rising risks of fraud, data breaches, and misinformation, research should focus on building trust mechanisms, exploring how businesses can enhance cybersecurity, ensure data privacy, and foster user confidence in digital transactions.

By addressing these research gaps, future studies can provide valuable insights into the ongoing transformation of digital business models, equipping companies with the knowledge needed to navigate technological advancements, regulatory landscapes, and evolving consumer behaviours.

Digital transformation has unlocked unprecedented opportunities for businesses to innovate and reach consumers in new ways. While each business model has unique strengths and challenges, their continued evolution will depend on technological advancements, regulatory adaptations, and changing consumer behaviours. As competition intensifies in digital markets, businesses must embrace flexibility, user-centric design, and ethical responsibility to sustain long-term success. Future research in this area will be instrumental in shaping the next generation of digital business models and their impact on the global economy.

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III. The Impact of Digital Economic Infrastructure Construction on the Development Level of Digital Economy in Countries Along the Belt and Road Initiative

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The global shift towards the digital economy necessitates accelerated development of digital infrastructure. Since the inception of the "Belt and Road" initiative, China and partner nations have significantly advanced economic cooperation. Mainly, with the introduction of the "Digital Silk Road" concept in 2017, nations along the initiative have actively pursued digital infrastructure projects. Through analysing domestic and international research, this article conducts an empirical analysis and assesses the impact of digital economic infrastructure on participating countries' digital economies. It is concluded that the level of digital economic infrastructure construction, such as mobile network coverage, fixed broadband penetration and complete Internet servers, can promote the development of the digital economy in these countries.

Keywords:
digital economy,
digital infrastructure,
Belt and Road initiative,
ICT development,
economic growth

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1 Introduction

The concept of the digital economy emerged in the 1990s. In 1995, the OECD discussed its potential trends, highlighting the shift from traditional to information processing driven by the Internet revolution. American scholar Tapscott (1996) further explored this impact in his book The Digital Economy: Promise and Peril in the Age of Networked Intelligence. In 1998, the U.S. Department of Commerce released the report The Emerging Digital Economy, outlining the transition from industrial to digital economies and emphasising key characteristics such as the Internet as infrastructure and e-commerce as an engine of growth (United States, Department of Commerce, 1998).

With the introduction of the concept of the digital economy, the international community has gradually formed a strategic consensus to develop the digital economy vigorously. Not only has the United States proposed a digital economic agenda strategy, but the European Union has also proposed a European digital agenda. It has successively introduced strategic plans such as Digital France, Digital Britain, and Digital Germany. Against this background, China has also actively implemented its big data development strategy, comprehensively promoted the construction of network power, promoted the construction of a digital China and smart society, advocated the digital economy and the sharing economy, and accelerated the construction of digital China (Nie & Zhang, 2022; Tian, 2017).

Internationally, the digital economy's importance has grown significantly. At the G20 Summit, China introduced the "China's 'Internet +' Digital Economy Index" with several departments. In 2017, the 19th National Congress of the Communist Party of China highlighted the "digital economy" for the first time, stressing integration with the Internet, big data, and artificial intelligence. President Xi Jinping reiterated this integration at the 2018 G20 Summit in Buenos Aires. In 2019, the central government prioritised R&D in big data and AI, aiming to bolster the digital economy. China's 14th Five-Year Plan for Digital Economy Development in 2022 signalled a new growth phase. On October 18, 2023, at the "Belt and Road" International Cooperation Summit Forum, China and 13 countries released the "Belt and Road" Digital Economy International Cooperation Beijing Initiative to deepen collaboration (Pan & Wan, 2020; Wang, 2017).

In the era of the digital economy, the "Belt and Road" initiative sees fresh opportunities. Technologies like mobile Internet and cloud computing have invigorated this initiative. China and Argentina's 2017 cooperation initiative aimed to foster technological, finance, and trade innovation, facilitating cross-border collaboration in e-commerce, smart transportation, and IoT. The Chinese government actively promotes the "Data Silk Road," forging partnerships with other nations for digital economy development (Fang, 2019; Geng, 2019; Liu et al., 2020).

Studying the impact of digital economy infrastructure on "Belt and Road" countries is academically significant and offers policy value. It provides policymakers with vital insights for guiding infrastructure investment decisions within the initiative. Existing literature underscores the crucial link between digital infrastructure and digital economy development. Effective infrastructure facilitates technology adoption and drives digital economy growth. Through case analyses and experience summaries, governments can receive tailored guidance for formulating policies and investments in digital infrastructure to advance digital economy development.

Secondly, studying the impact of digital economic infrastructure construction on the development level of the digital economy in countries along the "Belt and Road" will help reveal the mechanism of digital infrastructure on economic growth and innovation capabilities. Academic research can use data analysis and empirical research to deeply explore the degree and path of the impact of digital infrastructure on various fields of the digital economy, thereby providing a theoretical basis and practical experience for improving the development level of the digital economy. In addition, by comparing the policy initiatives and effects of different countries in digital infrastructure construction, we can provide a reference for other countries and promote healthy competition and cooperation in developing the global digital economy.

Finally, studying the impact of digital economic infrastructure construction on the development level of the digital economy in countries along the Belt and Road Initiative will help promote the global digitalisation process and the realisation of sustainable development goals. The development of digital economic infrastructure is important not only for economic growth and innovation capabilities but also for promoting social inclusion and sustainable development. By strengthening international cooperation and jointly promoting digital infrastructure construction and digital economic development, we can achieve the sharing of digital development results and promote the prosperity and sustainable development of the global digital economy.

Therefore, an in-depth study of the impact of digital economy infrastructure construction on the development level of the digital economy in countries along the “Belt and Road” initiative has not only important academic significance but also has important policy implications and strategic significance for promoting the development of the digital economy and promoting the global Economic growth, and sustainable development has important practical significance.

The research content layout is presented in Figure 1.

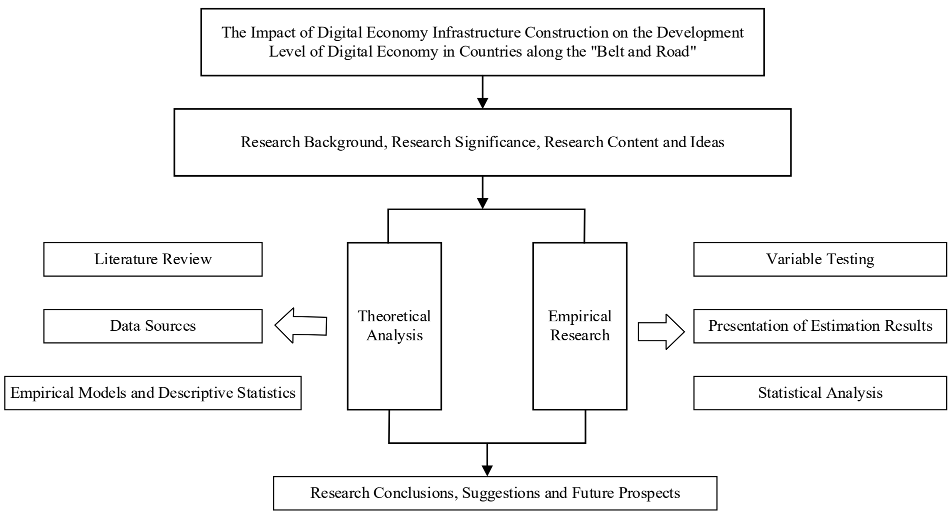

Figure 1: Research content layout

2 Literature review

2.1 Digital economy

The concept of "digital economy" was first proposed by Tapscott in the book The Digital Economy: Promise and Peril in the Age of Networked Intelligence, where he described all aspects of it in detail. One of the most classic descriptions in the book defines the digital economy as an economy that "uses bits rather than atoms" (Tapscott, 1996). With the rapid development of digital technology, the scope of the digital economy has expanded. Industries such as optical fiber, software publishing, software copying, programming services, equipment management, cables, and artificial satellite communications have all become part of the digital economy. The U.S. definition of the digital economy focuses on viewing it as the sum of measurable e-commerce and information technology industries (Terence et al., 2023). The digital economy represents a new development paradigm following the agricultural and industrial economies, where data has become a crucial means of production.

At present, the academic community primarily explores the theoretical connotation, promoting factors, and measurement systems of the digital economy. Therefore, the following literature review is divided into three perspectives.

(1) Theoretical Connotation of the Digital Economy

According to the Statistical Classification of Digital Economy and its Core Industries (2021) released by the National Bureau of Statistics of China in May 2021, the digital economy is defined as "a series of economic activities that utilise data resources." Information and communication technology (ICT) is a key factor of production in modern times, where information networks serve as an important carrier, and the effective use of ICT acts as a driving force for efficiency improvement and economic structure optimisation. The digital economy is an economic form that primarily uses digital technology for production, closely integrating capital, labour, and infrastructure construction (Li, 2017). Infrastructure construction significantly impacts local industrial structures, fostering technological progress through the "spillover effect," which enhances technological development in local enterprises (Wang et al., 2014).

Based on this theoretical framework, the digital economy includes core software and hardware, network platforms, and industrial digitisation. Network platforms promote core technological advancements while simultaneously driving industrial digitisation, ultimately enhancing efficiency and supporting the development of the real economy. Many scholars have further expanded on the connotation of the digital economy by analysing its effects. For instance, the digital economy plays a critical role in reducing search, copying, transportation, tracking, and verification costs, ultimately contributing to economic growth and productivity improvements (Goldfarb & Tucker, 2019). The core of the digital economy revolves around the development of ICT and its impact, with digital communications influencing international trade in both digital and non-digital goods (Freund & Weinhold, 2004).

(2) Promoting Factors of the Digital Economy

Domestic and foreign scholars have conducted multi-dimensional analyses of the factors that drive the development of the digital economy, summarising them into three main categories: dependence on digital lifestyles, the construction of digital economic infrastructure, and the development of digital financial policies.

First, in terms of digital lifestyles, the rapid growth of China's digital economy is largely attributed to the widespread adoption of digital applications in daily life. The convenience and improved quality of life of digitalisation have significantly increased people's interaction with digital technologies. According to CNNCI (2022), the number of internet users in China reached 1.051 billion, with an internet penetration rate of 74.4%, highlighting China's status as the world's largest digital society, where digital applications have permeated all aspects of life. Online shopping, in particular, has become a defining characteristic of China's digital economy.

Second, Terence Tai Leung Chong argues that China's digital economy has flourished due to its strong foundation in digital infrastructure (Terence et al., 2023). Furthermore, scholars such as Chen emphasise that developing a country's digital economy is closely tied to expanding and enhancing national infrastructure, particularly information infrastructure that bridges urban and rural areas (Chen & Kang, 2018). As a global leader in infrastructure development, China has made remarkable progress in digital infrastructure. By the end of 2021, the number of data centre servers in China had reached 5.2 million, with an annual growth rate exceeding 30%. In 2021, China's cloud service market reached 322.9 billion yuan, and communication infrastructure development continued to accelerate. China's high-quality and large-scale digital infrastructure has provided a solid foundation for the digital economy.

Finally, according to the McKinsey Global Payments Report (2022), China is now a global leader in digital financial services. This achievement is closely linked to the country's financial policies, which have played a crucial role in fostering growth in this sector. Hasan et al. (2022) argue that the promise of high-interest returns has motivated private investors, microfinance companies, and financing guarantee companies to enter the peer-to-peer (P2P) industry since 2013, establishing China as a dominant force in digital financial services.

(3) Measurement System for the Development Level of the Digital Economy

Regarding systematically measuring the digital economy's development level, Chinese and international institutions have introduced various digital economy-related indices (see Table 1). Additionally, numerous scholars have provided theoretical insights and explanations regarding measurement methodologies. Xu et al. (2018) conducted a comparative analysis of 12 international and domestic digital economy-related index systems, evaluating their advantages, limitations, and reference values. Their study highlights the importance of index framework design and survey data collection mechanisms as key elements for reference.

Table 1: List of China and Worldwide Digital Economy Related Indicator Systems

	Index Name	Issuing Authority	Relevancy	Release Time	Source from
China	Digital Economy Index	China Academy of Information and Communications Technology	High	2017	White Paper on the Development of China's Digital Economy (2017)
	Global Digital Economy Competitiveness Index	Shanghai Academy of Social Sciences	High	2017	Global Digital Economy Competitiveness Development Report (2017)
	"Internet +" Digital Economy Index	Tencent Group	High	2017	China "Internet +" Digital Economy Index 2017

	Index Name	Issuing Authority	Relevancy	Release Time	Source from
	China City Digital Economy Index	New H3C Group	Relatively High	2017	China City Digital Economy Index White Paper (2017)
Worldwide	Digital Economy and Society Index (DESI)	European Union	High	2014	DESI 2017: Digital Economy and Society Index
	Evaluation & Suggestions on the Digital Economy	U.S. Department of Commerce Digital Economy Advisory Council	High	2016	Measuring the Digital Economy-BEA
	Network Readiness (NRI)	World Economic Forum	Relatively High	2004	The Global Information Technology Report2016
	ICT Development Index (IDI)	ITU	Relatively High	1995	Measuring the Information Society Report2017

Thomas L. Mesenbourg (2001) notes that definitions of the digital economy are intentionally broad to create an inclusive framework for planning statistical measures. This flexibility allows researchers and policymakers to continuously adapt and incorporate emerging trends in the digital economy.

2.2 Research on constructing digital economic infrastructure in China and countries along the "Belt and Road"

First, before deeply understanding the construction of digital economic infrastructure in China and countries along the Belt and Road, it is necessary to examine relevant research on the definition of digital economic infrastructure. The foundation must first be established if one wants to build a house. General Secretary Xi Jinping has emphasised the importance of building solid digital infrastructure as the cornerstone of development in the information age. In February 2014, President

Xi Jinping emphasised "the need to have good information infrastructure and form a strong information economy at the first meeting of China's Central Leading Group on Cyber Security and Informatization."

Many scholars define digital economic infrastructure as both a factor of production and its application. For example, Junmo Kim (2006) defines digital infrastructure as the digital equipment manufacturing industry, which facilitates data collection, transmission, and production execution through sensors, networks, and other basic hardware, enabling data storage, analysis, and application in the digital industry. Pan and Wan (2020) offer a broader definition, identifying ten major infrastructure areas, including intelligent digital infrastructure, digital technological innovation infrastructure, modern energy, modern transportation, and national security and governance infrastructure. Additionally, Nong (2022) integrates multiple scholarly perspectives, categorising digital economic infrastructure into hard infrastructure, represented by traditional communications, cloud computing, the Internet of Things, and blockchain technology, and soft digital economic infrastructure, aimed at ensuring network security.

Regarding research on digital economic infrastructure, Grimes (2003) points out that Internet infrastructure is necessary for developing the digital economy. Roxburgh (2011) further highlights that digital economic infrastructure plays a critical role in transforming and upgrading basic industries, with a particularly significant impact on small and medium-sized enterprises.

Regarding the importance of digital economic infrastructure in economic activities, existing literature generally agrees that digital economic infrastructure has strong spillover effects on economic growth and contributes to economic transformation and high-quality development. Early scholars focused on exploring the relationship between Internet infrastructure and economic growth, confirming through empirical research that telecommunications infrastructure significantly promotes national economic growth and plays a crucial role in economic transformation. Wang (2017) argues that achieving information interconnection between China and ASEAN is a key aspect of international cooperation under initiatives such as the 21st Century Maritime Silk Road. Network construction and deepening interconnectivity have also become important components of the Belt and Road initiative (Fang, 2019). The construction of information network infrastructure and sharing public information resources provide crucial information support for the Belt and Road initiative (Geng, 2019).

Finally, in terms of the role of digital economic infrastructure in trade promotion, empirical studies indicate that investments in communications, transportation, and technological infrastructure in Belt and Road countries significantly enhance national trade competitiveness (Xin & Li, 2020).

2.3 Summary

To sum up, existing research primarily focuses on in-depth discussions and analyses of the digital economy's theoretical connotation, promotion factors, and measurement systems. Most studies agree that the digital economy relies on information and communication technology (ICT) as its core element, with modern information networks serving as the carriers that effectively utilise ICT to enhance efficiency and optimise economic structures. Additionally, reliance on digital lifestyles, digital economic infrastructure development, and the robust expansion of digital financial policies constitute the multi-dimensional factors driving a country's digital economy. At the same time, many scholars emphasise that digital economic infrastructure plays a critical role across multiple sectors and contributes to economic transformation and high-quality development.

However, much existing research primarily concentrates on the theoretical framework, development planning, statistical measurement, and economic implications of digital economic infrastructure construction. From a micro perspective on infrastructure, limited literature comprehensively considers and empirically analyses digital economic infrastructure in a detailed and structured manner. Additionally, due to the "intentionally broad" definition of digital economic development (Mesenbourg, 2001), most empirical studies remain at a macro and general level, incorporating broad digital economy indicators such as ICT frontier metrics and digital economic infrastructure, including internet server connectivity indicators, into empirical research. This inclusion aligns with the evolving needs of the digital economy and contemporary development trends.

3 Data sources, empirical models and descriptive statistics

3.1 Data Sources

Taking the countries along the "Belt and Road" as the research object, based on the reliability and availability of the above indicator data, countries with serious missing indicator data were deleted, and finally, the data of 38 countries along the "Belt and Road" including China from 2000 to 2022 were selected (see Table 2). The relevant data covers six major regions, and important areas along the "Belt and Road" are not missed. China's statistics do not include Hong Kong, Macao and Taiwan. The data mainly comes from the World Development Indicators, World Bank database, etc. (see Tables 2, 3&4).

Table 2: Sample of countries along the Belt and Road

Regions and Areas	Main Countries
East Asia and ASEAN	China, Mongolia, Indonesia, Malaysia, Thailand, Vietnam, Brunei, Philippines, Singapore
Central Asia	Kazakhstan, Kyrgyzstan
South Asia	Sri Lanka, Nepal, Pakistan, Bangladesh
CIS	Ukraine, Georgia, Russia, Azerbaijan, Moldova, Armenia
West Asia	Bahrain, Israel, Saudi Arabia, Cyprus, Jordan, Egypt, Iran

Table 3: Comprehensive indicator system for digital economy infrastructure construction

First Level Indicator	Secondary Indicators	Indicator Description	Source from
Digital Economy Infrastructure Construction	Mobile Network Coverage	Mobile Network Subscriptions Per 100 People	World Bank Database
	Landline penetration rate	Mobile Phone Subscriptions Per 100 People	World Bank Database
	Fixed broadband penetration	Fixed broadband subscriptions per 100 people	World Bank Database
	Secure Internet Servers (per million people)	Number of secure Internet servers per million people	World Bank Database
	Mobile cellular subscriptions	Mobile cellular subscriptions per 100 people	World Bank Database

Table 4: Comprehensive Indicator System for Digital Economy Development Level

First level Indicator	Secondary Indicators	Indicator Description	Source from
Digital Economy Development Level	ICT Service Export	Earnings by the country from the provision of ICT-related services	WDI
	Information and Communication Services Export	Export volume of Information and Communication Services	WDI
	Number of ICT-related Papers Published	Number of Scientific Papers Published Related to Information and Communications Technology	WDI
	R&D Expenditure as a Share of GDP	National Expenditure on R&D Activities as a Share of GDP	WDI
	ICT Cutting-edge Technology Readiness	Measure the Country's Technological Reserves and Readiness in the Field of Information and Communications Technology	WDI
	Availability of Latest Technology	Ability and Ease of Access to the Latest Information and Communications Technologies	WDI

3.2 Empirical models and descriptive statistics

When measuring the development level of the digital economy, this study analyses the digital economy from six indicators: ICT service exports, information and communication service exports, the number of ICT-related paper publications, the proportion of R&D expenditures in GDP, ICT cutting-edge technology readiness and the availability of the latest technology. The impact of infrastructure on the development level of digital economy in countries along the “Belt and Road”. Based on the panel data of six major regions from 2000 to 2022, this study uses the least squares method to conduct further empirical analysis. The specific model is as follows.

$$Yi=\beta 0+\beta 1X1+\beta 2X2+\ldots+\beta nXn+\varepsilon \tag{1}$$

Yi (i=1,2,…,n) is the explained variable, that is, the relevant indicators of the development level of the digital economy; x1, x2,..,xn are the explanatory variables, that is, the relevant indicators of the digital economy infrastructure construction; β1, β2,..,n, is the coefficient of the OLS model, indicating the impact of the independent variable on the dependent variable, and ε is the error term.

To eliminate the influence of outlying values, this study first winsorises all continuous variables, eliminating samples below the 1% quantile and above the 99% quantile. At the same time, variables with larger values (number of ICT-related paper publications, secure Internet servers, mobile cellular subscriptions) are subjected to natural logarithm processing, and the descriptive statistics are as follows (see Table 5).

Table 5: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Y1	793	9.615	10.156	.326	48.867
Y2	823	35.124	15.871	7.043	77.644
Y3	481	7.291	1.902	2.833	12.145
Y4	614	.794	.807	.048	4.255
Y5	532	.506	.226	.079	.947
Y6	420	4.793	.74	3.215	6.354
X1	866	41.555	29.976	.24	97.862
X2	889	18.598	12.407	.548	51.866
X3	814	10.647	10.523	.002	37.36
X4	429	5.387	2.781	-.308	11.33
X5	892	4.135	1.228	-.929	5.167

From the descriptive statistics results, on the one hand, in terms of the explained variables, first of all, Y1 shows significant dispersion, with an average value of 9.615 but a standard deviation as high as 10.156, which reflects the dispersion of this indicator in the entire data set. Greater volatility. Secondly, the mean value of Y2 is approximately 35.124, and the standard deviation is 15.871, which shows that although these countries have huge potential and development opportunities in the field of the digital economy, the actual situation shows an obvious imbalance. Furthermore, in terms of Y3, the mean is 7.291, and the standard deviation is 1.902, implying lower publication volume volatility among regions or countries. In addition, the mean value of Y4 is about 0.794, and the standard deviation is 0.807, which shows obvious differences in the degree of investment in innovation among the sample countries. Coincidentally, the standard deviation of Y5 is 0.226, which further reflects the obvious imbalance in ICT technology preparation among regions, with values ranging from 0.079 to 0.947. Finally, the mean value of the latest technology accessibility is about 4.793, with a standard deviation of 0.74, which shows significant differences in access to the latest technology across regions, possibly due to the relative lag in economic development of some countries along the Belt and Road. It faces greater challenges in acquiring the latest technology, a weak foundation for scientific and technological innovation, a shortage of technical talents and other reasons.

On the other hand, in terms of explanatory variables, X1 has a mean of about 41.555% and a standard deviation of 29.976%. Regarding X2, there are significant differences in the coverage and popularity of these indicators in countries and regions along the Belt and Road. The average values of X4 and X5 are approximately 5.387 and 4.135, and the standard deviations are also large, which reflects the significant volatility of these two variables in different regions.

This study proposes:

Null hypothesis H0: *The explanatory variables related to the construction of digital economy infrastructure have no significant impact on the explained variables related to the development level of digital economy in the countries along the "Belt and Road".*

Hypothesis H1: *Explanatory variables related to digital economy infrastructure construction have a significant promoting effect on explanatory variables related to the development level of digital economy in countries along the "Belt and Road".*

4 Empirical analysis

4.1 Variable test

After testing, the variance inflation factors between the respective variables are all less than 10, indicating no multicollinearity problem in our empirical analysis. This result gives us more confidence in the model we built because it shows that the independent variables we used are not highly correlated and will not affect the stability and accuracy of the model. Multicollinearity can lead to inaccurate or unreliable model coefficient estimates, but we can continue the analysis with confidence in this case.

In addition, we chose to use robust standard errors to build the OLS linear regression model to solve the possible heteroskedasticity problem. Heteroscedasticity may lead to low standard errors in the model, affecting the accuracy of parameter estimates and the reliability of confidence intervals. By using robust standard errors, we can better cope with the existence of this heteroskedasticity and ensure the accuracy and credibility of the model estimation results. As a result, we can conclude with greater certainty and have greater confidence in the trustworthiness of our findings.

4.2 Estimation results and statistical analysis

Joint significance test

From the test results in Table 6, it can be seen that the F statistics of each group of models are large. The corresponding p values are less than 0.01, indicating that at the 1% significance level, the null hypothesis H0 should be rejected: All independent variables have no significant impact on the dependent variable, indicating that at least one independent variable has a significant impact on the dependent variable. The goodness of fit r2 and the corrected goodness of fit adj_r2 of the model with Y4 as the dependent variable are both large, indicating that the changes in the independent variables explain the changes in the dependent variables to a greater extent, and the model has good fit. Both r2 and adj_r2 are small, indicating that changes in independent variables generally explain changes in dependent variables well.

Table 6: OLS Linear Regression Model Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)
	Y1	Y2	Y3	Y4	Y5	Y6
X1	-0.177***	0.127*	-0.00321	0.00211	0.00377***	0.00809***
	(-5.68)	(1.91)	(-0.47)	(0.75)	(10.60)	(3.11)
X2	0.103	0.268***	-0.0332***	0.0145**	0.00237***	-0.00296
	(1.57)	(3.62)	(-2.91)	(2.29)	(3.13)	(-0.83)

	(1)	(2)	(3)	(4)	(5)	(6)
	Y1	Y2	Y3	Y4	Y5	Y6
X3	0.0905	-0.0552	0.0614**	0.0388***	0.00227**	0.0317***
	(1.22)	(-0.36)	(2.48)	(5.04)	(2.00)	(3.83)
X4	1.712***	1.257**	0.0895	-0.0226	0.0283***	-0.00690
	(5.77)	(2.51)	(1.21)	(-0.97)	(9.23)	(-0.29)
X5	-14.45***	-10.27**	-0.863	-0.310**	0.00266	-0.128
	(-5.47)	(-2.45)	(-1.65)	(-2.02)	(0.11)	(-0.76)
_cons	76.80***	65.92***	10.72***	1.437**	0.0709	4.721***
	(6.29)	(3.57)	(4.47)	(2.12)	(0.68)	(6.53)
N	386	394	399	313	410	302
F	21.23	21.85	8.408	27.88	392.3	44.04
p	0.000	0.000	0.000	0.000	0.000	0.000
r2	0.189	0.181	0.0818	0.315	0.792	0.361
r2_a	0.178	0.171	0.0701	0.304	0.790	0.350

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Regression coefficient t-test

Y1: Increasing mobile network coverage by 1 unit significantly decreases ICT service exports by 0.177 units. A 1% increase in secure Internet servers (X4) boosts ICT service exports by 1.712 units, while a similar increase in mobile cellular subscriptions significantly reduces 14.45 units.

Y2: Mobile network coverage (x1) positively impacts information and communication service exports (Y2) by 0.127 units. A 1% increase in fixed telephone penetration (x2) raises Y2 by 0.268 units. The number of secure Internet servers (X4) positively influences Y2, while mobile cellular subscriptions (X5) have a significant negative impact.

Y3: Increasing fixed phone penetration (x2) by 1% decreases ICT-related paper publications by 3.32% at a 1% significance level. Conversely, a 1% increase in fixed broadband penetration (x3) significantly increases ICT-related paper publications by 6.14% at a 5% significance level.

Y4: Increasing fixed phone penetration (x2) by 1% correlates with a 0.0145% increase in the proportion of R&D expenditure in GDP at a 5% significance level. Similarly, a 1% increase in fixed broadband penetration leads to a 0.0388% increase in the proportion of R&D expenditure in GDP at a 1% significance level.

Y5: Mobile network coverage (x1), fixed phone penetration (x2), and secure Internet servers (x4) significantly impact ICT frontier technology readiness at a 1% significance level. Additionally, a 1% increase in fixed broadband penetration significantly increases Y5 at a 5% significance level.

Y6: Both mobile network coverage (x1) and fixed broadband penetration (x3) positively influence the availability of the latest technology at a 1% significance level. Specifically, a 1% increase in mobile network coverage increases availability by 0.00809 units, while a similar increase in fixed broadband penetration increases availability by 0.0317 units.

5 Conclusion

Main conclusions

It can be seen from this that the impact of digital economic infrastructure construction on the development level of the digital economy in countries along the Belt and Road is complex and diverse. In the regression model with ICT service exports as the dependent variable, the significant positive impact of mobile network coverage suggests the key role of mobile networks in digital economic infrastructure, which is consistent with the discussion of the importance of digital infrastructure in the literature. However, in the model of information and communication services exports, the positive impact of mobile network coverage is observed with the positive impact of fixed-line telephone penetration, which may reflect the comprehensiveness of communication infrastructure in terms of information and communication services exports. Development plays a key role in expanding the market. In addition, for the model of the number of ICT-related paper publications, the negative impact of fixed phone penetration may reveal certain constraints of fixed communication infrastructure on digital economic innovation activities. The research results on the proportion of R&D expenditures in GDP highlight the close relationship between the improvement of digital infrastructure and technological innovation, which is related to the importance of technological investment and innovation capabilities in the development of the digital economy. Overall, the above model results provide in-depth insights into the development of the digital economy in countries along the Belt and Road and provide an important academic basis and decision-making reference for relevant policy formulation.

Suggestions for digital infrastructure construction

(1) Strengthening digital infrastructure coverage and quality improvement

Digital infrastructure plays a key role in the modern economy. However, some developing countries face challenges in constructing digital infrastructure due to limitations in capital, technology, and talent. Therefore, China can assist these countries in building modern digital infrastructure and achieve seamless connections between network facilities and information technology by providing financial support, technical assistance, and personnel training. At the same time, special funds and assistance projects will be established to provide low-interest funds to these countries along the route, accelerate the popularisation and implementation of digital infrastructure, and help develop their digital economy. In addition, given the positive impact of mobile network coverage on ICT service exports and information communication service exports, the government should increase investment in digital infrastructure construction, especially in strengthening the coverage of mobile communication networks and improving network quality. This includes strengthening infrastructure construction in remote areas and developing countries to ensure the inclusiveness and sustainability of digital economic development.

(2) Promoting the upgrade and innovation of communications infrastructure

Strengthen the digital technology innovation capabilities of countries along the "Belt and Road" and promote the balanced development of the digital economy in countries along the "Belt and Road". To solve the gap in the development level of the digital economy, countries along the "Belt and Road" can promote in-depth cooperation between relevant academic circles, research institutions and enterprises and countries along the route and make full use of research and innovation opportunities in areas of common interest and the initiative of a community with a shared future for mankind. In addition, countries along the "Belt and Road" can also carry out joint training projects for digital technology talents to promote technological innovation exchanges and provide intellectual support for developing the digital economy. In particular, fixed communications infrastructure remains an important component of the development of the digital economy. The government should encourage and support the upgrading and innovation of fixed communications infrastructure to improve its role and efficiency in digital economic innovation and development.

(3) Increasing investment in scientific research and development

Since the proportion of R&D expenditure in GDP is closely related to the improvement of digital infrastructure and technological innovation, the government should increase investment in technological R&D. This includes increasing government financial support for scientific research institutions and enterprises, encouraging enterprises to increase independent innovation, and promoting the development of digital technology and innovation.

Establish a transnational cooperation mechanism: Facing the huge investment needs and complex challenges in the construction of digital economic infrastructure, countries along the Belt and Road should strengthen the establishment and deepening of transnational cooperation mechanisms to promote the interconnection and shared development of digital infrastructure jointly. This includes strengthening the construction of international cooperation platforms, promoting information sharing and technology exchanges, and jointly responding to challenges and risks in the development of the digital economy.

Research prospects

In future research, in addition to exploring the impact of digital economic infrastructure construction on the development level of the digital economy in countries along the Belt and Road, we can also further explore the complex interactive relationships between different digital economic infrastructure elements. Specifically, research can be carried out from the following two aspects.

The synergy between infrastructure elements: Conduct a comprehensive analysis of digital economy infrastructure elements such as mobile network coverage, fixed phone penetration, number of secure Internet servers, etc., and explore the synergy between them. For example, will the increase in mobile network coverage have an impact on fixed phone penetration, or will the increase in the number of secure Internet servers have an impact on mobile network coverage?

The relationship between technological innovation and digital economic infrastructure construction: Study the role of technological innovation in promoting digital economic infrastructure construction and explore the impact and application of emerging technologies, such as artificial intelligence, big data, cloud computing, etc., on digital economic infrastructure construction, as well as technology How innovation accelerates the updating and upgrading of digital economic infrastructure.

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IV. The Impact of Digital Economy on Innovation Performance Among Belt and Road Countries

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The digital economy has deeply influenced all sectors of national economic development, becoming a critical engine for global economic growth and national innovation performance. Nevertheless, significant gaps persist among developed, developing, and less-developed countries in their levels of digital economic advancement. Given this imbalance, exploring how the digital economy impacts innovation performance in "Belt and Road" countries is essential. This study examines mechanisms through which the digital economy influences innovation performance across these nations. Findings provide valuable insights to enhance competitiveness, support innovation, and address global disparities. The study offers practical recommendations for policymakers in "Belt and Road" countries aiming t.

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1 Introduction

The digital economy, as a new economic form, has been widely considered around the world because of its characteristics of high efficiency, intelligence, and greenness. At present, the world is facing technological and industrial innovation, digital economy, as an important driving force for global economic growth, is having an important impact on the innovation-driven development of the social economy of countries along the "Belt and Road", the Belt and Road Initiative aims to strengthen economic, political, cultural and other fields of cooperation among countries along the route, and achieve common prosperity. Therefore, it is significant to explore the impact of the digital economy on the innovation performance of Belt and Road countries to achieve the common prosperity of China and countries along the Belt and Road.

2 Literature review

In recent years, the digital economy has received extensive attention and research worldwide. Many scholars have discussed the impact of the digital economy on economic growth, employment and innovation from different perspectives. In particular, the integration and development of the digital economy and the local economy and its impact on innovation performance have become the focus of research, and many authors have done a lot of research on innovation performance based on the digital economy. Based on the existing literature's research on the impact of the digital economy on innovation performance, Li and Mao (2023) conducted a more in-depth study on the regional differences and spatial effects of the digital economy on innovation performance in countries along the "Belt and Road". It is concluded that the digital economy can significantly improve countries' innovation performance along the "Belt and Road". It has a stronger promoting effect on countries with a higher level of digital economy development (Li and Mao, 2023). The existing literature mainly carries out a series of studies on the innovation performance of the digital economy from the aspects of market, network and region after the digital economy promotes global economic growth.

At the market level, Dong (2023) discusses the impact of the development of the digital economy on the innovation performance of commercial circulation enterprises and its mechanism. It is believed that the development of a digital economy can promote the improvement of the innovation performance of commercial circulation enterprises by stimulating enterprises to increase R&D investment and optimise their human capital structure. Tang et al. (2022) found through their research that the development of the digital economy promoted the improvement of innovation performance overall, but it had a typical dynamic nonlinear impact. Hou et al. (2021) put the digital economy, market integration and enterprise innovation performance into the same analytical framework. They tested the impact mechanism and path of digital economy and market integration on enterprise innovation performance. The results show that both digital economy and market integration are conducive to promoting the improvement of enterprise innovation performance. The digital economy has a positive regulating effect on the innovation incentive effect of market integration.

At the network level, Xin et al. (2022) discussed the economic effects of dual network embedment on innovation performance from the perspective of social networks and digital networks of digital economy enterprises. They believed that social networks and knowledge networks can effectively alleviate the financing constraints of enterprises, thus improving innovation performance. Chen (2021) explored how enterprise network embeddedness affects the decision of enterprise openness to innovation, thus affecting enterprises' innovation performance. The experimental conclusion shows that innovation network structure embeddedness has a significant positive impact on both innovation quantity and innovation quality. In contrast, relationship embeddedness has a U-shaped effect on innovation quantity.

At the regional level, Liu (2022) tested the internal impact between the development of the digital economy and regional innovation performance, and the final study showed that the development of the digital economy had a significant positive impact on regional innovation performance, and this impact was characterised by increasing "marginal effect". Through research, Xu and Hou (2020) found that the development of the digital economy significantly promoted the improvement of regional innovation performance. The development of the digital economy has a nonlinear effect of increasing marginal effect on regional innovation performance and invention innovation performance. The development of the digital economy has a significant negative impact on the innovation performance and non-invention innovation performance of neighbouring regions. However, it has no significant impact on invention innovation performance. Accordingly, corresponding policy suggestions are put forward. Based on previous studies, this paper will explore the internal impact of the digital economy on the innovation performance of Belt and Road countries, which is of great significance for the in-depth cooperation between China and "Belt and Road" countries to improve innovation performance.

3 Digital economy and innovation performance status and characteristics

3.1 Analysis of the current situation and characteristics of the digital economy

Based on digital technology, the digital economy promotes the digital, networked and intelligent development of economic activities by mining and utilising data resources. In recent years, the scale of the digital economy has continued to expand, with a growth rate far exceeding that of the traditional economy. The wide application of the Internet, big data, artificial intelligence and other technologies has provided a solid foundation for the rapid growth of the digital economy; the digital economy has penetrated various industries, including retail, finance, manufacturing, etc. Digital technology has improved production efficiency, reduced operating costs, and brought more choices to consumers. At the same time, the globalisation trend of the digital economy has become increasingly obvious. Multinational enterprises use digital technology to break geographical restrictions and realise the optimal allocation of resources.

First of all, the digital economy level of Belt and Road countries is measured by Internet popularity. According to data availability, this paper will evaluate the mobile network coverage rate, fixed telephone penetration rate and fixed broadband penetration rate obtained from the WDI database. It can be seen from Table 1 that the development level of the overall digital economy of the countries along the "Belt and Road" from 2010 to 2022 continues to rise. From Table 1, it can be seen that the growth rate of network penetration of the countries along the "Belt and Road" is fluctuating but tends to increase slowly. Rapid growth in fixed broadband penetration between 2010 and 2022. In addition, the number of fixed and mobile phones in the countries along the "Belt and Road" has been increasing, and the ICT infrastructure has been continuously improved, laying a good foundation for developing the digital economy. The continuous popularisation of fixed broadband, mobile broadband and the Internet has provided great convenience for the application of the digital economy industry. This will also, to a certain extent, promote the competitiveness of ICT innovation, the "Belt and Road" countries along the increasing attention to the cultivation of human capital, technology research and development capabilities and innovation and transformation capabilities are gradually enhanced, providing technical support for the development of the digital economy. Under the combined effect of the above mobile network coverage rate, fixed telephone penetration rate, and fixed broadband penetration rate, the development level of the digital economy in the "Belt and Road" countries continues to improve.

Table 1: Internet penetration rate in Belt and Road countries

	Mobile network coverage	Fixed-line telephone penetration	Fixed broadband penetration
2010	29.068	16.397	7.060
2011	31.810	16.042	7.560
2012	34.763	15.947	8.280
2013	37.354	15.505	8.954
2014	40.448	15.166	9.414
2015	43.123	15.032	10.015
2016	46.533	14.300	10.325
2017	49.759	13.962	11.151
2018	49.124	12.926	11.280
2019	55.770	13.480	12.119
2020	58.697	13.398	13.042
2021	62.106	13.086	13.455
2022	21.939	10.947	12.295

Data source: WDI database

From the perspective of the export situation of digital economy-related enterprises, ICT service exports generally show a steady growth trend from 2010 to 2022, and reach a rising peak in 2020, but there is a significant decline in 2022. The growth of the export of information and communication services is generally consistent with that of the export of ICT services, which also achieved substantial growth in 2020 and a relatively large decline in 2022, with a large fluctuation in these two years; the details are shown in Table 2.

Table 2 Export situation of enterprises related to the digital economy

	ICT service exports	Export of information and communication services
2010	1125.603	5079.153
2011	1199.968	5056.822
2012	1156.491	5134.032
2013	1263.063	5450.064
2014	1265.680	5715.392
2015	1171.760	5596.611
2016	1167.775	5668.293
2017	1099.051	5444.081
2018	1112.436	5437.910
2019	1140.241	5512.053
2020	1635.700	6302.020
2021	1593.677	5615.014
2022	1012.502	3628.660

Data source: UNCTAD database

3.2 Analysis of current situation and characteristics of innovation performance

Innovation performance refers to the achievements and benefits achieved by enterprises in innovation activities. Innovation performance reflects the achievements and benefits of enterprises in innovation activities. In the era of the knowledge economy, the level of innovation performance directly determines the competitiveness of enterprises. With the increase of innovation input, enterprises have made remarkable achievements in product innovation, process innovation and organizational innovation, which effectively improves the competitiveness of enterprises. The Global Innovation Index (GII), jointly constructed by Cornell University, InSEAD and the World Intellectual Property Organization (WIPO), is a comprehensive indicator for evaluating innovation performance. This paper will use this data to evaluate the innovation performance of the Belt and Road countries.

From the perspective of overall innovation performance, from 2011 to 2023, the overall innovation performance of the countries along the Belt and Road fluctuates, but the change is small. As can be seen from Figure 1, the level of innovation output drops from 32.47 to 27.67, which may be due to the low level of digital economy development in most countries along the Belt and Road. Solidified at the downstream level, it is difficult to promote improving innovation performance.

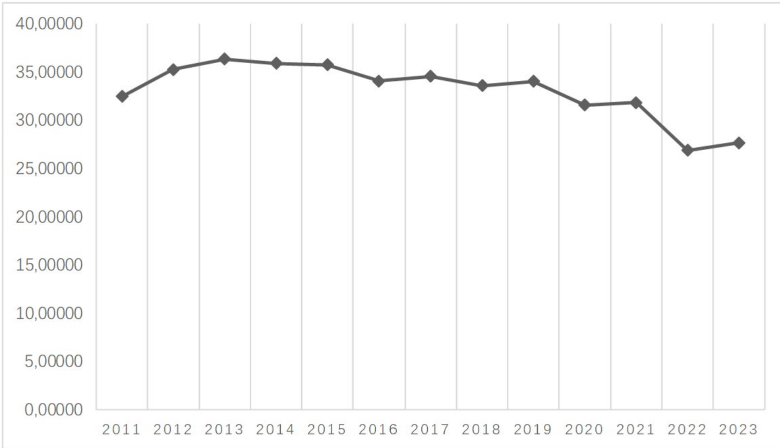

Figure 1: Average innovation index of Belt and Road countries
Data Source: Global Innovation Index Report

Secondly, from the perspective of sub-regional innovation performance, there is a big difference in the average annual growth rate of innovation output in Europe, Asia, and Africa from 2011 to 2023. The innovation output in Europe is at a higher level and its growth is relatively stable. This also reflects from the side that the innovation performance in Asia and Africa has a huge room for growth.

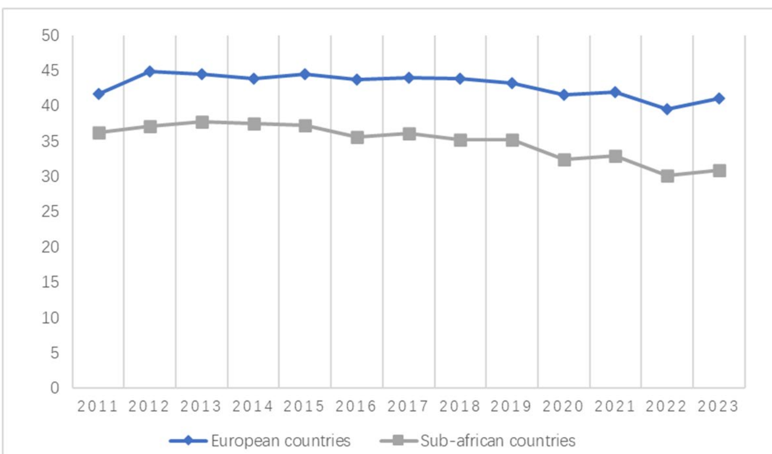

Figure 2: Average innovation index for Europe and Asia Africa
Data Source: Global Innovation Index Report

From the perspective of the innovation performance of various countries, there are also large differences in the level of innovation output of sample countries along the Belt and Road from 2010 to 2023. As can be seen from Table 3, the top five countries with annual average growth rates from 2010 to 2023 are Italy, Philippines, Indonesia, Lithuania and Greece.

Table 3: The top 30 Belt and Road countries in the Innovation Index (unit:%)

Rank	Nation	Average annual growth rate
1	Italy	0.011
2	The Philippines	0.010
3	Indonesia	0.008
4	Republic of Lithuania	0.008
5	Greece	0.008
6	Estonia	0.007
7	Portugal	0.005
8	Austria	0.004
9	The United Arab Emirates	0.003
10	Singapore	0.003
11	Denmark	0.003
12	Belgium	0.002
13	Latvia	0.002
14	Bulgaria	0.002
15	Israel	0.001
16	Cyprus	0.001
17	Australia	0.001
18	Vietnam	-4.535
19	Morocco	-0.001
20	Thailand	-0.001
21	Croatia	-0.001
22	Norse	-0.002
23	Luxembourg	-0.002
24	Georgia	-0.002
25	Czech Republic	-0.003
26	Saudi Arabia	-0.003
27	Slovenia	-0.004
28	Ukraine	-0.004
29	Jamaica	-0.004
30	Romania	-0.004

Data Source: Global Innovation Index Report

The bottom five countries - Slovenia, Ukraine, Jamaica, and Romania - have large differences in average annual growth rates, which also indicates large differences in innovation performance among countries in the same region.

4 The impact mechanism of digital economy on the innovation performance of "Belt and Road" countries

In Figure 3, we present the impact mechanism of how the digital economy, through technological innovation, industrial upgrades, and new business forms and models, affects innovation performance, which is explained in more detail in the following subsections.

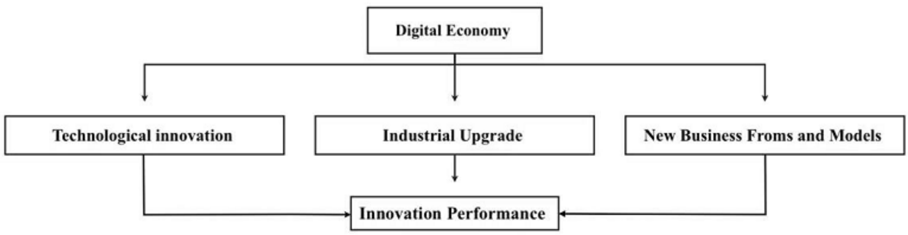

Figure 3 Impact Mechanism

4.1 Digital economy promotes technological innovation

Through the wide application of digital technology, the technological innovation of the countries along the Belt and Road is promoted in the transformation and upgrading of traditional industries, and the cultivation and development of emerging industries and innovation performance is improved. The digital economy has a direct transmission mechanism for the improvement of innovation performance, mainly through three levels.

First, digital technology is the foundation of the development of the digital economy and the driving force for the iterative upgrading of new business forms and models. It will also stimulate consumers' innovative demand for product diversification. The one-way output flow of traditional producers and suppliers will be transformed into a two-way exchange flow between producers and suppliers, thus promoting the increase of product output and the expansion of service types and gradually producing scale effects. By increasing returns to scale, various production costs can be saved, which improves the R&D efficiency of innovation entities and ultimately improves the innovation performance of the entire region.

Second, the digital economy breaks the limitation of time and space and expands the path and scope of information transmission, thus promoting the spillover of information, which makes it more convenient for innovation subjects and participants of innovation activities to obtain external information and enjoy efficient innovation services more easily, thus releasing the innovation spillover dividends in the digital economy. In addition, the digital economy has changed traditional industries' innovation methods and promoted emerging industries' innovation methods. In order to meet the diversified innovation needs of consumers, innovation entities will continuously improve their innovation capabilities. After consumers enjoy the innovation spillover dividends the digital economy brings, they will put forward higher level and dynamic innovation needs. Encourage innovation entities to enhance the innovation spillover effect further and achieve a virtuous cycle of continuous improvement of the digital economy and innovation performance.

Third, the development of the digital economy will optimise products and promote the improvement of product quality. On the one hand, the expansion of product scale and the increase of product types increase the complexity of the economic system and bring new matching problems. In this process, the digital economy improves the flow efficiency of production factors, speeds up the diffusion of logistics, capital flow, business flow and information flow, optimises the environment for the use of factors, reduces the cost of factor flow, and thus promotes the optimal allocation of various production factors. In addition, the development of digital technologies such as big data, the Internet, and blockchain has provided solutions to the matching problems in the economic market. On the other hand, the digital economy makes the market more transparent, reduces the information asymmetry between the supply and demand of innovation factors, intensifies competition among enterprises, and forces them to improve their innovation ability, produce more optimised products, and thus improve innovation performance.

4.2 Digital economy helps industrial upgrading

The development of the digital economy will help countries along the Belt and Road optimise and upgrade their industrial structure, promote the development of traditional industries in the direction of high-end, intelligent and green, and improve the overall innovation performance of industries. The digital economy improves innovation performance by promoting the optimisation and upgrading of traditional industries. The digital economy is characterised by high permeability and creativity. Digital technologies and digital services have penetrated every link of traditional industries through big data, cloud computing, information technology and other means, changing the production mode and organisation mode of traditional industries, stimulating the innovation ability of traditional industries, and promoting the optimal allocation of production factors of various traditional industries. It has promoted the upgrading of the industrial chain of traditional industries to the middle and high-end, helped the transformation of traditional industries to the direction of digitalisation and intelligence, and reconstructed the industrial ecology of traditional industries. In contrast, the transformation and optimisation of traditional industries have further provided a strong driving force for the improvement of industrial innovation performance.

On the other hand, the digital economy improves innovation performance by promoting the formation of new industries. The high permeability of the digital economy breaks the boundaries between industries, promotes the deep integration of information and communication technology with various fields, accelerates the speed of upstream and downstream integration of the industrial chain, and then realises the increase of product types and the innovation of product models through digital industrialisation and industrial digitalisation, and gives birth to a new form of networked, intelligent and collaborative industry. Continuously promoting the optimisation and upgrading of industrial structure will force the digital economy to carry out technological innovation and product innovation, thus further promoting the improvement of innovation performance.

4.3 The digital economy has spawned new business forms and models

The digital economy has spawned a series of new business forms and models, providing a broader space and platform for innovation activities in countries along the Belt and Road and helping to improve innovation performance. The digital economy is spawning many new business forms and models, injecting new vitality into economic development. The continuous innovation of digital technology provides technical support for generating new business forms and models. For example, the integrated application of technologies such as big data, artificial intelligence and the Internet of Things has promoted the rapid development of new business forms such as smart manufacturing, smart logistics and the sharing economy.

Secondly, consumer demand drives the emergence of new business forms and models, and in the era of the digital economy, consumer demand is increasingly diversified and personalised. To meet the needs of consumers, enterprises continue to innovate business models, giving birth to new business forms and models such as customised economy and experience economy.

Finally, industrial upgrading accelerates the development of new formats and models: the digital economy has promoted the digital transformation and upgrading of traditional industries and the reconstruction of industrial chains and value chains. In this process, new business forms and models came into being, supporting industrial upgrading. The new business forms and models spawned by the digital economy have profoundly impacted economic development. On the one hand, new business forms and models have improved economic efficiency and promoted industrial upgrading and structural adjustment. On the other hand, new business forms and models have also brought new employment opportunities and social challenges.

Looking forward to the future, with the continuous innovation and popularisation of digital technology, the digital economy will continue to give birth to new business forms and models and promote the sustainable development of economic society.

5 Conclusion and countermeasure suggestions

The development of the digital economy has promoted the wide application of digital technology, improving production efficiency and economic growth rate. Data and information technology have become important production factors in the digital economy, promoting industrial upgrading and economic transformation. This trend also exists in the countries along the Belt and Road, already impacting economic growth patterns. First, the rapid development of the digital economy has provided countries with broad opportunities and platforms for entrepreneurship. In the digital economy, entrepreneurs can use new media, such as the Internet, to innovate and start businesses, thus stimulating more innovative vitality. At the same time, the digital economy has also promoted cultural exchange integration and mutual understanding and respect among different civilisations. Second, the development of the digital economy requires global collaboration and sharing. In the field of digital economy, countries along the "Belt and Road" can carry out international cooperation by jointly setting standards and sharing experience and technology to achieve mutual benefit and win-win results. This is conducive to China's development and the prosperity and development of the digital economy of countries along the route.

However, to take full advantage of this opportunity and achieve sustainable development, countries need to strengthen policy communication and cooperation, promote digital infrastructure construction, strengthen personnel training and cooperation, and deepen market opening and cooperation. This will help promote the economic development and social progress of countries along the Belt and Road and achieve common prosperity and development. First, we need to strengthen policy communication and cooperation. By strengthening policy communication and cooperation in the field of digital economy, we will promote the development and mutual benefit of the digital economy of all countries. This includes establishing dialogue mechanisms, sharing experiences and exchanging technologies in the field of digital economy to promote cooperation and development among countries. Second, promote the construction of digital infrastructure. Digital infrastructure is an important support for developing the digital economy and needs further promotion and improvement. Countries can jointly fund the construction of digital infrastructure, improve network coverage and speed, and provide better basic conditions for the development of the digital economy. Third, strengthen personnel training and cooperation. Talent is one of the key factors in the development of the digital economy. Countries can strengthen cooperation in personnel training, jointly train digital economy talents with an international perspective, and promote the exchange and sharing of digital economy technologies. Fourth, deepen market opening and cooperation. The digital economy is an open economic form which needs to deepen the openness of the market further and promote the interconnection of the markets of all countries. Countries can jointly formulate market access rules, remove trade barriers and obstacles, and promote the free flow and development of the digital economy. Fifth, strengthen supervision and risk prevention. The digital economy faces new challenges and risks, requiring countries to strengthen supervision and risk prevention. Countries can jointly formulate relevant standards and norms, strengthen supervision and management of the digital economy, and ensure the healthy and orderly development of the digital economy.

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V. Aligning Business Solutions and Business Requirements for Digital Transformation – Case Research

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This study explores how Business and IT Alignment (BITA) influences business performance (PERFO) and corporate sustainability (SPACS) using a mixed-methods case study of an international manufacturing enterprise. The quantitative analysis (PLS-SEM) indicated BITA affects PERFO indirectly through IT service quality (ITSQ), while remote work (EWORK), despite its relation to BITA, showed no significant impact. BITA strongly predicted SPACS by enhancing employees' sustainability knowledge, confidence, and willingness to act. Qualitative findings from semi-structured interviews revealed a BITA maturity of 3.3 (on a 5-point scale), highlighting its role in sustainability via better decision-making, process optimization, and IT-enabled transparency. Notable discrepancies between managerial and employee perceptions of BITA maturity were identified. Results suggest successful BITA fosters sustainability-oriented behaviour and IT-driven performance improvements, though continuous reinforcement within organizations is required. The study emphasizes the value of integrating qualitative and quantitative methods for comprehensive insights into BITA's impact.

Keywords:
business and IT alignment (BITA),
IT service quality (ITSQ),
business performance (PERFO),
corporate sustainability (SPACS),
remote work (EWORK),
mixed methods research (MMR),
PLS-SEM,
organizational maturity,
sustainability awareness,
case study

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1 Introduction

The concept of Business-IT Alignment (BITA) was first mentioned in the late 1970s (Mclean & Soden, 1976; IBM, 1981). Various definitions of BITA exist, but they can be generally grouped into two conceptual approaches (Chan & Reich, 2007b): the first considers alignment as a final state, focusing on the outcomes of alignment; the second regards alignment as a continuous process involving specific behaviours, responses, and identifiable patterns.

Alsolamy et al. (2014) describe business and IT strategy as a detailed plan to align IT with business goals. As suggested by Benbya and McKelvey (2006), alignment is a continuous process of dynamic adaptation. Luftman (2000) defines it as the appropriate and timely application of IT to meet business strategy requirements, emphasising the relationship between business strategy and IT. Pereira and Sousa (2005) define BITA as the extent to which IT plans are supported by business strategy. BITA concerns the mutual alignment and integration of IT and business within an organisation to achieve organisational goals better (Zhang et al., 2010).

Thus, aligning business and IT is a process that ensures that an organisation's technological resources, capabilities, and investments are aligned with its business strategies, objectives, and needs (Chan & Reich, 2007a). Luftman and Brier (1999) emphasised that BITA refers to coordinated managerial efforts to ensure that IT goals are aligned with the functional objectives of various departments, such as marketing, finance, and production. BITA aims to align IT with overall business objectives and vice versa.

Numerous studies have shown that organisations aligning in these domains are more successful than those not (Chan & Huff, 1997; Irani, 2002; Kearns & Lederer, 2000). Therefore, aligning IT strategy with business strategy has become one of the most critical challenges for IT professionals and business executives (Luftman, 2005). The concept of BITA is associated with several synonymous terms such as "integration" (Broadbent et al., 1999), "congruence" (Venkatraman et al., 1993), "harmony" (Luftman & Brier, 1999), "fusion" (Smaczny, 2001), and "linkage" (Henderson & Venkatraman, 1993). Regardless of the terminology used, the literature emphasises the significance of BITA for developing core organisational competencies (Sledgianowski et al., 2008; Versendaal, 2013).

Authors such as Chan and Reich (2007), Aversano et al. (2012), Silvius et al. (2009), Luftman et al. (2017), and Yang (2020) have highlighted BITA as one of the key success factors in strategic business operations and competitive advantage. Jonathan et al. (2021) further noted that effective alignment between business and IT enhances the value derived from digital transformation projects and supports organisations in achieving long-term sustainability. Ben-Zvi and Luftman (2022) argue that mature alignment is essential if businesses want IT to transform operations. Mature alignment is associated with organisational success and is a crucial goal for modern organisations (Panda, 2022).

The growing importance of IT in business can be attributed to several factors that have transformed how companies operate and compete in today's business environment. These include digital transformation, data analytics, improved operational efficiency, e-business, enhanced customer experience, technological innovation, remote work, and flexibility. Feroz et al. (2021) emphasised that technologies such as artificial intelligence (AI), big data, the Internet of Things (IoT), cloud computing, and mobile technologies enable organisations to reshape sustainability domains by monitoring pollution impacts, managing waste and promoting sustainable production.

However, achieving effective BITA is far from simple, as many organisations face numerous challenges and complex issues. BITA requires a holistic, advanced, and adaptive approach due to rapidly evolving technological and market demands, as well as ongoing communication gaps between IT stakeholders and other organisational actors.

Chan and Reich (2007) and Aversano et al. (2012) pointed out that even well-designed strategies can fail due to poor communication, lack of alignment (e.g., when business and IT strategies diverge), and insufficient support across organisational levels. Furthermore, organisations' information systems (IS) are often not aligned with business objectives. Kyriazoglou (2012a, 2012b) noted that such issues prompt organisational leadership to implement more comprehensive and effective business controls across governance, risk management, enterprise architecture, strategy, finance, IT, sales, and other areas. Luftman et al. (2017) highlighted several persistent issues in BITA research. Firstly, many alignment models portray alignment as static, failing to examine the scope and evolution of measures necessary to achieve alignment. Secondly, these models often lack solid theoretical foundations. Lastly, due to their static perspective, such models provide limited guidance on how organisations can improve their alignment.

Chan and Reich (2007) emphasised that, despite extensive research, challenges remain in two key areas of BITA. The first concerns the continuous alignment of IT and business strategies, requiring IT governance capabilities and involving specific measures and responses that display patterns over time. The second focuses on alignment as an outcome, emphasising past actions and BITA results. For organisations, today's BITA domain is shaped by breakthrough technologies linked to digital transformation and global influences such as sustainability and environmental concerns.

More than thirty years of research into IT and business strategies emphasise the practical value of aligning them, as alignment directly influences organisational performance. Initial studies focused on comparing business and IT plans. Subsequent research shifted toward examining the relationship between business and IT strategy and the alignment between business needs and IT priorities (Chan & Reich, 2007). Some scholars argue that alignment is not always desirable. They present several arguments, including the mechanistic nature of research that may not reflect the real world (Ciborra, 1997), the impossibility of alignment when the business strategy is undefined or in development (Vitale, 1986), the lack of alignment as a preferable outcome due to the need for constant business adaptation, and the view that IT should drive business transformation rather than merely implement it (Chan & Huff, 1993). Furthermore, some organisations may struggle to adapt to new environments if alignment is too rigid and the business context changes abruptly (Ciborra, 1997). Additional arguments in the literature assert that IT should challenge business operations rather than merely support them. Aligning IT plans with business plans may create a competitive advantage but may also result in losses (Chan & Huff, 1993; Kearns & Lederer, 2000). Sauer and Burn (1997) warn that alignment can lead to problematic situations requiring careful management to avoid unnecessary IT and business costs. They identify three types of undesired outcomes from strategic alignment:

- misalignment, when the organisation aligns IT with internally inconsistent business strategies.

– IT stagnation, which occurs as part of the natural, virtually unavoidable innovation cycle in IT.
– globalization presents a unique challenge in terms of cultural and scope compatibility for alignment.

2 Factors influencing alignment of business solutions and business requirements

Luftman et al. (1999) conducted a study involving more than 500 companies to investigate the factors that promote and inhibit business-IT alignment (BITA). The results indicate that the same themes appeared on both sides—enablers and inhibitors—namely, top management support, IT department's understanding of business, the relationship between business and IT, and IT leadership, all of which are critical to successful BITA (see Table 1).

Table 1: BITA Enablers and Inhibitors

Enablers	Inhibitors
Senior executive support for IT	Lack of close IT/business relationships
IT involvement in strategy development	IT does not prioritise effectively.
IT understands the business.	IT fails to deliver commitments.
Partnership between business and IT	IT does not understand business.
Well-structured IT projects	Business executives do not support IT
IT shows leadership	IT leadership lacks managerial skills.

Source: Adapted from Luftman et al. (1999)

Successful BITA implementation depends on several critical factors:

– strong top management support.
– effective prioritisation.
– fostering positive working relationships.
– building trust among stakeholders.
– encouraging effective communication.
– developing a comprehensive understanding of the business environment.

These enablers and inhibitors can be categorised into two groups based on the locus of responsibility or influence. The organisation's leadership controls factors such as strategic involvement of IT and top management support, while IT departments are responsible for prioritisation, business understanding, and IT governance. This classification emphasises the need for shared responsibility between business and IT units, ensuring alignment is driven both top-down and bottom-up.

The study builds upon the work of Henderson and Venkatraman (1990), structuring the alignment model into four categories comprising twelve factors, described below.

1. Business Strategy

– Business scope: Includes markets, products, services, customer groups, locations, competitors, suppliers, and potential entrants that shape the competitive business environment.
– Distinctive competencies: Critical success factors and core capabilities that potentially offer a competitive advantage, such as branding, R&D, product development, cost structure, pricing, sales, and distribution channels.
– Business governance: How organisations determine the balance among governance, shareholders, and boards of directors, including government regulations and partnerships with strategic allies.

2. Organizational Infrastructure and Processes

– Administrative structure: The organisational structure of business operations (e.g., centralised, decentralised, matrix, horizontal, vertical, geographic, federal, or functional models).
– Processes: Executing business activities (employee work routines), focusing on value-adding activities and process improvements.
– Skills: Human resources, including hiring, firing, motivation, training, education, and corporate culture.

3. IT Strategy

– Technology scope: Critical information applications and technologies.
– Systemic competencies: Capabilities that distinguish IT services, such as access to information relevant to strategy formulation and execution.

- IT governance: Distribution of authority among business partners, IT leadership, and service providers over resources, risks, and IT responsibilities, including project selection and prioritisation.

4. IT Infrastructure and Processes

- Architecture: Technological priorities, policies, and choices that integrate applications, software, networks, hardware, and data management into a cohesive platform.
- Processes: Practices and activities related to developing and maintaining applications and IT infrastructure.
- Skills: IT human resources, recruitment, termination, motivation, training, education, and IT culture.

The findings suggest that specific actions foster alignment while others clearly obstruct it. Achieving alignment is both evolutionary and dynamic. It requires strong executive support, healthy working relationships, strong leadership, proper prioritisation, trust, effective communication, and a deep understanding of the business context. Success depends on maximising enablers and minimising the number and influence of inhibiting factors. Evidence shows that these factors remain consistent over time and are nearly identical for business and IT leaders (Luftman et al., 1999).

Many studies and analyses have previously focused on the interplay between business and IT (Chan & Huff, 1993; Luftman, 1996; Earl, 1993; Henderson et al., 1992), the role of partnerships between IT and business management (Keen, 1996; Ives et al., 1993), and the need to understand the transformation of business strategies due to the competitive application of IT (Boynton et al., 1996). IT innovations have prompted changes in business scope and organisational infrastructure (Keen, 1996). The breadth of topics covered in prior literature underscores the complexity and multi-dimensionality of BITA as a research domain.

However, much of this research has been conceptual. Empirical BITA studies (e.g., Henderson & Thomas, 1992; Broadbent & Weill, 1993; Chan & Huff, 1993; Baets, 1996) often focused on a single industry or organisation. Consequently, the findings may be biased and not generalisable across sectors. The lack of consistent findings across industries, functional roles, and time periods has motivated the present study.

Many researchers highlight communication as a crucial precondition for alignment, often linked with mutual understanding. Effective communication plays a key role in achieving alignment between business and IT. It is essential for fostering shared learning, collaboration, and common goals. Organisations should prioritize regular and inclusive communication using a variety of coordination channels and methods (Reich & Benbasat, 2000; Campbell, 2005; Sledgianowski & Luftman, 2005). Given the socio-technical nature of alignment, communication should be seen as both a process and a capability that must be continuously developed.

Key research studies, their authors, objectives, and factors influencing BITA are summarised in Table 2.

Table 2: Key Research Contributions in the BITA Domain

Authors	Main Objective	BITA Factors
Feeny et al. (1992)	CEO/CIO relationship	Communication between business and IT executives
Henderson in Venkatraman (1993)	Achieving alignment	Business and IT strategy; IT infrastructure and processes
Sabherwal in Kirs (1994)	IT performance factors	Environmental uncertainty, organisational integration, IT governance maturity
Luftman, (1996)	Exploring twelve BITA factors	Factors described above
Teo in Ang (1999)	IS planning alignment success	Strategic IT use, business understanding, trust in IT, service quality, frequent communication
Luftman in Brier (1999)	IT and business planning alignment	Relationship quality, IT understanding, support, leadership
Luftman (2000)	BITA enablers/inhibitors	Six enablers and inhibitors (e.g., CEO support, prioritisation, leadership)
Maes et al (2000)	General BITA framework.	Management capacity, ICT systems, infrastructure
Reich in Benbasat (2000)	Social factors in alignment	Shared knowledge, IT history, communication links
Hussin et al (2002)	Measuring BITA	Executive commitment, IT maturity, external expertise
Bergeron et al (2001)	IT strategy-environment alignment	Mediation, fit
Broadbent in Kitzis (2005)	Success factors for IT-based business projects	CIO, executive team, governance clarity

Authors	Main Objective	BITA Factors
Chan et al. (2006)	Business strategy supported by IS strategy	Shared knowledge, planning sophistication, IS success, firm size, uncertainty.
Kim in Park (2007)	Impact of BITA on business performance	Knowledge exchange, IT belief retention
Kashanchi in Toland (2008)	Social dimension of alignment	Misaligned strategies, long-term relationships, communication
Preston in Karahanna (2009)	Business-IT alignment	Shared understanding
Silvius et al. (2009)	BITA as a strategic success factor	Strategic governance, sustainability, IT contribution
Johnson in Lederer (2010)	IS contribution to organisations	IT-business governance relationship, BITA direction
Strong in Volkoff (2010)	Causes of misalignment	Data, roles, availability, control, culture
Alaceva in Rusu (2015)	Social barriers to alignment	Misunderstanding, poor communication, vague specifications, limited collaboration
Yang (2020)	BITA as a competitive advantage	Alignment and digital transformation
Jonathan et al. (2021)	BITA and digital transformation value	Transformation value, long-term sustainability
Feroz et al. (2021)	Role of technologies in sustainability	AI, big data, IoT, cloud computing, sustainable innovation
Ben-Zvi & Luftman (2022)	Maturity of BITA for transformation	Alignment maturity, organisational performance
Panda (2022)	BITA maturity as an organisational goal	BITA maturity, modern organisational goal

Source: Adapted from Luftman et al., 2017; Alaceva & Rusu, 2015 and additional recent studies

2.1 The impact of BITA on organisational performance

Over the past thirty years, researchers have extensively examined business-IT alignment (BITA) (Coltman et al., 2015; Gerow et al., 2015). More specifically, studies have explored how aligning IT-related processes creates business value for the organisation (Celuch et al., 2007; Kim et al., 2011). Generally, BITA emerges as a continuously adaptive and synergistic relationship that integrates business strategy and IT resources (Chan & Reich, 2007). From the foundational studies by Henderson and Venkatraman (1999) to more recent contributions (Gerow et al., 2015; Coltman et al., 2015), scholars have emphasised that organisations must align their IT resources and capabilities with their strategies and associated business processes. BITA refers to high-level strategic alignment and addresses how organisational strategies support—and are supported by—IT resources (Gerow et al., 2015).

Melville et al. (2004) argue that a diverse portfolio of information assets can generate various potential benefits. Realising these benefits largely depends on whether the organisation can achieve its long- and short-term goals through balanced IT strategy alignment (Ross et al., 1996).

Business processes enable organisations to accomplish critical objectives (Kaplan & Norton, 1996; Porter, 2002). The fulfilment of these organisational objectives is generally described as business performance (Melville et al., 2004; Tallon, 2008; Tallon & Pinsonneault, 2011). Process-level performance refers to measures related to enhancing the operational effectiveness of business processes. Such metrics include customer acquisition and retention, product innovation, and the delivery of products or services to customers (Kaplan, 2010).

Business process performance is reflected in activities that convert inputs into outputs (Melville et al., 2004; Raschke, 2010). These activities include innovation, operations, and after-sales support (Kaplan & Norton, 2001). Moreover, analytical activities that support organisational decision-making (Davenport et al., 2010) are also part of business processes and thus impact firm performance (Daft et al., 2021; Grant, 2010; Kaplan, 2010). Given their importance, the quality of business processes is a key indicator of a company's ability to deliver products and services efficiently (Tarhan et al., 2015).

Performance measurement models use various financial and non-financial metrics to evaluate outcomes related to an organisation's ability to achieve its objectives (Ouakouak & Ouedraogo, 2013; Kaplan, 2010). Financial performance typically reflects the long-term value of a firm (Baum & Wally, 2003), which is generally the result of how effectively the firm produces and markets its goods and executes its strategies (Ouakouak & Ouedraogo, 2013; Kaplan & Norton, 1996). Financial productivity metrics relate to the effective management of expenditures (costs, spending, and investments), while growth metrics focus on revenue generation (Kaplan, 2010; Kaplan & Norton, 2001, 2008). According to Kaplan and Norton (1996), achieving long-term shareholder value requires understanding the conditions and needs that create customer value.

These non-financial performance indicators (Ong & Teh, 2009) refer to the characteristics of the goods and services provided, the relationships an organisation cultivates with its customers, and its brand image (Kaplan et al., 2010; Sila & Ebrahimpour, 2005; Tracey et al., 1999). Delivering product attributes that meet customer expectations enhances product value and increases customer satisfaction (Tracey et al., 1999), fostering customer retention (Sila, 2007; Sila & Ebrahimpour, 2005).

In contrast to earlier studies that examine BITA as a whole, some researchers have focused on more detailed relationships between business strategy, IT governance structure, the IT department, and organisational performance (Tiwana & Konsynski, 2010; Banker et al., 2011; Bharadwaj et al., 2013). For example, Bharadwaj et al. (2013) explored the impact of collaboration between IT and manufacturing based on data from 169 U.S. firms and found positive correlations with organisational performance. This offers novel insights into BITA from the perspective of cross-functional and inter-organizational alignment.

3 Research model

3.1 Research approach

This study adopts a mixed methods research (MMR) approach to investigate two distinct perspectives: the organisational perspective and the employee perspective. MMR combines a single study's quantitative and qualitative research methods (Venkatesh et al., 2013). Integrating quantitative and qualitative data can significantly enhance the value of MMR (Bryman, 2006; Fetters et al., 2013). It enables researchers to obtain a more comprehensive and in-depth understanding of the research topic or phenomenon. By combining both approaches, researchers can access a broader range of data, viewpoints, and insights, leading to a more holistic comprehension of complex research questions. MMR is particularly suitable for addressing research gaps that cannot be adequately explored through a single methodological lens. In this study, we followed the guidelines for conducting MMR in the field of IS/IT as proposed by Venkatesh et al. (2013, 2016).

The first focus of our research concerns employees and was addressed through a quantitative analysis of the research model using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. The second perspective focuses on the organisation and examines how BITA-enabled activities and strategies influence business performance and corporate sustainability.

3.2 Conceptual framework and hypotheses development

The core research thesis states:

"*The level of BITA, directly and indirectly, influences organisational performance through IT service quality and remote work factors. Furthermore, there are differences in the maturity levels and strength of individual BITA factors across various industries, which collectively impact corporate sustainability.*"

This thesis and the corresponding hypotheses were tested using the research model presented in Figure 1.

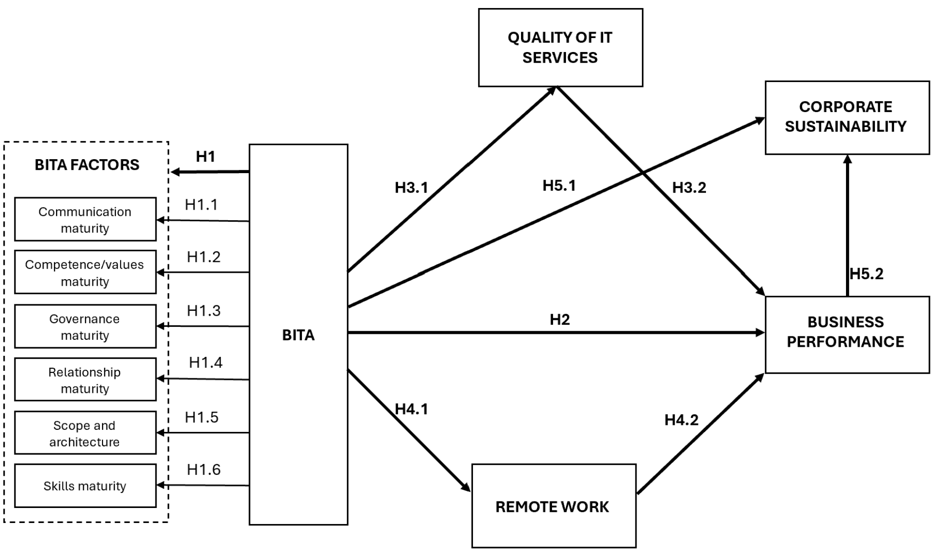

Figure 1: Research model

Hypotheses:

- H1: First-order BITA factors have a statistically significant impact on the second-order BITA factor.
- H2: BITA has a statistically significant impact on business performance.
- H3: BITA statistically significantly impacts business performance through IT service quality.
- H4: BITA statistically significantly impacts business performance through remote work.
- H5: BITA has a statistically significant impact on corporate sustainability directly and indirectly through business performance.

In the remainder of this chapter, a more detailed explanation of the connection in the research model.

3.3 First-order and second-order BITA factors (H1)

BITA is conceptualised as a second-order construct composed of multiple first-order maturity factors:

- Communication maturity (H1.1) – How IT and business communicate effectively.
- Competence/values maturity (H1.2) – Aligning IT skills and business needs.
- Governance maturity (H1.3) – The presence of IT governance structures that align with business strategy.
- Relationship maturity (H1.4) – The strength of partnerships between IT and business units.
- Scope and architecture maturity (H1.5) – The extent to which IT architecture supports business agility.
- Skills maturity (H1.6) – The degree to which IT personnel possess the required skills for digital transformation.

These first-order constructs contribute to the overall BITA construct, suggesting that higher maturity levels in these areas lead to stronger overall BITA.

The Impact of BITA on business performance (H2)

A well-aligned IT and business strategy enhances business performance by improving operational efficiency, resource utilisation, and decision-making processes. Organisations with higher BITA maturity can better leverage IT resources to achieve their strategic goals, resulting in improved financial and non-financial performance metrics.

The mediating role of IT service quality in business performance (H3)

BITA influences IT service quality, affecting business performance (H3.1, H5.1). High-quality IT services ensure that business processes run smoothly, enhance user satisfaction, and contribute to improved innovation capacity. If IT service quality is suboptimal, it can act as a bottleneck, limiting the potential benefits of IT-business alignment.

Mediating role of remote work in business performance (H4)

BITA is also crucial in facilitating remote work (H4.1, H4.2). Organisations with higher BITA maturity are more likely to have IT infrastructures that support remote work efficiently. This includes secure access to data, cloud-based collaboration tools, and digital workflows, all of which contribute to increased flexibility, employee satisfaction, and productivity.

The Impact of BITA on corporate sustainability (H5)

BITA influences corporate sustainability in two ways:

1. Directly (H5.1) – Organizations with strong IT-business alignment implement sustainability-driven IT initiatives, such as green IT practices and energy-efficient systems.
2. Indirectly through business performance (H5.2) – Strong business performance supports long-term sustainability by ensuring financial stability, regulatory compliance, and corporate social responsibility (CSR) initiatives.

3.4 Research context and data collection

The research was conducted in a manufacturing company with production facilities in Slovenia and Europe. The company has an impressive history of over seventy years and manages globally recognised brands, delivering cutting-edge and innovative products worldwide. The company implements various IT practices and technologies, enabling us to examine diverse BITA factors. It employs advanced enterprise-level technological solutions that are generally inaccessible to smaller firms. In addition, the organisation is characterised by a well-established corporate culture and formalised processes.

The case company is a large multinational enterprise operating in the home appliance manufacturing sector, specifically within the broader manufacturing industry. It is part of a foreign-owned corporate group, with its headquarters based outside of the country in which the case company operates. The company develops, produces, and distributes various household appliances, such as refrigerators, ovens, and dishwashers. Its products are in more than 60 markets worldwide, and its production facilities span multiple European countries. This organisational profile positions the company as a key player in the European white goods market, strongly emphasising innovation, international competitiveness, and operational scale.

Following initial outreach via email and phone, the company designated a contact person responsible for the research process. A web-based version of the quantitative questionnaire was created using LimeSurvey (LimeSurvey, 2023) and sent to the company. The organisation distributed the questionnaire to selected participants. After receiving 20 responses, the company sent a reminder and extended the deadline by one week.

An interview with company management was arranged for the qualitative part of the study. This was followed by data familiarisation and manual coding. The analysis employed both inductive reasoning (data-driven) and deductive reasoning (based on existing theory and company documentation). The interpretation of the obtained results followed this.

To understand our research question comprehensively, we first conducted a quantitative analysis by cleaning the data and performing descriptive statistics, followed by data analysis in SmartPLS (Ringle et al., 2022). The qualitative data were then analysed. The final step included the interpretation of the quantitative and qualitative results and the combined findings as prescribed by the MMR methodology.

4 Quantitative analysis of the case study

4.1 Descriptive statistics of the case study

The research model includes four second-order factors: BITA, remote work (EWORK), business performance (PERFO), and corporate sustainability (SPACS). BITA consists of six first-order constructs (communication, competence/values, governance, relationship, scope/architecture, skills maturity), SPACS includes three (knowledge of action possibilities, confidence in impact, willingness to act), EWORK originally consisted of three (organisational trust, interaction, productivity), and PERFO includes two (organisational and work performance).

A web-based questionnaire distributed among 35 mid-level managers and key users yielded 26 valid responses (74.29%). Given the homogeneity of respondents (all from one company), the sample size was deemed sufficient for analysis (Hair et al., 2019).

Demographically, respondents were predominantly male (76.9%) and relatively evenly distributed across age groups (30–59 years), with a slight underrepresentation of the youngest group (20–29 years). Managers (57.7%) slightly outnumbered key users.

Indicators exhibited mean scores generally between 3 and 4, indicating moderate to positive evaluations. Most indicators showed high factor loadings (>0.7), demonstrating good construct validity. However, the indicator for organisational trust showed insufficient loading and was removed from subsequent analyses. Overall, the descriptive statistics support the validity and reliability of the measurement instrument, indicating effectively measured latent constructs.

4.2 Measurement model of the case study

To evaluate the measurement model, we applied a two-step approach as recommended by Crocetta et al. (2021), Garson (2016), and Hair et al. (2019). First, we assessed the latent variables (LVs) of first-order constructs, followed by validation at the second-order level. Reliability analysis confirmed internal consistency and indicator reliability, with almost all Cronbach's alpha and composite reliability values above the threshold of 0.70. Convergent validity was verified, as all Average Variance Extracted (AVE) values exceeded 0.50.

Discriminant validity was assessed using cross-loadings, the Fornell–Larcker criterion, and HTMT ratios. All indicator loadings were higher than their respective cross-loadings. The Fornell–Larcker criterion was fulfilled, with each construct's AVE square root exceeding bivariate correlations, and all HTMT values remained below the threshold of 0.90.

Although the SRMR value (0.121) slightly exceeded the ideal threshold (0.08), it remains acceptable for complex exploratory models. Therefore, the measurement model demonstrates sufficient reliability and validity for further structural model evaluation.

4.3 Structural model for the case study

Following Hair et al. (2019), we first examined collinearity issues using Variance Inflation Factor (VIF) values. All constructs showed VIF values below or around 3, indicating moderate collinearity, allowing further structural model assessment. The explanatory power of the structural model was evaluated using coefficients of determination (R^2), with all endogenous constructs displaying moderate explanatory power ($R^2 > 0.33$).

We used a bootstrapping procedure with 10,000 subsamples to test the significance of the hypotheses. Table 3 summarises the key results from the analysis:

Table 3: Results of the Structural Model for the Case Study

Path	β coefficient	t-value	p-value
ITSQ → PERFO	0.587	2.469	0.007*
BITA → ITSQ	0.665	5.233	0.000*
BITA → PERFO	0.168	0.477	0.317 ns
BITA → SPACS	0.554	4.269	0.000*
BITA → EWORK	0.628	6.515	0.000*
PERFO → SPACS	0.188	1.153	0.124 ns
EWORK → PERFO	-0.199	0.821	0.206 ns

Note: $^*p < 0.05$ (significant); ns = not significant.

The analysis revealed significant relationships among the constructs. BITA had a crucial direct influence on IT service quality (ITSQ), significantly impacting business performance (PERFO), confirming an indirect effect of BITA on PERFO. However, BITA did not directly influence business performance significantly.

Moreover, BITA significantly influenced remote work (EWORK), though EWORK did not significantly affect business performance. Consequently, the indirect relationship between BITA and business performance via EWORK was not supported.

Finally, BITA significantly predicted corporate sustainability (SPACS). However, no significant relationship emerged between business performance and corporate sustainability, thus confirming that BITA directly affects sustainability independently from business performance. These findings underline the importance of BITA in enhancing IT service quality, enabling remote work environments, and directly contributing to corporate sustainability.

4.4 IPMA case research

We conducted an Importance–Performance Map Analysis (IPMA) to identify and prioritise factors influencing business performance (PERFO). Results show that IT service quality (ITSQ) is the most critical factor, exhibiting the highest importance yet the lowest performance among analysed constructs. Consequently, management should prioritise enhancing IT service quality through better infrastructure, employee training, and optimised IT processes.

Business and IT Alignment (BITA) displays moderate importance but has the highest performance, suggesting effective organisational utilisation. Management should sustain current BITA practices and continue investments in technological and informational initiatives.

Remote work (EWORK) shows negative importance, indicating no beneficial impact on business performance despite moderate performance scores. Therefore, management should reevaluate resource allocation towards remote work practices concerning direct business outcomes.
These insights guide targeted management actions, highlighting ITSQ improvement as a primary strategic focus to maximise business performance.

5 Qualitative analysis of the case study

The second perspective of this research focuses on the company and explores the influence of BITA-enabled activities and strategies on business performance. This qualitative investigation aims to gain more in-depth insights into how the maturity of BITA factors affects organisational performance. Since the assessment of BITA maturity factors is based on the questionnaire by Luftman et al. (2017) and the sustainability dimension is addressed through open-ended questions derived from theory (explained in more detail below), the method of semi-structured interviews (SSI) was used.

Semi-structured interviews are the most commonly used qualitative method in mixed methods research (McIntosh & Morse, 2015). An interview is a data collection method involving conversational communication in which the researcher (interviewer) asks questions and the interviewee (respondent) provides answers (Holstein & Gubrium, 2003). The advantage of interviews lies in their focused approach, which directly targets the case study topic while enabling the exploration of perceived causal relations and deeper insights. However, interviews also have limitations, including potential bias from poorly formulated questions, response bias, inaccuracies due to limited memory, and reflexivity, where respondents may offer answers they believe are expected (Baškarada, 2014). Interviews can range from highly structured and formalised to completely unstructured, resembling informal conversations. A structured interview is a formalised questioning method that controls questions' content, sequence, and formulation (Campion et al., 1988). It involves using predefined, standardised questions, implementing rules for evaluating responses and incorporating follow-up questions as needed. Responses are typically recorded in real-time, followed by a summary immediately after the interview (Pettersen & Durivage, 2008). In addition, interviewers must pay attention to non-verbal communication (e.g., facial expressions, tone of voice, posture), as these cues provide valuable context to verbal responses.

Our qualitative research was conducted through the SSI method, supported by analysing publicly available information on the company's website and in its environmental reports. The interview structure was sent to the company in advance. Based on our guidance and discussion with the company's research contact, two interview participants were selected: a member of the executive board (also responsible for IT and digital transformation) and a senior IT manager (liaison between business and IT). The questionnaire was based on Luftman et al. (2017) and consisted of 39 independent statements designed to assess each of the six BITA dimensions. The managers were asked to select the response that best described their view of BITA. This part of the questionnaire was used for two purposes:

1. To assess the level of BITA maturity in the company, as perceived by the managers.
2. To collect additional explanations for each BITA dimension where necessary.

For each BITA statement, respondents could provide elaborations by answering prompts such as: "Please describe how this measure is implemented in your company/context," "How could this measure be improved to achieve better alignment?" or "Do you believe this measure contributes to the company's sustainability?"

Based on the qualitative analysis, the company's overall BITA maturity level was assessed at 3.3 on a 1-to-5 scale. At level 3, the organisation has transparent processes for aligning business and IT strategies, which are consistently followed. BITA is managed proactively, with regular communication and collaboration between business and IT leaders. In contrast, organisations at maturity level 4 have established BITA processes and continuously improve them based on defined metrics. Business and IT strategies are tightly integrated, and the organisation can quickly adapt IT capabilities to changing business needs. The score of 3.3 aligns with maturity level 3, but a deeper analysis of the six BITA factors and leadership responses reveals that the company already implements several practices associated with level 4. This is consistent with the view of company leadership, which believes the system is well established but could still be improved.

The measured value for the communication maturity dimension was 3.8. The company demonstrates good knowledge of the IT environment and its business potential. Similarly, the IT department is well-informed about the business context. Formal knowledge transfer processes have been implemented and are mainly used in onboarding. A training budget is in place, and employees complete training required by their roles or projects. The company has introduced key users (mainly for business information systems) who are IT employees. A "train-the-trainer" model is used for knowledge transfer. A liaison function is defined between the IT and business departments, with a protocol for reporting and coordination with top management.

The measured maturity for the competence/values dimension was 3.5. The company uses standard metrics such as ROI and ABC to evaluate technical and financial project performance (IT and non-IT). A formal procedure is in place for corrective action based on outcomes. These procedures are applied to investment and development projects. According to management, the process could be improved by defining more explicit ex-ante project selection criteria. A Service Level Agreement (SLA) is defined in corporate IT policies. Benchmarking is usually conducted before launching major IT projects or in case of disruptions. The company has a process improvement department that operates at the corporate level. Management considers IT a valuable strategic partner with a measurable impact on corporate goals.

The measured maturity of the IT governance dimension was 3.2. Strategic planning is formally established at the departmental and corporate levels. IT governance is included in strategic planning regarding content, cost, and staffing. The IT department is sometimes considered a cost, investment, or profit centre. Management would classify IT as a cost centre if only one definition were allowed. IT investments are selected based on traditional financial criteria. IT projects and investments are seen as enablers of business processes. Priorities are set jointly by

IT and business functions. A formal steering committee is in place for IT initiatives and projects, meeting regularly. When asked about IT's ability to respond and adapt to changes and disruptions, leadership rated it low (2 out of 5), citing the inertia of large IT systems and limited resources as the main barriers.

The measured maturity of the partnership dimension was 3.3. IT is viewed as an enabler integrated into business processes. The relationship between business units and IT is managed but not always formalised. Trust exists and is seen as part of a long-term partnership. Risks and rewards are shared between business and IT. IT projects have business sponsors, usually from senior management.

The maturity score for the scope and architecture dimension was 3.4. It is recognised as a process enabler. The company operates an extensive IT system managed centrally at the corporate level. IT system standards are defined and implemented group-wide. Systems are integrated internally and, to some extent, with external partners. Regarding flexibility, IT systems are developed based on business needs and aligned with strategy.

The maturity of the skills dimension was rated 2.9. An innovative and entrepreneurial culture is strongly encouraged at all levels. Innovation is embedded in the company's vision and values. The company has a formal organisational change readiness program. Knowledge transfer between IT and business functions is possible and encouraged at the departmental level. Social interaction and trust between IT and business functions are established. Equal emphasis is placed on technical and business knowledge during recruitment. However, there is no formal program for attracting and retaining top talent.

The second part of the interview focused on the company's sustainability orientation. Before the interviews, we reviewed publicly available information from the company's website and environmental reports concerning its approach to ecological, social, and governance (ESG) aspects. All ESG components and their implementation were discussed in depth during the interviews. The company enforces policies and procedures related to environmental, social, and governance sustainability. It recognises the key role played by individuals and the work environment in the daily dynamics of the organisation. Promoting creativity, strengthening interpersonal relationships, and maintaining a competitive edge through non-aggressive management techniques are central to the company's culture. The organisation focuses on education, fostering an innovation-friendly environment, and open communication with employees. In addition, employees are offered international career development opportunities.

From the perspective of customers and end users, the company emphasises safe, environmentally friendly, high-quality products supported by excellent after-sales services. The organisation's development strategy prioritises environmental preservation. The environmental protection policy covers the entire product life cycle—from design, manufacturing, and use to end-of-life disposal. By utilising advanced technologies, processes, and materials, the company continuously reduces production waste and manages the consumption of electricity, water, natural gas, and compressed air. Environmentally conscious customers have received the commitment to innovation in sustainable product development. The primary goal is to manufacture products that consume less electricity, water, and other resources.

Table 4 summarises the key findings of the qualitative analysis across all BITA maturity dimensions and ESG-related aspects assessed in the case study.

Table 4: Summary of Qualitative Findings – BITA Maturity and Sustainability

BITA Dimension / ESG Area	Maturity Score	Key Observations	Challenges / Remarks
Communication	3.8	Knowledge transfer formalised; liaison role defined; training via "train the trainer".	Strong practice; continuous reinforcement is recommended.
Competence / Values	3.5	ROI/ABC metrics applied; corrective actions in place; SLA defined	Improvement is suggested in defining ex-ante project acceptance criteria.
IT Governance	3.2	IT is included in the strategy; the steering committee is in place.	Limited agility due to legacy systems and resources.
Partnership	3.3	IT is seen as a process enabler; trust with business units exists.	The formalisation of relationships could be enhanced.
Scope and Architecture	3.4	Centralised system governance; integration with internal and external partners.	Flexibility aligned with business needs.

BITA Dimension / ESG Area	Maturity Score	Key Observations	Challenges / Remarks
Skills	2.9	An innovation culture is promoted, and a change readiness program exists.	There is no formal program for talent attraction and retention.
Corporate Sustainability (ESG)	-	Environmental focus, ESG policies, and culture are in place.	Strong strategic orientation, room for expansion in ESG metrics integration.

The summarised results of the qualitative analysis provide a foundation for further discussion and integration with the quantitative findings presented in the next chapter.

6 Discussion

This case study employed a mixed methods research (MMR) approach, which offers the opportunity to develop new theoretical insights by combining the strengths of both quantitative and qualitative methods. This integration enables a deeper and more nuanced understanding of the research phenomenon by going beyond the limitations of any single method (Venkatesh et al., 2016). MMR allows researchers to derive more robust conclusions than possible using a single methodological approach, resulting in more diverse and complementary perspectives (Venkatesh et al., 2013).

This type of research is especially relevant when the investigated research questions are associated with unpredictable or context-dependent conditions. Johnson et al. (2007) further emphasise that MMR will likely yield more substantial findings and comprehensive results.

By the fourth stage of the MMR framework, this chapter presents meta-findings of the case study. We begin with the quantitative analysis results (Section 6.1.1), followed by the qualitative analysis results (Section 6.1.2), and conclude with an integrated interpretation, i.e., the meta-inferences of the MMR study (Section 6.1.3).

6.1 Discussion of the quantitative analysis of the case study

In the quantitative part of the analysis, we examined the research model presented in Chapter 3 (Figure 1). The model is based on Type I second-order constructs (reflective-reflective) and focuses on three structural paths between BITA (Business and IT Alignment) and business performance (PERFO), as well as two structural paths toward corporate sustainability (SPACS).

To determine the minimum required sample size, we applied the 10-times rule (Hair et al., 2011, 2019a; Kock & Hadaya, 2018), which is frequently used in information systems (IS) research employing PLS-SEM. According to this rule, the sample size should be at least ten times the number of the maximum-paths pointing at any construct in the structural model. Based on this guideline, the minimum sample size required for this study was 30.

Another rule, the inverse square root rule (Kock & Hadaya, 2018), recommends that the sample size be equal to or greater than the square of the number of structural paths. Given that our model includes seven paths, the recommended sample size would be 49. Our sample comprised 26 cases, which does not meet this stricter threshold. However, since all data were collected within a single company among middle managers and key users—representing a homogeneous population—using a smaller sample is acceptable, according to Hair et al. (2011). Furthermore, the complementary qualitative component in our mixed methods design supports and reinforces the findings. Based on this rationale, the sample is considered sufficient for quantitative analysis.

The second-order construct BITA comprises six reflective first-order constructs, as Chen (2010) and Yang (2020) defined. The mean values of BITA maturity dimensions indicate that communication maturity (COMM) is rated at 3.625, suggesting a maturity level between 3 and 4 on a five-point scale. Competence/values maturity (COMP) is rated at 4.058, corresponding to level 4 maturity. IT governance maturity (GOVE) is rated at 3.904, approaching level 4. Partnership maturity (PART) has a mean value of 4.039, and scope and architecture maturity (SCOP) is rated at 3.442. Finally, skills maturity (SKIL) is rated at 3.808, indicating a maturity level close to level 4.

From these self-assessments, it can be concluded that there is still room for improvement across all BITA dimensions—most notably in scope and architecture, followed by communication, skills, governance, partnership, and competence.

Table 5: Average Maturity Scores by BITA Dimension

BITA Dimension	Employees (Survey)	Organisation (Interview)
Communication	3.625	3.833
Competence / Values	4.058	3.500
Governance	3.904	3.286
Partnership	4.039	3.333
Scope & Architecture	3.442	3.400
Skills	3.808	2.857
Average	3.813	3.368

Each first-order construct contributes uniquely to the second-order BITA construct, with the strength of their contributions represented by β coefficients. As previously discussed, β values indicate the strength of the relationship between predictor (independent) and outcome (dependent) variables. All six first-order constructs have statistically significant effects on the BITA second-order construct.

Among them, partnership maturity (PART) is the most influential ($\beta = 0.872$; $t = 20.631$; $p < 0.001$), followed by governance maturity (GOVE) ($\beta = 0.844$; $t = 10.901$; $p < 0.001$), and skills maturity (SKIL) ($\beta = 0.806$; $t = 8.267$; $p < 0.001$). The remaining dimensions also demonstrate strong significance: communication (COMM) with $\beta = 0.762$ ($t = 9.153$; $p < 0.001$), scope and architecture (SCOP) with $\beta = 0.736$ ($t = 6.334$; $p < 0.001$), and competence (COMP) with $\beta = 0.695$ ($t = 5.471$; $p < 0.001$). Based on these results, all six factors significantly contribute to BITA, thus confirming hypothesis H1 and all six associated sub-hypotheses.

The second-order construct of business performance (PERFO) consists of two first-order constructs. Work performance (WorkPer) was defined by Yang (2020), while organisational performance (OrgPer) was based on the work of Yoshikuni and Albertin (2020). In our study, both constructs demonstrated a strong influence on PERFO. WorkPer had a β value of 0.909 ($t = 3.355$; $p < 0.001$), while OrgPer had a slightly lower but still substantial value of 0.800 ($t = 4.648$; $p < 0.001$). Both are essential and valid components of business performance.

However, the direct path between BITA and PERFO is not statistically significant ($\beta = 0.168$; $t = 0.477$; $p > 0.05$), suggesting that BITA does not exert a direct observable effect on business performance. Thus, hypothesis H2 is rejected. BITA likely influences performance indirectly through mediating constructs.

According to researchers such as Henderson et al. (1993), Luftman et al. (1999), and Reich et al. (2000), BITA is directly linked to IT service quality (ITSQ). Organisations that invest in aligning IT with business processes tend to have higher-quality IT services, contributing to better business outcomes. In our case study, BITA has a strong and statistically significant influence on ITSQ ($\beta = 0.665$; $t = 5.233$; $p < 0.001$), explaining 44.2% of the variance in ITSQ, reflecting a moderate explanatory power level.

Furthermore, ITSQ exerts a moderate and statistically significant influence on business performance ($\beta = 0.587$; $t = 2.469$; $p < 0.01$), confirming its mediating role. These findings support hypothesis H3, stating that BITA influences business performance via IT service quality.

We hypothesised that IT solutions would better align with employee needs for remote work in organisations with higher BITA maturity and that BITA would improve business performance through this alignment. The second-order construct remote work (EWORK) was designed to include organisational trust (ORTR), interaction (INTER), and productivity (Prod). However, ORTR was removed from the model during the measurement phase. Productivity shows a powerful effect on EWORK ($\beta = 0.913$; $t = 17.935$; $p < 0.001$), while interaction also indicates a strong impact ($\beta = 0.782$; $t = 5.747$; $p < 0.001$).

BITA has a strong and significant influence on EWORK ($\beta = 0.628$; $t = 6.515$; $p < 0.001$), but EWORK has a negative and non-significant effect on business performance ($\beta = -0.199$; $t = 0.821$; $p > 0.05$). Therefore, hypothesis H4, stating that BITA affects business performance indirectly through EWORK, is rejected. These results align with the findings of Yao et al. (2019), who observed a decline in employee productivity and business performance associated with remote work. Although the company studied is a manufacturing firm, remote work is enabled for administrative staff. Managers and key users perceive BITA maturity as necessary for enabling remote work, but they also believe that remote work hurts business performance.

Together, BITA, ITSQ, and EWORK account for 42.9% of the variance in business performance (PERFO), which means they have a significant but not exclusive influence.

We also examined the second-order construct SPACS (Sustainable Performance Awareness Capability of Staff), as perceived by employees. SPACS, developed by Olsson et al. (2020), is an aggregate reflective-reflective construct composed of three first-order dimensions: knowledge of action possibilities (KAP), confidence in one's influence (COI), and willingness to act (WA). Their average scores were 4.077, 4.019, and 4.163, respectively.

All three factors significantly contribute to SPACS. COI is the strongest predictor ($\beta = 0.944$; $t = 49.671$; $p < 0.001$), followed by WA ($\beta = 0.909$; $t = 21.998$; $p < 0.001$) and KAP ($\beta = 0.811$; $t = 8.974$; $p < 0.001$). This confirms that COI, WA, and KAP are essential components shaping employees' sustainability awareness and capability.

BITA has a moderate and statistically significant effect on SPACS ($\beta = 0.554$; $t = 4.269$; $p < 0.001$), confirming hypothesis H5.1. All first-order BITA constructs indirectly affect SPACS through the second-order BITA construct, suggesting a comprehensive BITA maturity contributes to employee readiness for sustainable action.

We tested the indirect path from BITA to SPACS through business performance, but both paths (BITA→PERFO and PERFO→SPACS) were statistically insignificant. Therefore, hypothesis H5.2 is not supported, and hypothesis H5 is rejected.

The R^2 value for SPACS is 0.433, indicating that the model explains 43.3% of the variance, representing a moderate level of predictive power. The BITA→SPACS path has a substantial effect size ($f^2 = 0.440$), while the PERFO→SPACS path has only a tiny effect ($f^2 = 0.051$). This highlights the role of BITA as a significant contributor to sustainability awareness, while the influence of business performance is limited.

These findings suggest that achieving sustainability goals depends more on integrating IT and business processes effectively than on current performance metrics. Other factors, such as organisational culture, market dynamics, leadership practices, and external environmental conditions, may also play a role and should be investigated in future research. A holistic approach is necessary to understand the drivers of sustainability in organisations fully.

In conclusion, BITA significantly affects employees' sustainability orientation, mainly through COI, WA, and KAP. COI is the most influential dimension. Digital tools and systems that provide feedback, support collaboration, and encourage visibility of individual contributions can enhance employee confidence and willingness to act. Platforms for sharing success stories and recognising efforts can foster a sense of community and commitment. Even gamified strategies may increase engagement. While slightly less influential, KAP remains critical for ensuring employees are well-informed about sustainability initiatives and opportunities for action.

6.2 Discussion of the qualitative analysis of the case study

In the qualitative part of the research, the organisation's level of BITA maturity was assessed using the Luftman instrument (Luftman et al., 2017). The maturity level was estimated at 3.3 on a scale from 1 to 5, where the scale is defined as follows (Table 6):

- Level 1 – Ad hoc process
- Level 2 – Committed process
- Level 3 – Established, focused process
- Level 4 – Improved/managed process
- Level 5 – Optimized process

Maturity levels are defined for all six domains of the Luftman model. A maturity level of 3.3 is consistent with the management's view that the company has a well-established system that allows room for improvement. According to Luftman and

Kempaiah (2008), achieving mature alignment requires a balanced development across all six model dimensions. Each component is critical and should not be overlooked or neglected. Their findings also indicated that during their study, most companies globally were situated around level 3 of BITA maturity.

Table 6: BITA Maturity Levels

Maturity Level	Communi-cation	Competence / Values	Governance	Partnership	Scope & Architecture	Skills
1 – Ad hoc	Lack of understanding between business and IT.	Few technical metrics	No formal process; cost centre; reactive priorities	Conflict: IT is seen as a cost	Traditional tools (e.g., accounting, email)	IT assumes risk, low reward, and technical training only.
2 – Committed	Limited understanding of business/IT	Functional cost efficiency.	Tactical at the functional level; occasionally responsive	IT is becoming a process enabler	Transactional support (e.g., ESS, DSS)	Varies across departments
3 – Established	Good understanding; emerging rapport	Some cost efficiency; dashboards established	Most major processes are managed	IT is seen as an enabler, process driver	Integrated into the organisation.	IT is becoming a valued service provider.
4 – Managed	Unified, connected communication	Efficiency; some partner value; dashboard-driven	Managed across the organisation	IT enables and is part of the strategy.	Systems integrated with partners.	Shared risk and rewards
5 – Optimized	Informal at all levels	Extended to external partners	Fully integrated internally and externally	Complete alignment between IT and business	Systems evolve with partners	Unified training and rewards throughout the organisation

Source: adapted from Luftman (2000)

As a multinational corporation with established corporate rules and processes and a complex IT system deployed at all organisational levels (strategic, tactical, and operational), the company under study has strong potential to leverage BITA to enhance corporate sustainability.

Based on the interviews and discussions with top management, several key areas were identified where BITA could contribute to organisational sustainability:

1. Efficiency enhancement: BITA can help organisations increase efficiency through the automation of routine processes, optimisation of activities, more effective resource utilisation, waste reduction, and enabling business growth without a proportional increase in resource consumption—thus supporting sustainability.
2. Improved decision-making: BITA enhances advanced data analytics capabilities. By leveraging these capabilities, companies can obtain insights that guide their decision-making processes, including those related to sustainability. For example, analytics can identify the most carbon-intensive segments of a supply chain, allowing companies to implement targeted actions to reduce emissions.
3. Facilitating sustainability reporting: IT can assist in collecting, analysing, and reporting sustainability-related data. This level of transparency is crucial for shareholders and stakeholders increasingly concerned about environmental and social impacts.
4. Fostering innovation: It is easier to introduce sustainability-oriented innovations when business and IT strategies are well aligned. The organisation can, for instance, develop new products or services that meet customer needs while minimising environmental impact.
5. Managing sustainability-related risks: IT can support identifying and managing risks related to sustainability. For example, IT systems can monitor and respond to climate-related risks in the organisation's operations or supply chains. Such risk mitigation is essential for long-term sustainability.
6. Supporting remote work: BITA facilitates remote work, which reduces CO_2 emissions by limiting employee commuting and decreasing office space requirements. This aligns with the goals of environmental sustainability.
7. Improving energy efficiency: IT can monitor and manage energy consumption across the organisation, ensuring operations are as energy-efficient as possible.

These insights underline the strategic value of BITA in contributing to sustainability efforts. Through IT-business alignment, organisations can create the foundations for sustainable innovation, responsible operations, and transparent performance management, which are critical in today's dynamic and environmentally conscious business environment.

6.3 Discussion of the MMR findings of the case study

The analysis in this section is based on meta-inference within the Mixed Methods Research (MMR) framework. Based on the MMR results, several key conclusions can be drawn.

First, the BITA factors have a strong influence on all three dimensions of the SPACS construct—knowledge of action possibilities (KAP), confidence in one's influence (COI), and willingness to act (WA). All BITA dimensions significantly impacted these SPACS components, suggesting that each BITA dimension deserves equal attention. As a result, employees are likely to be more willing to support corporate sustainability initiatives when BITA maturity is well developed.

These findings are further supported by the overview of qualitative insights in Table 6, which summarises key BITA maturity scores and ESG-related observations obtained through interviews. The table highlights consistent strengths and areas for improvement, aligning with the SPACS constructs of knowledge, confidence, and willingness to act (Zabukovsek, 2024).

Second, there is a noticeable difference between how top management and employees perceive BITA maturity levels. According to management, communication is the most mature dimension, followed by competence and partnership. In contrast, employees perceive partnership as the most mature, followed by competence and governance. These differences may stem from varying perspectives on the same issues or from the fact that employees may experience BITA differently than top executives, who have a more comprehensive view of the organisation.
Although different instruments assessed BITA maturity for employees and the organisation, both results can be meaningfully interpreted on a comparable scale. Perceptions were gathered from employees (survey) and top management (interviews). As shown in Figure 2, both groups rate BITA maturity levels between 3 and 4 for all dimensions, with one notable exception: skills maturity, which the organisation rated at 2.86, while employees rated it much higher at 3.81—a difference of 0.95, the most significant gap observed.

The following most significant differences were found in:

- Partnership maturity: employees rated it at 4.04, compared to 3.33 by management (Δ = 0.71),
- Governance maturity: 3.90 vs. 3.29 (Δ = 0.62),
- Competence maturity: 4.06 vs. 3.50 (Δ = 0.56),
- Communication maturity: management rated it slightly higher than employees (3.83 vs 3.65; Δ = -0.18),
- Scope and architecture: both groups rated this dimension equally at 3.4.

Figure 2 and Table 5 also show that employees rated overall BITA maturity higher, with an average of 3.81, compared to 3.37 reported by the organisation. These findings suggest that there may be discrepancies in how BITA maturity is perceived across organisational levels. Such differences could be attributed to distinct experiences, roles, or interpretations of what each BITA dimension entails.

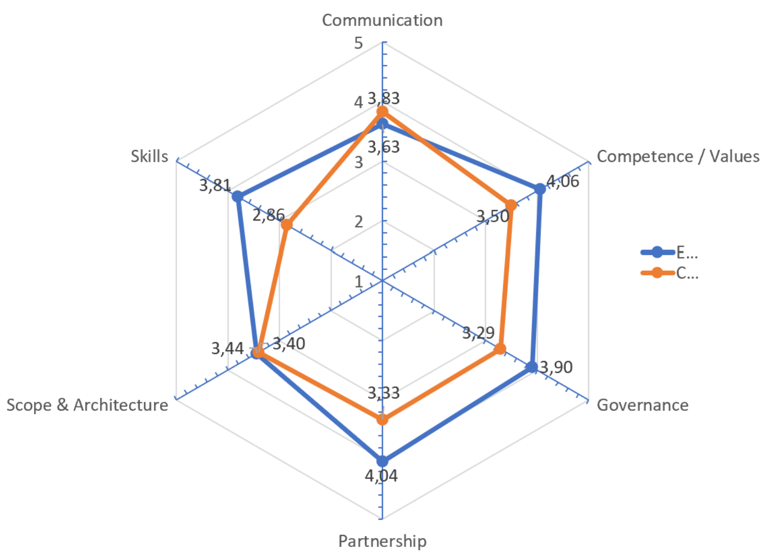

Figure 2: Comparative radar chart of BITA dimensions – employees vs. organization

For the organisation, exploring and reconciling these perception gaps may be valuable, especially in areas such as skills, which were rated significantly lower by management. Furthermore, it would be beneficial to understand why employees rated specific dimensions—such as partnership and competence—more positively than the organisation itself. Continuous dialogue and establishing formal feedback mechanisms could help bridge these differences and ultimately improve overall BITA maturity.

7 Conclusion

This case study adopted a mixed methods research (MMR) approach to examine the relationship between Business and IT Alignment (BITA), business performance (PERFO), IT service quality (ITSQ), remote work (EWORK), and corporate sustainability (SPACS). The quantitative findings revealed that while BITA does not exert a statistically significant direct effect on business performance, it has a strong indirect influence through IT service quality. ITSQ was confirmed as the most critical mediator in the model, demonstrating both strong explanatory power and a significant direct effect on PERFO (Zabukovsek, 2024).

In contrast, remote work, although enabled by BITA, does not contribute significantly to business performance in this context, and the hypothesised indirect effect of BITA via EWORK was rejected. BITA's most substantial and consistent influence was observed in its relationship with SPACS, confirming that mature IT-business alignment significantly enhances employees' awareness, confidence, and willingness to engage in sustainable practices.

The qualitative results support these conclusions and provide additional depth. Management rated BITA maturity at 3.3, indicating an established process with room for improvement. Interviews confirmed BITA's strategic role in enabling sustainability through better decision-making, energy efficiency, remote work support, and risk management. However, differences in BITA maturity perception between employees and management were identified—particularly in skills, partnership, and governance—suggesting the need for improved alignment of perspectives within the organisation.

Overall, this study confirms the centrality of BITA in driving sustainability awareness and the performance potential of IT when adequately aligned with organisational strategy. It also highlights the value of MMR in producing complementary and actionable insights that would remain hidden in single-method studies.

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VI. The Impact of Intermediate Goods Import on the Improvement of Enterprise Innovation Ability Among One Belt One Road Countries

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This chapter reviews prior research relevant to the import of intermediate goods, firm innovation, and the relationship between the two. Studies on intermediate goods imports focus on their impact on enterprise productivity, global value chain positioning, and export quality. Research on firm innovation explores various influencing factors, including cross-border mergers and acquisitions, imports of intermediate goods, and digital transformation strategies. The literature linking intermediate goods imports and innovation emphasizes the role of technological spillovers, diversification, and quality improvements. Drawing from these insights, this chapter summarizes key findings and offers policy recommendations aimed at enhancing both the quality and volume of China's intermediate goods imports and strengthening firms' innovation capabilities.

Keywords:
import of intermediate goods,
corporate innovation,
technology spillovers,
One Belt One Road,
China

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1 Study background and implication

1.1 Study Background

As one of the world's largest manufacturing countries, China's enterprises are generally involved in the import of intermediate goods in the face of international market competition. Intermediate goods play a vital role in the manufacturing industry, directly affecting enterprises' production efficiency and product quality. However, importing intermediate goods is not only a business decision in the production process but also a topic closely related to enterprise innovation. With the deep integration of the global industrial chain, the impact of intermediate goods imports on the innovation ability of enterprises has become increasingly important. Therefore, an in-depth study of the effects of intermediate goods imports on the innovation ability of Chinese firms clarifies the innovation behaviours and strategies of firms in the global environment better.

1.2 Study Implication

By studying the relationship between the import of intermediate goods and the direct impact on the innovation capacity of firms, we can reveal how firms can improve their competitiveness in the international market by bringing in external resources and knowledge to enhance the quality of products and innovative technologies. An in-depth understanding of the relationship between intermediate goods imports and firm innovation can help the government to guide and formulate relevant policies more accurately. The government can encourage enterprises to strengthen innovation activities and promote industrial upgrading by developing policies to support importing intermediate goods.

Studying the impact of intermediate imports on enterprise innovation helps strengthen cooperation and exchanges among international enterprises. Through in-depth collaboration with foreign enterprises, Chinese enterprises can better integrate into the global value chain and achieve a win-win situation. With the changes in the international economic situation and trade environment, understanding the impact of intermediate goods imports on innovation capabilities enables enterprises to respond more flexibly to changes in the external environment and better adapt to the evolution of the global industrial chain.

Therefore, an in-depth study of the impact of intermediate goods imports on the innovation ability of Chinese enterprises will not only help to improve the innovation level of enterprises but also play a positive role in promoting the government's formulation of industrial policies, promoting international cooperation, and promoting the sustainable development of enterprises.

2 Literature review

2.1 Literature review on intermediate goods imports

Many scholars have researched and analysed the economic benefits of importing intermediate goods from different perspectives. There are many issues related to the impact of intermediate goods imports on firm productivity, global value chains, and export quality in terms of the quality and diversification of intermediate goods imports and the geographical location of imports.

From the perspective of the global value chain of enterprises, Hu et al.(2023) and other studies on intermediate goods imports, independent innovation and enterprise global value chain upgrading pointed out that the import of intermediate products can make the production activities of enterprises enter the downstream links of the value chain and have different impacts on the role of enterprises in different development periods in joining the global value chain. The import of intermediate products and the independent innovation of enterprises will have a "threshold effect" and a "complementary effect" because of the specific value of intermediate product imports. Hao et al. (2022) show that improving the intensification and extensibility of the regional intermediate goods import network of the countries along the "Belt and Road" is conducive to promoting their position in the division of labour in the global value chain. Kee and Tang (2016) pointed out that the import trade of intermediate goods is crucial in enhancing the division of labour in the global value chain of importing countries through technological spillover effects. From the technical level of enterprises, Liu et al.(2023) studied the impact of the liberalisation of intermediate goods import on enterprise innovation from the two stages of technology opening and technology transformation. They concluded that deregulating intermediate products by import is conducive to improving the quality and quantity of enterprise technology opening and technology transformation. Its effect is more evident in high-intensity import enterprises and high-tech industries.

Based on the social network analysis method, Chen and Guo (2023) clarified that the optimisation of the source structure of intermediate goods imports plays a crucial role in the improvement of enterprise productivity in high-tech industries, capital or technology-intensive industries from the perspective of the source of intermediate goods imports and that the optimisation of the structure of import sources other than primary, intermediate inputs has a significant effect on enterprise productivity.

By participating in global procurement, Ethier (1982) enterprises have diversified the types of intermediate products, and the organic complementarity of internal products and foreign imported products enables enterprises to break the shackles of domestic endowments to achieve a rational allocation of resources, thereby improving enterprise productivity. Based on the relevant data on the export competitiveness of the "Belt and Road" countries, Sun (2021) analysed that the larger the import volume of intermediate goods, the more conducive to promoting the production efficiency of enterprises, and it also has a promoting effect on the technical complexity of export products, which indicates that the import of intermediate products by enterprises is conducive to improving the competitiveness of their products. In terms of export products, Song and Zheng (2020) started from the manufacturing industry subdivision to study the import of intermediate products to the export product quality of Chinese manufacturing enterprises. The results showed that intermediate products have a quality improvement effect on the quality of export products through the mechanisms of "competition effect," "knowledge spillover effect," and "intermediate product quality effect." Moreover, the effect on enterprises in the early and growth stages is more prominent. Jiang et al. (2023) study intermediate goods import, geographical agglomeration, and export complexity; importing differentiated products can help enterprises improve the export complexity in learning. Wei et al. (2021) studied the impact of import tariffs on the quality of export products from the level of subdivided industries, and the research showed that the import tariff reduction of intermediate products has a promoting effect on the quality of export products, especially in sectors with large import scale of intermediate products. Song et al. (2019) pointed out that importing intermediate goods affects the quality of export products through competition, knowledge spillover, intermediate mass, and intermediate effects.

However, at the same time, in studying the import benefits of intermediate goods, some scholars have researched and analysed the adverse effects they bring. From the perspective of the technical quality of intermediate goods imports, Liu (2021) discovered that the high technical content of the final goods exported by China's manufacturing industry is mainly due to the risk of a country's dependence on intermediate goods imports caused by the ultra-high imports and may also hurt the domestic value-added rate. Chen et al.(2021) analysed the import of intermediate goods in the manufacturing and service industries. They pointed out that the import of intermediate goods with high technical complexity will exacerbate the risk of a country's dependence on imported intermediate goods and inhibit the capital accumulation of the manufacturing industry. Still, at the same time, importing intermediate goods will help a country's economic development level and improve input and output. Starting from the enterprise category. Linker(2012) addressed that companies far from the forefront of technology will give up independent innovation due to frustration. Then, it will be difficult to absorb the spillover effect of imported R&D. Wei et al.(2020) explored the impact of the quality of imported products on enterprise productivity by distinguishing the types of enterprises and pointed out that the import of high-quality intermediate goods by general trade enterprises and mixed trade enterprises can improve enterprise productivity through technological innovation channels and competitive incentive channels while processing trade enterprises will have the phenomenon of enterprise R&D investment and enterprise productivity decline due to the import of high-quality intermediate goods.

2.2 Review of the literature influencing corporate innovation

In the existing literature, many factors affect enterprise innovation, such as cross-border mergers and acquisitions, enterprise import of intermediate products, and enterprise digital transformation strategy.

Chu et al. (2023) pointed out that cross-border mergers and acquisitions of enterprises have a significant role in promoting enterprises' patents and innovation performance. Jiang et al. (2023) studied the relationship between product diversification, digital transformation, and enterprise innovation performance and the digital transformation and product diversification strategies can significantly improve the innovation performance of enterprises, and product diversification has a promoting effect on digital transformation and innovation performance, especially in high-tech and high-tech enterprises. Wen et al. (2023) studied the mechanism of research and development internationalisation and enterprise innovation performance in digital transformation. They pointed out that the digital transformation of enterprises promotes the internationalisation of enterprises and the improvement of innovation performance. In terms of imports, Zhang (2023) started with the import of software and information technology services and concluded that the import of software and information technology services has a different effect on the innovation level of enterprises, and the impact on innovation in various industries and other regions is also different. In addition, the internationalisation of enterprises is also a major driving force for enterprise innovation. Liu et al. (2023) study that multinational enterprises can enhance innovation by obtaining foreign technology, talents, and resources through international operation and cooperation. They promote enterprises to increase innovation activities to improve competitiveness and occupy market share through competitive effects. Regarding subdividing imports into intermediate goods, Liu et al. (2018) concluded that diversifying intermediate goods imports can significantly promote the innovation of manufacturing enterprises. The technological innovation ability to manufacture enterprises positively correlates with the international technology spillover effect of intermediate goods imports. Lin et al.(2017) and Hao et al. found that the liberalisation of intermediate goods imports is generally conducive to enterprise innovation, and there are many mechanisms, such as cost-utility, market expansion utility, technology spillover utility, and R&D complementarity to promote the improvement of enterprise innovation. Yoo (2012) pointed out that digital transformation can improve enterprises' ability to innovate independently. At the same time, Chen (2022) pointed out that digital transformation is expected to reduce the cost of debt financing, provide more favourable financial support for enterprises' green innovation projects, and promote the development of enterprises' green innovation.

2.3 Literature review on the impact of intermediate goods imports on firm innovation

Based on many literature studies, intermediate products have a particular influence on enterprise innovation, and scholars at home and abroad have made many summaries on the influence mechanism, including the "product diversification mechanism," "quality mechanism," and "technology spillover mechanism."

From the perspective of technology spillovers, intermediate goods trade is one of the essential carriers of technology spillovers, which can affect the innovation status of final goods through the increase of intermediate import types. Geng et al. (2012), in their study of intermediate goods imports and firms' environmental performance, concluded that intermediate goods imports could bring technology spillovers to firms, thereby improving firms' productivity. Wan (2023) studied the impact of intermediate goods imports on industrial pollution emissions and verified that importing intermediate products promotes technological progress through technological spillovers, thereby improving the production efficiency of enterprises and strengthening the innovation research and development of green technologies and products. Zhang et al. (2023) pointed out that the technological spillover of intermediate products has a good role in promoting the rise of the global value chain status of the manufacturing industry. This effect is because the technological spillover of intermediate products encourages the development of the independent innovation model of enterprises, thus bringing about the rise of the global value chain status. Ji et al. (2023) conducted an empirical study on the internal mechanism of imported intermediate products affecting the innovation of export products through the technological spillover effect, and the technological spillover effect of intermediate goods imports has a significant role in promoting the innovation of export products of enterprises. The participation of intermediate products in the domestic market competition positively affects the research and development of innovative products. Wang et al. (2019) studied the internal mechanism of intermediate product import on the choice of enterprise technological innovation mode. They analysed the impact of the technology spillover effect brought by the import of intermediate products on the technological innovation mode of enterprises affected by the absorption capacity of enterprises. The more robust the absorption power, the more pronounced the effect of the technology spillover effect on enterprise innovation, and the easier it is for enterprises to engage in high-end technological innovation. Yao et al. (2019) studied the mechanism of intermediate goods import and enterprise technological progress. They believed that when Chinese enterprises imported intermediate products, they obtained a spillover effect and encouraged enterprises to choose to carry out research and development and increase investment in research and development. From the mass effect, Keller (2004), through import trade, allows developing countries to learn from advanced technologies and high-quality processes exported from developed countries, improving their product quality and innovation level.

Through empirical regression analysis, Gong et al. (2023) confirmed that improved imported intermediate quality significantly promotes the number of enterprises' patent applications. Through heterogeneity analysis, improving imported intermediate quality in enterprises with export behaviour, general trade enterprises, and enterprises with high export product quality can significantly promote enterprise innovation. Wei et al.(2017) started with the quality of imported goods at the enterprise level under general trade, explored its impact on enterprise innovation, and pointed out that the improvement of the quality of imported products can significantly enhance the innovation ability of enterprises, whether it is imported capital goods or imported intermediate goods, it has a positive impact on the innovation of enterprises. The primary mechanism is to enhance the time for continuous innovation of enterprises by absorbing technology and expanding the market. Wu et al. (2022) examined the mechanism of the influence of enterprise intermediate goods imports on enterprise innovation based on the enterprise level. They pointed out that improving the import quality of intermediate goods can promote enterprise innovation through market expansion effect, enterprise productivity, and human capital level improvement, especially foreign-funded enterprises, advanced enterprises, patent-intensive enterprises, etc., and the effect is more prominent. From the perspective of product diversification, Halpern (2015) pointed out that with the deepening of the liberalisation of intermediate goods trade and the expansion of the scale of imported intermediate goods, the diversification level of intermediate varieties is also increasing, which has an essential impact on enterprise innovation. Li (2020) analysed the influencing mechanism of intermediate goods import diversity, enterprise innovation, and wage level by establishing a model and concluded that the diversification of intermediate goods imports is helpful to promote enterprise innovation because the technology transfer effect brought by the import of core parts and advanced technology intermediate goods from abroad and the digestion and absorption contained in the diversified intermediate goods of domestic enterprises reduce the innovation cost of enterprises, and then promote the innovation and development of enterprises. Li (2019) studied the relationship between the innovation of Chinese manufacturing enterprises and the import of intermediate goods and concluded that the diversification of intermediate goods imports has a positive effect on the binary margin of enterprise innovation, especially the diversification of enterprises with rich types of imported intermediate varieties has a more significant innovation effect on their companies. Importing intermediate goods mainly promotes enterprise innovation through cost saving, quality improvement, technology diffusion, or R&D substitution. Zhang et al. (2023) explored the mechanism of intermediate goods imports and enterprise innovation from the multi-dimensional perspective of importation, diversification, and sophistication. They pointed out that "the diversification of related intermediate goods imports" is more conducive to enterprise innovation, especially for enterprises whose productivity is close to the frontier of science and technology. The diversification of intermediate goods imports has a more noticeable effect on the innovation promotion of enterprises. In addition, from the perspective of trade liberalisation, Yu (2021) and others believe that developing trade liberalisation can reduce the cost of importing intermediate goods, optimise the production process, and make it easier for enterprises to enter the international market and enjoy economies of scale.

To sum up, the impact of intermediate goods imports on enterprise innovation is generated through many mechanisms, and it is also the willingness of enterprises to enhance their innovation power. First of all, through the increase in the types of imported intermediate products, enterprises also provide more innovation resources for the development of enterprises and increase the input of more raw materials, parts, components, and technologies, which plays a vital role in promoting the innovation and development of enterprises, improving the production efficiency of enterprises, reducing production costs, and providing more funds and resources for enterprise innovation. The diversification of product categories allows enterprises to come into contact with different develop new innovative ideas.

Enterprises can better meet market demand, improve product quality and competitiveness, and provide more opportunities and motivation for innovation. Secondly, by enhancing the import of high-quality intermediate products, enterprises have improved the quality of raw materials and parts required in their production process, and the production of high-quality intermediate products has improved the quality and competitiveness of enterprise products, providing opportunities and motivation for innovation. Importing high-quality intermediate goods can promote technical exchanges and cooperation between enterprises and international advanced enterprises and bring innovative funds and resources to enterprises. The products and high-quality intermediate goods will also enhance the brand image of the company's products, improve consumers' trust and recognition of the company's products, and promote the innovation and development of the enterprise. Finally, in the technology spillover mechanism, enterprises can get in touch with foreign advanced technologies and processes, technology transfer and diffusion through the import of intermediate goods, to learn and imitate these technologies, and these products can stimulate the innovation inspiration of enterprises, develop new innovative ideas, and achieve the role of enhancing enterprise innovation.

2.4 Summary

First, Throughout the literature at home and abroad, many factors influence enterprise innovation, and the research results on the impact of intermediate goods on enterprise innovation from the perspective of intermediate goods import are also abundant. Through the above literature review, most scholars have an impact on enterprise innovation from the perspective of the import quality of intermediate products, the diversification of imported products, the market expansion effect, the cost-saving effect, the quality improvement effect, the technology spillover effect and the R&D substitution effect of imported products. The study of this paper provides a research basis. Finally, by combing the above literature, it is found that there are some limitations in the methods and contents of previous research, which provides research innovation space for this paper. Most studies on the impact of the import of intermediate goods on enterprise innovation are from the perspectives of technology spillover, mass effect, and product diversification, but the conclusions differ.

Second, In the past, empirical research methods were mainly used to analyse the relationship between intermediate imports and firm innovation by constructing econometric models. However, these studies often needed more data availability and sample selectivity. Therefore, this paper attempts to use new data sources and research methods, such as using the data level of firms or conducting case studies, to explore the impact of intermediate goods imports on firm innovation.

Last, The existing studies mainly focus on the direct impact of intermediate goods imports on firm innovation but rarely explore how intermediate goods imports affect firm innovation. Therefore, this paper can conduct a more in-depth study from the perspective of the mechanism of action and analyse how the import of intermediate goods affects the innovation behaviour of enterprises through technology spillovers and quality effects.

3 The status of China's intermediate goods imports and enterprise innovation

3.1 Definition of import of intermediate goods

By the United Nations BEC Classification methodology, we adopt a more objective and relatively uniform classification by further subdividing trade data into capital goods, intermediate goods, and consumer goods according to the different purposes for which the products are used, with particular consideration of primary products such as foodstuffs, raw materials, pre-processed products, and components, which constitute an essential part of intermediate imports. This classification helps to eliminate the subjectivity that can be introduced when classifying products based on their name while being more in line with the requirements of the System of National Accounts (SNA). Through such segmentation, we have a more comprehensive understanding of the structure of imported products, which leads to a more accurate analysis and understanding of the impact of international trade on different sectors and levels. This relatively unified statistical system allows us to study more deeply the effect of imports of various categories of products on economic development, industrial structure, and innovation capacity.

Table 1: BEC classification

SNA category	BEC Code	Description
Primary products	111	Primary food and beverages for industrial use
	21	Primary industrial goods that are not classified
	31	Primary fuels and lubricants
Semi-finished products	121	Processed food and beverages for industrial use
	22	Unclassified processed industrial products
	322	Other fuels and lubricants
Parts and components	42	Capital goods, parts and accessories
	53	Transportation of spare parts for equipment

3.2 The scale of intermediate goods imports

Since China acceded to the WTO in 2001, the total import of intermediate goods has shown an apparent growth trend, and its proportion in the overall import trade is relatively high and tends to be stable, highlighting the critical position of intermediate goods imports in China's trade system. One of the main reasons for this trend is that after China acceded to the WTO, it gradually lowered the level of international tariffs, thereby reducing import costs and promoting domestic enterprises to continue to increase imports of diversified intermediate goods.

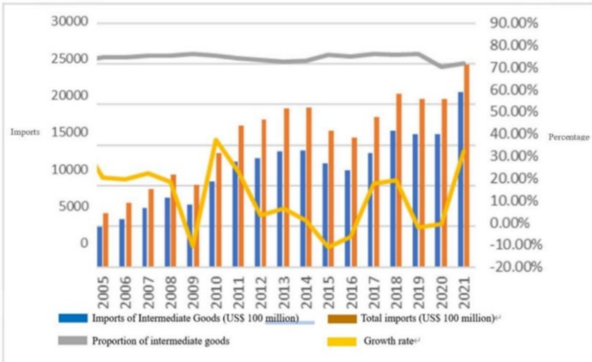

Figure 1: China's imports of intermediate goods and total trade imports from 2000 to 2021
Source: UN COMTRADE database

From 2001 to 2014, imports of intermediate goods continued to grow, and despite the impact of the financial crisis in 2009, they recovered rapidly the following year. However, since 2014, China's economic structural transformation and industrial policy adjustment have impacted many traditional manufacturing industries, which has led to a significant decline in domestic import demand for intermediate goods, which has been declining for two consecutive years. The recovery of the global economy has promoted increased global consumer demand. However, due to the impact on the worldwide supply chain, the decrease in consumer demand and the decline in product prices, China's intermediate goods imports have decreased significantly.

However, with the continuous optimisation of China's economic structure, the improvement of consumer demand and the improvement of the government's opening up to the outside world, China's imported goods began to improve significantly in 2017. The import value of intermediate goods reached a record high of 1,613.225 billion US dollars in 2018. In 2020, affected by the new crown epidemic in 2019, the global supply chain was impacted, consumer demand declined, trade frictions increased, and the total import volume of intermediate goods and imports showed a downward trend. In 2021, with the gradual resumption of work and production, the import value of intermediate goods will show an upward trend.

Behind this economic phenomenon are the complex changes in China's import trade, which are closely related to factors such as the global financial situation, industrial restructuring, and international trade environment.

3.3 Types of intermediate goods imported

As a key component between raw materials and final consumer goods, the evolution of the import structure of intermediate goods intuitively reflects the transformation of China's economic development mode and the adjustment of China's position in the international division of labour. Figure 2 shows the changes in the import structure of intermediate goods in China from 2005 to 2020. From 2005 to 2008, primary products, semi-finished products and parts showed a steady growth trend, reflecting the rapid development of China's economy. However, the shock of the 2009 global financial crisis has dampened this growth trend somewhat. With the alleviation of the subsequent impact of the crisis, China has adjusted its import strategy and increased the procurement of primary products from European and American countries, resulting in significant changes in the internal structure of imported intermediate goods. The share of primary products increased sharply, while the share of semi-finished products decreased slightly. Imports of primary, semi-finished products and components declined between 2014 and 2016, mainly due to the weakening global economy.

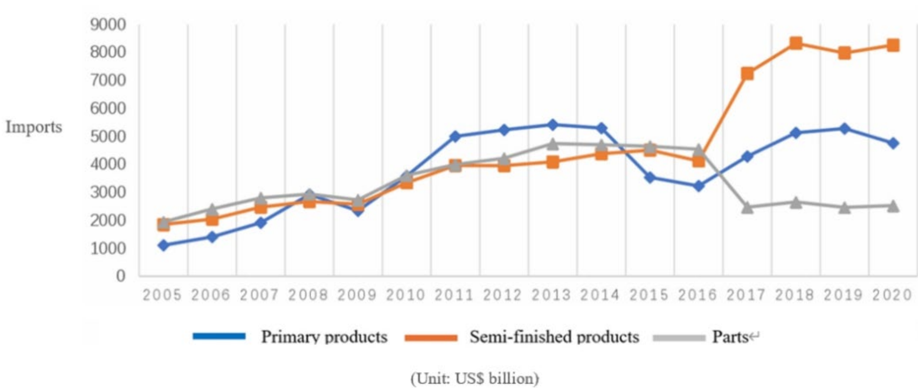

Figure 2 China's total imports of intermediate goods from 2005 to 2020
Source: UN COMTRADE database

The lack of growth momentum in European and American countries and the sluggish demand in the international market have led to a corresponding decrease in China's total imports of intermediate goods. At the same time, domestic economic development has entered a normalised situation, facing downward pressure on the economy, and domestic and international demand is insufficient, especially the slowdown in the growth rate of imports of bulk commodities.

Between 2016 and 2020, the import value of China's primary and semi-finished products increased significantly, while the import value of spare parts decreased slightly. This trend is affected by the Sino-U.S. trade friction and China's independent innovation policy, resulting in the total import of capital goods and other components from 406.279 billion US dollars in 2016 to 195.877 billion US dollars. At the same time, the total import value of primary products increased from 323.31 billion US dollars to 476.374 billion US dollars, and the import value of semi-finished products also increased from 412.926 billion US dollars to 822.653 billion US dollars. China has been developing processing trade for a long time, mainly focusing on the processing and assembly of capital goods parts and components with low technical content. However, this practice restricts enterprises from obtaining core technologies, which restricts China's technological innovation and is not conducive to China's high-end extension of the global value chain. Since 2019, the new crown epidemic has restrained the import of primary products in China, and imports have a significant downward trend. Since 2016, China has begun to promote supply-side structural reforms to encourage the construction of a manufacturing power. With the introduction of several innovation policies and the implementation of the two plans of Industry 4.0 and Made in China 2025, China has encouraged the development of an advanced manufacturing industry, especially the independent innovation ability of local parts and components, which has been significantly improved. As a result, China has reduced its imports of low-tech components. However, China's domestic energy resources cannot meet the strong demand for production scale, especially the demand for non-agricultural primary products such as copper ore, iron ore and crude oil has increased significantly, resulting in the continuous growth of the import amount of intermediate products in the primary products. Semi-finished products are mainly used in the food processing and textile industries, which are intermediate inputs with low technical content and are less affected by Sino-US frictions from 2016 to 2020, and the import value has increased significantly. This change reflects China's continuous adjustment in international trade to adapt to the development of the global supply chain and improve the technical level of the domestic manufacturing industry.

3.4 The basic situation of Chinese enterprise innovation

After China acceded to the World Trade Organization (WTO), it gradually integrated into the global value chain. It plays a role that cannot be ignored in the international division of labour. In the early stage, due to the relatively low level of innovation in China, coupled with the fact that economic growth mainly depends on factor input and investment, the investment in R&D and innovation is relatively limited. Hence, the process of improving innovation ability is relatively slow. With the rapid growth of China's comprehensive national strength, the advantages of factors such as the demographic dividend that it relied on in the early stage have gradually weakened, and China has steadily adjusted its economic growth strategy to be innovation-driven, forming an economic growth model with innovation as the core, thereby significantly improving its innovation ability. Figure 3 illustrates the evolution of the number of patent applications in China between 2000 and 2018, from 25,346 in 2000 to 1393815 in 2018, an increase of 5,399% year-on-year.

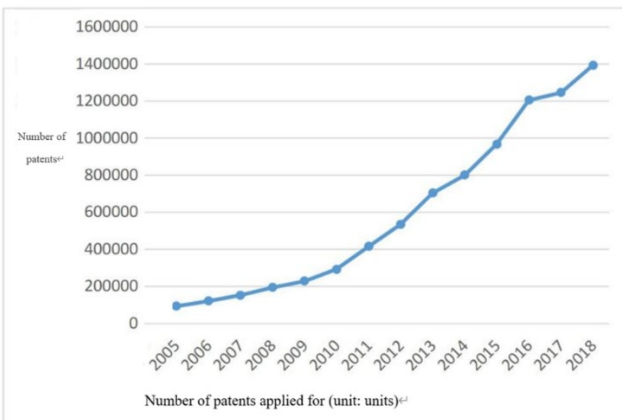

Figure 3: The number of patent applications filed in China from 2000 to 2018
Source: UN COMTRADE database

This explosive growth trend reflects the significant improvement in China's innovation capabilities. China's economy has gradually shifted from a growth model that relies on factor inputs and low-cost labour to a growth model that relies on scientific and technological innovation, intellectual property rights, and high-value-added industries. This innovation-driven approach to economic growth has enabled China to participate more effectively in global value chains, laying a solid foundation for sustainable economic development. It also shows that China's role in the worldwide economy gradually changes from that of a manufacturing provider to that of a technology and innovation leader.

3.5 Specific characteristics of Chinese enterprise innovation

From the data on enterprise innovation patents in Figure 4, patent-related indicators showed a significant upward trend in the sample year. First, the number of enterprises with patents increased rapidly between 2000 and 2007, from 348 to 1,029, while the number of enterprises with patents at the end of the sample was nearly three times that of the early year of the sample. This shows that more and more companies are beginning to realise the importance of innovation and actively participate in patent application activities. Second, the total number of patents also experienced a significant increase in the sample year, from 2,447 patents in 2000 to 19,789 patents in 2007, an increase of about eight times. This means that the intensity of innovation activities of enterprises as a whole has increased significantly, and the importance of intellectual property rights has increased. At the same time, the average number of patents per enterprise has also increased with the rapid growth of the total number of patents, from an average of 0.6548 patents per enterprise in 2000 to an average of 2.7213 patents per enterprise in 2007. This shows that enterprises' average level of innovation has improved, and the investment and efforts of enterprises in innovation have achieved apparent results. This innovation trend is in line with the expectations of this article.

With the development of trade liberalisation, the rapid growth of China's economy and the gradual improvement of the position of Chinese enterprises in the global value chain, the development concept of enterprises has changed from the initial factor-driven to innovation-driven. Although there is still a problem of "low-end lock-in" as a whole, the number of innovative enterprises with technology content is increasing, and their proportion in the overall innovation activities of enterprises is increasing. The company has gradually evolved from the primary product processing stage, where the concept is to complete the task as much as possible, to the innovation-driven stage, constantly striving for progress. This positive innovation trend has dramatically increased the innovation output of enterprises and injected new vitality into high-quality development. Therefore, it can be concluded that enterprises' investment in innovation activities is gradually increasing, the cost of innovation is slowly rising, and the weight of innovation is increasing.

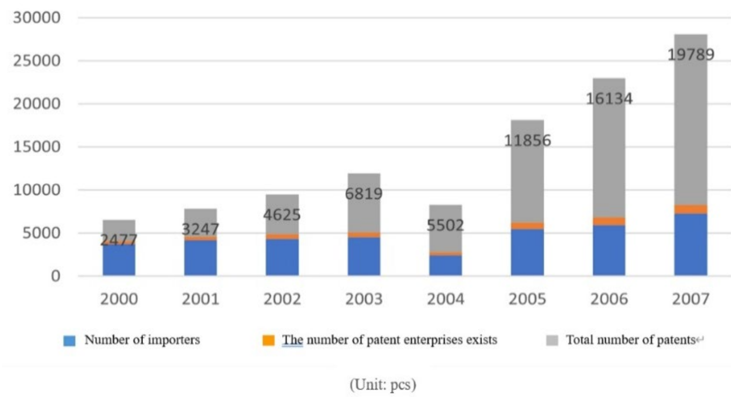

Figure 4 Enterprise innovation patents from 2000 to 2007
Source: UN COMTRADE database

4 Conclusion and recommendation

The import of intermediate goods has many influencing mechanisms on firm innovation, including product diversification, quality improvement and technology spillovers. These mechanisms have had a positive impact on enterprises' innovation activities. Judging from the data on patent filings, Chinese companies have shown explosive growth in innovation, especially after 2000. The number of enterprises, the total number of patents, and the average number of patents per enterprise all show a significant increasing trend, indicating that the input and output of Chinese enterprises in innovation activities have increased significantly.

The total import value of intermediate goods is essential in China's economy, showing a fluctuating growth trend. The international trade environment, the global economic situation, and the adjustment of China's policies have all impacted the import of intermediate goods, especially in the context of China's structural economic transformation in recent years.

Strengthen technology spillover mechanisms, encourage enterprises to acquire advanced technology and knowledge through intermediate product imports, and establish technology spillover mechanisms to transform these technologies into local innovation. Supporting SME innovation and developing policies to support SMEs, reduce innovation costs, promote participation in international innovation cooperation, and improve their position in global value chains. Promote innovation-driven development, further increase investment in innovation, strengthen the construction of R&D infrastructure, formulate incentive policies, and promote the transformation of enterprises from factor-driven to innovation-driven. Optimise the import structure of intermediate goods, according to domestic demand and industrial development, optimise the import structure of intermediate goods, reduce the dependence on low-tech parts and components, and increase the import of high-tech intermediate products.

In turn, the future development direction of China's intermediate goods imports and enterprises should be in-depth research on the innovation mechanism and further in-depth study on the impact of intermediate goods imports on the innovation mechanism of enterprises, including the differences in different industries, enterprise scales and technical levels. Strengthen international innovation cooperation, promote the in-depth cooperation between Chinese enterprises and international enterprises and scientific research institutions, promote the sharing of international innovation resources, and improve China's position in the global innovation network. Promote digital transformation, further study the impact of digital technology on enterprise innovation performance given the relationship between digital transformation and enterprise innovation, and provide scientific guidance for enterprises to improve their digital level. Pay attention to environmental protection and sustainable development, strengthen the consideration of environmental protection and sustainable development factors in the research of intermediate goods import and enterprise innovation, and promote the development of enterprises in the direction of green innovation and sustainable development. These recommendations and future development directions are aimed at further promoting the innovation of Chinese enterprises, improving their position in the global value chain, and promoting sustainable economic development.

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VII. Can the Digital Economy Boost the Trade Position of Countries Along the Belt and Road?

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With the rapid development of digital technology, the digital economy has become an essential component of the global economy, injecting new impetus into international trade. With the "Digital Silk Road" development, the digital economy is becoming a new engine for economic and trade cooperation between China and countries along the "Belt and Road". This paper analyses the development level of the digital economy of countries along the Belt and Road through the TIMG index. It concludes that the overall development level of the digital economy of countries along the Belt and Road is still low and unbalanced, and the underlying reasons are analysed. Secondly, the impact of the digital economy on the trade status of countries along the route was analysed from three paths: trade costs, trade prices, and trade diversity. Finally, four relevant policy recommendations are proposed: digital technology, digital infrastructure, digital market, and digital governance.

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1 Introduction

1.1 Research background and significance

In the rapid development of international trade, from traditional goods trade to service trade and then to the emerging digital trade, data is gradually becoming a key production factor, and the digital economy industry is also gradually becoming the dominant industry (Gao, 2022). Global trade has gradually entered a critical period of digital transformation, and digital resources have gradually become the main competitiveness in international trade. The digitisation and networking of information have greatly improved production efficiency, optimised economic structure, and better promoted the integration and high-quality development of emerging and traditional industries in various countries. Therefore, the digital economy has, to some extent, promoted the high-quality development of trade and played a positive role in enhancing the current trade status of various countries.

Currently, China's digital economy is in a rapid development stage, with many new models and formats of digital economy emerging (Ren, 2022). With the continuous development of the "Belt and Road" initiative, the concept of digital economy has been gradually introduced into the "Belt and Road". At present, the role of developing a digital economy in promoting and deepening the construction of the "Belt and Road" has been emphasised by scholars in China. Li adopts the dynamic panel data method to measure the impact of the Internet on the gross domestic product (GDP) through the data of 65 countries/regions in the Belt and Road region from 1996 to 2014 and finds that the impact of the Internet on GDP is not limited to the countries along the Belt and Road region. These are not only China's key partners but also among the most significant countries in the world. Through R-factor analysis, it is found that countries along the "Belt and Road" should adopt various strategies according to their national conditions, actively build up their information industries, and jointly promote the development of the "Digital Silk Road".

Some studies take the countries and regions along the "Belt and Road" as examples to discuss the development of the digital economy. Eugenia suggests that under the Belt and Road Initiative, the digital economy of the Eurasian Economic Union plays an important role in the modernisation of the economy, new industrialisation, and the establishment of cloud infrastructure (Lun & Liu, 2022). Zhuang discusses the development of the digital economy in the countries along the Belt and Road Initiative by region and puts forward some suggestions for the development of the Belt and Road digital economy. Some studies start from a macro point of view, integrating the digital economy with the Belt and Road and conducting related studies on the connotation of the Digital Silk Road. Xiang Kun believes that the strategic connotation and future development path of the Digital Silk Road are closely related to the development of the digital economy. According to Su, the "Digital Silk Road" relies on China's modern Internet technology to build network infrastructure based on cross-border e-commerce, mobile payment, and intelligent logistics systems and then establish cooperation mechanisms. Overall, in the construction of the Belt and Road Initiative, the digital economy, with its advantages of efficient allocation and innovation concentration, will continue to inject new kinetic energy into the participating countries of the Belt and Road Initiative and help them realise leapfrog development (Xu, 2022).

1.2 Research content and methods

Mainly based on the relevant data of the global digital economy development report, this paper analyses the current situation of the digital economy development of countries along the Belt and Road and concludes that the overall development level of the digital economy of countries along the Belt and Road is not high and remains unbalanced. Further, based on the secondary indicators of the measurement index, this paper analyses the causes of the current problems and examines the impact path of the digital economy on the trade status of countries along the Belt and Road. Finally, it puts forward corresponding policy recommendations from four aspects: digital economy infrastructure, digital technology, digital market, and improving digital governance.

This article mainly uses literature analysis and comparative analysis methods. By reviewing relevant literature on measuring the level of digital economy development and international trade both domestically and internationally, this paper summarises the literature from two aspects: the selection of measurement indicators for the level of digital economy development and its impact on trade, determining the research purpose of this article.

2 Connotation of digital economy

The digital economy was first proposed and defined by Tapscott (1996), who believed that the digital economy was first proposed and defined by Tapscott (1996), who believed that the digital economy is a new economic form based on the use of information and communication technology, pointing out the essential difference between the digital economy and the traditional economy. After this concept was put forward, it did not cause enthusiastic discussion in the academic community at that time. After entering the 21st century, the rapid development of the global Internet, ICT applications are changing day by day, and the digital economy has released great vitality and become an important force to pull economic growth, which has been widely concerned and highly valued by the industry, academia, as well as governments and institutions of various countries. In 2013, the International Trade Commission of the United States first proposed the concept of digital trade (Ma, 2022). In 2016, the G20 Summit launched a discussion on the digital economy and pointed out that the digital economy is a new economic form based on digital content as the production factor and on the basis of the characteristics of the elements, the characteristics of the carriers, and the sources of the driving force. Digital content is a production factor that relies on information networks and information technology, improves efficiency, and optimises the economic structure of economic activities.

OECD (2017) takes the manifestation of the digital economy as a starting point and defines economic activities that are transacted and delivered through digital means as digital economic activities. Different from the previous definition, BEA (2019) defines the digital economy from the perspective of digital transactions, digital media, and digital infrastructure, and for the first time, digital infrastructure is included in the connotation of the digital economy, making the definition more concrete. Xu (2020) expands the connotation of the digital economy to digital transactional products based on which the goods, services, and data traded through digital means are included in the digital economy. The goods, services, and data traded are included, affirming the value of data output in the development of the digital economy (Li, 2022).

The China Academy of Information and Communication Research (2020) breaks down the digital economy from the perspective of the value added to the industry, arguing that digital industrialisation and industrial digitisation constitute the main content of the digital economy and that digital governance and data valorisation are brand-new connotations that cannot be ignored in the process of the integration of the digital economy with the economy and society (Jiang & Duan, 2021). This definition of the scope reflects the dynamic change of the connotation level of the digital economy in the process of development. Also, it adds a new note to the traditional factors of production, productive forces, and production relations (Chen, 2020).

In 2021, the National Bureau of Statistics (2021) issued the Statistical Classification of the Digital Economy and Its Core Industries (2021), which defines the scope of the digital economy in terms of demand orientation, international comparability, a foothold in the present, and a focus on the practical as the starting point. It defines the scope of the digital economy into five categories, namely "digital product manufacturing," "digital product service," "digital technology application," and "digital factor-driven industry" as the core industries of the digital economy (Yu & Guo, 2022). These are "digital product manufacturing," "digital product service," "digital technology application," and "digital factor-driven industry" as the core industries of the digital economy, as well as the "digital efficiency enhancement industry," which integrates with the efficient development of traditional industries. For reasons of statistical data availability and continuity, the definition of the digital economy by the NBS does not reflect the role of the digital economy in improving quality and efficiency in social governance, while the rest of the definition is roughly the same as that of the China Academy of Information and Communications Technology. Although there are some differences between the two definitions of the scope of the digital economy, they basically reflect the main connotations of the digital economy and are the two broad definitions of the digital economy with a high degree of acceptance (Ruan, 2021).

3 Analysis of the current status of digital economy development in countries along the "Belt and Road"

3.1 Low overall level of development

Since 2013, the overall development of the global digital economy has shown an upward trend, and the digital economy has gradually become an important part of the construction of the "Belt and Road" and a breakthrough for future international cooperation. Regarding the measurement of the level of development of the digital economy, the report of the Global Digital Economy Development Index measures the level of development of the digital economy of each country based on the TIMG index, which includes the level of digital technology, digital infrastructure, digital market, and digital governance of each country.

Table 1: Regional distribution of the top 20 countries in the TIMG index

Region	Country	Rank
European	United Kingdom	3
	Germany	4
	Netherlands	5
	France	7
	Switzerland	9
	Finland	11
	Sweden	13
	Denmark	15
	Belgium	16
	Norway	18
	Ireland	19
Asian	Singapore	2
	Japan	6
	China	8
	South Korea	10
	United Arab Emirates	17
	Israel	20
North America	United States	1
	Canada	12
Oceania	Australia	14

According to the 2023 Global Digital Economy Development Index Report, Table 1 shows that the top 20 countries in terms of the level of development of the digital economy are mainly concentrated in the European region, followed by the Asian region. Only four countries, namely Singapore, China, the United Arab Emirates, and Belgium, belong to the countries along the Belt and Road Initiative, so it can be seen that the overall development level of the digital economy in the countries along the Belt and Road Initiative is not high.

3.2 Uneven levels of development among countries

From the current data, the digital economy of the countries along the Belt and Road has the problem of uneven development. The level of digital economic development of the countries along the Belt and Road, in accordance with the TIMG index for sorting, selects the top 20 countries to form Table 2. It can be seen that the first-ranked Singapore has a TIMG index as high as 87.55, while the twentieth-ranked Latvia has a TIMG index of only 60.47, indicating that digital economic development is relatively weak.

Table 2: Top of TIMG index for countries along the Belt and Road in 2021

Rank	Country	TIMG exponents
1	Singapore	87.55
2	China	81.42
3	United Arab Emirates	76.18
4	Israeli	75.91
5	Malaysia	74.03
6	India	72.17
7	Russian	71.43
8	Saudi Arabia	70.46
9	Turkey	70.13
10	Estonia	68.88
11	Poland	67.86
12	Indonesia	66.41
13	Czech Republic	65.83
14	Lithuania	65.24
15	Thailand	63.77
16	Cyprus	62.64
17	Greece	61.55
18	Hungary	61.18
19	Slovenia	60.98
20	Latvia	60.47

The setting of the TIMG index includes four indicators: digital technology, digital infrastructure, digital market, and digital governance. According to the sub-indicators, the countries along the Belt and Road that rank highest in the TIMG index, such as Singapore, the United Arab Emirates, and Israel, all have advantages in these four indicators. Singapore ranks 6th globally in the Digital Technology

Index, while Israel ranks 10th globally. Singapore ranks second globally in the Digital Infrastructure Index, while the United Arab Emirates ranks 17th globally. Singapore and Israel both rank in the top 20 globally in the Digital Market Index rankings. Singapore ranks first in the world in the Digital Governance Index.

From the TIMG index level, the overall level of digital economy development of countries along the Belt and Road is extremely low, and there is a serious imbalance between regions. From the current development status of the digital economy in Singapore, the United Arab Emirates, and Israel, it can be seen that digital technology, digital infrastructure, digital markets, and the level of government digital governance all play a crucial role in promoting the development of the country's digital economy. Therefore, improving and promoting them requires starting from these aspects.

4 The impact path of digital economy on the trade status of countries along the "Belt and Road"

4.1 Digital economy and trade costs of countries along the Belt and Road

The digital economy gives full play to the advantages of Internet technology, strengthens direct access to information and rapid circulation, enables all kinds of economies to cooperate, compete, and communicate on an equal footing more economically and efficiently, promotes the flattening of the business structure, and significantly reduces the cost of each trade link (Zhang & Song, 2017).

First, the interconnection of the digital economy of the economies along the "Belt and Road" guarantees the timeliness, globality, and interactivity of information communication, greatly improves the level of information facilitation, and effectively alleviates the problem of information asymmetry in international trade (Jullien, 2012; Schor, 2017; Huang et al., 2019).

Second, the digital "One Belt and One Road" utilises a networked infrastructure platform to promote trade enterprises to eliminate intermediate distribution links, making the matching of production and consumption more efficient. The Internet removes time constraints and spatial barriers between trading partners, improves the efficiency and frequency of communication, and reduces the cost of information for trade negotiations (Hagar et al., 2019; Hagiu, 2012; Freund, 2016).

Third, the rapid promotion of the digital economy in the "Belt and Road" has significantly improved logistics enterprises' utilisation and analytical capabilities regarding digital technology and big data. It has broken country boundaries in global trade, reduced transportation costs in the "Belt and Road," and accelerated the transformation of the logistics system to smarter storage control and management. Additionally, the logistics system of the economies along the route is developing into a more efficient and frequently communicating network, further supporting intelligent warehousing control, goods sorting, and order processing.

4.2 Digital economy and trade price formation in Belt and Road countries

On the one hand, the digital economy expands the operating margins of trading enterprises, enhances market competition, and significantly improves the transparency of trade prices (Chen, 2020). The construction of the digital "Belt and Road" has made it easier for production enterprises along the route to access the dynamics of global competition, resulting in more rapid decisions to enter or exit the international market. At the same time, new business opportunities, new consumer markets, and Internet business models have attracted a large number of cross-industry enterprises to participate in global trade competition (Sun, 2020). The more firms integrate into the international market with the same product, the more intense the competition becomes, leading to lower prices of goods.

On the other hand, the digital economy has the characteristics of being shareable, replicable, and having unlimited use, which can effectively reduce some of the fixed and marginal costs directly transferred by enterprises to consumers. This leads to a reduction in the price of bilaterally traded products and impacts the traditional cost-pricing paradigm (Li, 2020). At the same time, the use of digital technology improves the efficiency of supervision, tracking, and evaluation in the trade process, enhances price transparency, and indirectly inhibits unreasonable product pricing.

4.3 Digital economy and trade diversity in countries along the Belt and Road

On the one hand, the digital economy expands the operating margins of trading enterprises, enhances market competition, and significantly improves the transparency of trade prices (Jiao, 2020). The construction of the digital "Belt and Road" has made it easier for production enterprises along the route to access the dynamics of global competition, resulting in quicker decisions to enter or exit the international market. However, new business opportunities, new consumer markets, and Internet business models have attracted a large number of cross-industry enterprises to participate in global trade competition (Sun, 2020). The more firms integrate into the international market with the same product, the more intense the competition becomes, leading to lower prices of goods.

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5 Suggestions for promoting the development of digital economy in the countries along the "Belt and Road"

5.1 Improving Digital Technology

Technology plays a crucial role in the development of anything, and the advantage of talent reserves is a crucial step in achieving technological progress. Therefore, governments of various countries should strengthen the construction of talent teams, ensure the enrollment rate of higher education, and further improve the digital literacy of the people (Lan, 2020).

In terms of methods, we should encourage school-enterprise cooperation, create a comprehensive ICT skills learning platform, support students to actively participate in ICT construction projects, and focus on the two-way cultivation of students' thinking and practical abilities. From the perspective of the government, in order to meet the demand for human capital, efforts need to be made to cultivate professional and applied talents and establish a complete ICT skills training network, which requires a more effective allocation of research funding for universities and ICT-related industries. From a communication perspective, universities and ICT-related industries should be encouraged to carry out large-scale and deep-level school-enterprise cooperation, enhance the intensity and speed of talent cultivation, and lead the establishment of high-tech talent training bases to improve further the level of skills training (Yang & Liu, 2020).

At the same time, attention should be paid to the research and development output related to the digital economy, the protection of digital technology patents, and the creation of a favourable environment for the progress of digital technology.

5.2 Accelerate the construction of digital infrastructure

For countries along the "Belt and Road" that have short board effects on information infrastructure, priority should be given to building and improving their digital infrastructure, ensuring the universality, convenience, and security of digital infrastructure, and creating hardware conditions for the development of the digital economy. Strengthening policy communication is an important measure for the construction of the "Belt and Road." Strengthening policy communication and interconnecting the core and foundation of digital economy development is an important measure for the construction of the "Belt and Road" (Li & Zhang, 2020).

From the data in Table 2 above, we can see that China's digital economy is at a high level of development, its information infrastructure is relatively complete, and its information technology is highly export-oriented and competitive. China should actively participate in the construction of the "Belt and Road" digital economy and leverage its advantages (Xiang, 2017).

Therefore, China should actively participate in the construction of the "Belt and Road" digital economy and leverage its advantages. On the one hand, the government should actively encourage the information industry and high-tech industry to "go global" and provide these enterprises with policy support and preferences. On the other hand, China's transnational development of the digital economy helps to learn from the development experience of other countries, further expand the market, promote connectivity construction, and provide countries along the route with higher-level and quality products and services.

5.3 Actively exploring the digital market

To promote the improvement of information technology's external and competitive level, countries along the Belt and Road should encourage domestic enterprises to cooperate with advantageous digital economy enterprises, starting from the supply and demand sides, and explore new trade and investment rules for e-commerce in the world today. Actively developing new service trade, such as education, tourism, and culture, should be a priority, along with focusing on building high-level open platforms. Strengthening coordination among countries along the Belt and Road in cross-border e-commerce, currency swaps, electronic payments, and other financial mechanisms can facilitate international market expansion. Additionally, adopting cross-border trade service systems and other innovative models will help open up diversified markets.

With the rapid progress of emerging technology industries such as big data and artificial intelligence, the upgrading and transformation of the industrial economy has also entered a rapidly evolving phase. Countries and regions with high levels of digital skills are increasingly utilising online banking and e-commerce platforms. These national enterprises not only leverage digital technology to improve efficiency and productivity but also expand their markets through online sales, which continue to grow at an accelerated pace.

Based on these trends, the overall overseas comprehensive layout of the "Belt and Road" is being strategically planned. This includes improving the working mechanism, strengthening supporting policies and financial frameworks, ensuring the efficiency of each stage of implementation, and advancing the construction of logistics, commerce, services, integration modules, and other critical infrastructure components.

5.4 Improving the level of government digital governance

Countries along the Belt and Road should pay more attention to the construction of digital government, promote the sharing of government data, strengthen the digital performance ability of governments at all levels, and improve their digital governance level. To create a favourable business environment for the development of relevant digital economy enterprises, it is essential to establish appropriate digital economy laws and regulations. Additionally, providing better and more comprehensive protection for intellectual property rights in the digital economy will further enhance the development level of the country's digital economy.

6 Conclusion

Based on the TIMG index, this paper finds that by 2023, only four countries along the Belt and Road have entered the top 20 in the world in terms of digital economy development, and the overall development level remains low. The ranking of countries along the Belt and Road indicates that the development level among participating nations is uneven.

As a new economic development model, the digital economy not only retains the general characteristics of the traditional economy but also introduces new features driven by digitisation, which can enhance the trade status of countries along the route through various pathways. Therefore, in response to the complex global economic environment, countries along the Belt and Road should actively enhance their digital technology, strengthen the construction of digital economy infrastructure, vigorously explore the digital market, and improve their digital governance frameworks to fully leverage the potential of the digital economy in promoting economic growth and trade.

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VIII. Perception of Document Management Systems in Digital Transformation

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Document Management Systems (DMS) are essential tools for managing organisational information throughout its lifecycle. Despite increasing adoption, many DMS implementations fail to deliver the expected value due to inadequate attention to Critical Success Factors (CSFs). This monograph investigates the impact of selected CSFs—such as top management support, process orientation, and organisational culture—on different phases of the DMS lifecycle: selection, implementation, and usage. Drawing on the ITIL framework and lifecycle-based thinking, the study employs a quantitative methodology using PLS-SEM on data collected from Slovenian organisations. The results show that CSFs vary in importance across lifecycle stages, highlighting the need for dynamic, phase-specific implementation strategies. The findings contribute to theory by integrating CSFs with DMS lifecycle management and provide actionable insights for practitioners seeking to optimise DMS adoption and performance.

Keywords:
document management systems (DMS),
critical success factors (CSFs),
information systems lifecycle,
ITIL,
system implementation,
PLS-SEM,
organisational change

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1 Introduction

In the digital transformation era, the ability to manage information efficiently has become a strategic imperative for organisations across all sectors. Document Management Systems (DMS) play a central role in this process, enabling structured, secure, and scalable management of business documents throughout their lifecycle. From document creation and processing to long-term archiving, DMS supports operational efficiency, regulatory compliance, institutional memory, and knowledge sharing (Sprehe, 2004; Hrašovec, 2011; Zebec, 2010). Despite their increasing relevance, many DMS implementations fall short of expectations due to poor alignment with business processes, insufficient user engagement, or inadequate strategic planning (Beheshti et al., 2014; Downing, 2006).

Over the past two decades, extensive research has been conducted to identify Critical Success Factors (CSFs) that influence the success of information systems, particularly Enterprise Resource Planning (ERP) systems. These studies have highlighted the importance of leadership support, training, organisational culture, and technological readiness in ensuring implementation outcomes (Ifinedo, 2008; Finney & Corbett, 2007; Alshibly et al., 2016). However, similar investigations into DMS remain limited, and existing models often treat CSFs as static or universally applicable without considering how their influence may evolve over the system's lifecycle. Yet, as emphasised by Yu (2005) and Munkelt and Volker (2013), the long-term success of business information systems depends not only on successful implementation but also on sustained usage and continual improvement.

To address this gap, the present study explores the relationship between selected CSFs and the DMS lifecycle. The lifecycle perspective adopted in this work follows the logic of IT governance frameworks, particularly ITIL, which structures service management into strategy, design, transition, operation, and continual service improvement (Hunnebeck, 2011; Kern, 2009). Applying this approach, the DMS lifecycle is divided into three key phases: selection, implementation, and usage (Jordan, 2023). The central hypothesis of the research is that the impact of CSFs is phase-dependent, meaning that different factors matter more to varying stages of the system's evolution.

The research is based on a quantitative study conducted among employees in Slovenian organisations implementing or using a DMS. The data were collected via an online survey (1KA, 2023), and the model was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is suitable for analysing complex relationships in smaller samples (Hair et al., 2017; Henseler et al., 2009). The results aim to identify which CSFs are most influential in each lifecycle phase and offer a structured framework organisations can use to guide DMS planning and implementation.

This monograph is structured into six chapters. The second chapter provides a comprehensive overview of DMS, including their definition, historical development, functionalities, components, and emerging trends. Chapter three introduces the concept of the DMS lifecycle and presents a lifecycle model based on ITIL methodology. Chapter four focuses on Critical Success Factors, their theoretical background, application in business information systems, and categorisation specific to DMS. Chapter five presents the empirical study, including the research hypothesis, methodological approach, data analysis, and discussion of the results. Finally, chapter six concludes the monograph by summarising key findings, identifying theoretical contributions and limitations, and proposing directions for future research.

By combining lifecycle thinking with a CSF-based analytical framework, this study contributes to a more nuanced understanding of success in DMS implementation and management. It highlights the need for phase-specific strategies and offers evidence-based insights to researchers and practitioners involved in designing, deploying, and optimising document management solutions.

2 Document management systems

2.1 Definition and historical development of DMS

DMS represent an essential technological solution for the structured handling of business documents throughout their entire lifecycle—from creation, processing, distribution, and storage to eventual archiving. The core function of a DMS is to support the capture, storage, retrieval, and management of both structured and unstructured data in digital form, enabling greater operational efficiency and compliance with regulatory requirements (Hrašovec, 2011; Odobašić, 2016).

A business process is a set of related activities that require input and yield an output, and documents are a fundamental component of these processes. With the growing volume and complexity of documents in organisations, traditional paper-based systems became inadequate. This led to the development of electronic document archives and DMS that help organisations maintain agility and improve decision-making capabilities (Limanowski, 1983; Mukhopadhyay et al., 1995).

The history of document management can be traced back to the late 19th century, with the invention of the vertical filing system by Edwin Grenville Seibels in 1898. However, the shift towards electronic document management began in the 1980s with the emergence of Document Imaging Processing (DIP) systems—essentially electronic filing cabinets enabling scanned and indexed document storage (Biels, 2021; Zebec, 2010).

Technological advancements such as personal computers, centralised servers, and optical scanners further accelerated this transition in the following decades. In the 1990s, the development of Electronic Record Management Systems (ERMS) and standards like MoReq and IDA brought more excellent structure and compliance orientation into document management practices (Zebec, 2010).

The ISO 15489-1 standard distinguishes between mutable documents and records, which are immutable and often serve as legal or procedural evidence. While DMS support the entire lifecycle and collaborative use of documents, ERMS is focused on the secure, unaltered storage of records for compliance and accountability (Zebec, 2010).

Over time, DMS evolved from simple storage systems to multifunctional platforms that support collaboration, version control, access management, and workflow automation. As companies increasingly pursue digital transformation, DMS is pivotal in enabling lean, paperless operations and securing institutional memory (Sprehe, 2004; Abaci & Medeni, 2022).

Recent advancements incorporate artificial intelligence, cloud computing, and mobile access, transforming DMS into intelligent systems capable of learning from usage patterns, optimising document workflows, and integrating seamlessly with other enterprise applications. These developments reflect the growing strategic importance of DMS in modern business environments.

2.2 Functionalities and types of document management systems

Modern DMS offer various functionalities that effectively support organisations in managing increasing volumes of digital content. These systems are designed to store and retrieve documents, streamline business processes, ensure legal compliance, and enhance organisational agility.

Core functionalities of DMS typically include (Hrašovec, 2011; Odobašić, 2016):

– Document capture and conversion: Input of documents, including scanning of paper records and conversion to searchable text through Optical Character Recognition (OCR).
– Indexing and classification: Assignment of metadata for efficient retrieval and categorisation.
– Document and archiving: Secure and structured long-term storage with version control and defined retention periods.
– Workflow and processing: Automating approvals, notifications, and document routing tasks.
– Access control and permissions: Role-based management of document accessibility, aligned with security and compliance requirements.
– Audit trails and version history: Tracking all changes and user interactions to ensure accountability and support audits.

These features reduce reliance on physical documents, minimise risks of data loss, and increase operational efficiency. For example, Sprehe (2004) and Adeneye & Ahmed (2015) emphasise benefits such as centralised document storage, faster processes, reduced paper usage, and cost savings.

DMS solutions vary in complexity and scope, depending on the size and needs of the organisation. Cracraft (2021) distinguishes between four primary types:

1. Basic DMS. Found mainly in small businesses, these solutions are simple and used primarily for file sharing. They typically lack audit trails, access control, or workflow functionalities.
2. Archival DMS. Commonly used in libraries and academic settings for storing non-editable content. They enable efficient searching and reading but do not support editing or collaborative features.
3. Commercial DMS. These systems are employed by larger companies with extensive document management needs. They offer robust functionalities like user access control, version management, and integration with other enterprise systems.
4. Enterprise/Industrial DMS. The most advanced solutions used in large organisations. These consist of distributed repositories integrated with enterprise systems (e.g., ERP, CRM), ensuring data consistency and scalability.

The evolution of these types reflects the growing demand for DMS functionalities across various sectors—including finance, healthcare, and manufacturing—where reliable document handling is crucial for regulatory and operational reasons (Joia, 1998; Eleoranta et al., 2001).

In the current landscape, organisations seek DMS solutions with cloud capabilities, mobile accessibility, and integration options, further influencing their selection of an appropriate system (Global Market Insights, 2021).

2.3 Core components of a document management system

DMS are complex information solutions that facilitate the efficient handling of documents throughout their entire lifecycle—from initial capture to long-term archiving. A DMS must have several interrelated components forming a robust technological infrastructure to achieve this.

A DMS's fundamental components are the document capture and input module. This component enables the conversion of physical documents into digital format, most commonly through scanning and Optical Character Recognition (OCR) technology. In addition, it supports the direct ingestion of digital files from emails, cloud storage, or enterprise applications. Upon capture, documents are typically enriched with metadata such as author, date, document type, and linkage to relevant business processes, facilitating efficient indexing and retrieval (Hrašovec, 2011).

The indexing and classification engine plays a crucial role in supporting structured access and document review. This system component ensures the logical organisation of content based on predefined taxonomies and classification schemes. Automated classification mechanisms based on content, layout, or source contribute to faster retrieval and consistency. Simultaneously, access rights are defined based on user roles, ensuring security and control over sensitive information.

At the core of every DMS is the document repository, which ensures secure and reliable storage of documents. Repositories may be organised hierarchically or relationally and typically support version control, change tracking, and data redundancy to prevent loss or corruption (Odobašić, 2016). Stored documents are subject to security policies, including retention schedules and rules for archiving or deletion.

Modern DMS platforms also include workflow automation features. These enable the digital execution of repetitive tasks such as approvals, notifications, and document routing. As a result, errors are reduced, process transparency and standardisation are improved, and organisational efficiency is enhanced.

The security layer is another essential component of DMS, facilitating authorised access based on predefined user roles and privileges. It includes various authentication mechanisms, such as multi-factor authentication and audit trails that log all system activities. This ensures traceability and supports compliance with legal and regulatory requirements (Sprehe, 2004; Zebec, 2010).

From the user's perspective, a powerful search and retrieval engine is essential. It should support full-text search capabilities, metadata filters, advanced queries, and saved searches, significantly improving document accessibility and user productivity.

Due to the need for integration with other enterprise systems, the role of Application Programming Interfaces (APIs) has become increasingly important. APIs enable seamless interaction with systems such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Human Resource Management (HRM), Business Intelligence (BI), and collaboration platforms, including Outlook, SharePoint, and Microsoft Teams (Mikroprimar, 2021). This facilitates data consistency and reduces duplication of effort.

Finally, DMS must implement well-defined retention and archiving policies. These policies regulate the time frames for document retention and determine when documents should be archived or deleted. Combined with digital signature support and adherence to standards such as PDF/A, they ensure the legal validity and long-term accessibility of documents.

Collectively, these core components constitute a comprehensive system that enables organisations to manage documents securely, efficiently, and by relevant legal and industry-specific standards.

2.4 Advantages and disadvantages of DMS

Implementing a DMS can benefit organisations significantly, particularly regarding efficiency, cost reduction, compliance, and operational transparency. However, these advantages are accompanied by certain limitations and challenges, especially in the initial implementation phases.

One of the most frequently cited benefits of DMS is cost reduction. Organisations face high expenses for managing large volumes of paper documents, including printing, physical storage, and labour. A DMS automates many document-related processes, reducing these costs and allowing employees to focus on more strategic tasks (Canteli, 2021). In addition, time savings are achieved through faster access to information, regardless of the user's location. This contributes to improved employee productivity and decision-making.

Another critical advantage is workflow optimisation. A well-implemented DMS reduces the number of manual steps required in document handling, thereby increasing the agility and responsiveness of business processes. Employees can locate and share information more quickly, which enhances collaboration and operational continuity (Azard, 2007; Wilkins et al., 2007).

DMS also support regulatory compliance by enabling organisations to meet legal obligations for data protection, retention, and auditability. Modern systems include built-in audit trails, automated retention policies, and secure storage mechanisms, all critical in sectors with strict regulatory requirements. Furthermore, the electronic audit trail ensures the traceability of all document-related activities, particularly important for internal and external audits (Canteli, 2021).

In addition to these measurable benefits, organisations experience several intangible advantages, such as improved employee satisfaction, easier collaboration, and enhanced security. Digital documents are less prone to loss or damage, and access rights can be tightly controlled. Moreover, electronic document handling reduces the risk of unauthorised duplication and ensures that only relevant personnel can view or modify sensitive content (Sprehe, 2004).

Despite these benefits, DMS implementations also face several challenges and disadvantages. One primary concern is the high initial investment, which includes acquiring hardware, software licenses, and infrastructure upgrades (Higl, 2011). Additionally, training costs for both users and technical staff can be substantial. Users may not utilise the system effectively without adequate training, leading to partial or failed adoption.

System disruptions pose another risk. Business operations may be severely hindered if the DMS experiences downtime due to technical issues or maintenance. Moreover, poor task distribution among users can create bottlenecks and reduce the expected efficiency gains.

A particularly critical issue is integration with existing systems. In many cases, DMS solutions are not fully compatible with legacy IT systems, resulting in fragmented workflows or duplicated efforts. Patel (2010) notes that many DMS implementations fail due to incomplete system design, lack of user involvement, inadequate classification structures, and insufficient preparation of business processes.

The human factor plays a key role in the success of DMS implementation. Resistance to change, lack of user engagement, and insufficient support from management can all contribute to the underutilisation of the system. To overcome these challenges, organisations must ensure the early involvement of users, alignment between the DMS and organisational workflows, and strong leadership to support the transition (AIIM, as cited in Patel, 2010).

In conclusion, while DMS offer a wide range of advantages—from measurable financial savings to improved compliance and information management—they also present significant implementation challenges. Careful planning, stakeholder engagement, and adequate resourcing are essential for maximising the benefits and minimising the risks associated with DMS adoption.

2.5 Current trends in DMS

As organisations undergo rapid digital transformation, DMS is also evolving to accommodate new technological developments and changing business needs. Integrating mobile access, cloud computing, artificial intelligence, and enhanced security mechanisms represents the most prominent trends in the DMS landscape.

One of the key developments is the integration of DMS with mobile devices. In modern organisations, employees often require access to documents remotely or on the move. Mobile-compatible DMS solutions allow users to view, share, and sign documents through dedicated applications or web interfaces. These mobile systems prioritise intuitive design and essential functionalities, such as document previewing, approval, and collaboration (Žorž, 2019). As mobile technologies continue to evolve, more advanced DMS features are expected to be accessible on mobile platforms.

Another critical trend is cloud-based document management, which offers continuous accessibility and eliminates the need for physical infrastructure. Cloud DMS solutions provide flexibility, scalability, and ease of maintenance. This model is beautiful for small and medium-sized enterprises (SMEs) that lack extensive IT resources. Many providers, including DocuWare Cloud, InDoc EDGE, and SharePoint Online, offer both on-premise and cloud-based options, allowing companies to choose the deployment model that best fits their strategic objectives (Mikroprimar, 2021; Mikrografija, 2021; Business Solutions, 2021).

Security and compliance remain central concerns, mainly as organisations handle increasing volumes of sensitive and confidential data. In addition to audit trails and access control, modern DMS platforms incorporate advanced encryption methods and role-based permissions at multiple levels. However, with the rise of cloud computing and remote access, additional safeguards are needed to ensure data integrity and regulatory compliance. Many vendors are now focusing on securing internal processes and those extended to mobile and cloud environments (Vrecl, 2019).

Interoperability and integration with other enterprise systems are also becoming essential features of DMS platforms. Organisations expect their document systems to connect with ERP, CRM, HRM, and BI tools, enabling unified workflows and eliminating data silos. Certified interfaces like Connect to Outlook, SAP, and SharePoint are now standard offerings (Mikroprimar, 2021). Additionally, collaborative functionalities—such as real-time editing by multiple users—are gaining traction, driven by the increasing demand for remote and team-based work environments.

The trend toward affordability and modularity is another critical factor shaping the DMS market. As competition intensifies and more vendors enter the space, solutions become more customisable and cost-effective. Organisations can now select specific modules according to their needs and budget, improving return on investment and reducing barriers to adoption (Docsvault Team, 2019).

The most transformative development in recent years is incorporating artificial intelligence (AI) into DMS platforms. AI enables advanced functionalities such as intelligent document classification, predictive search, metadata extraction, and user behaviour analysis. Techniques such as machine learning and deep learning are increasingly used to automate complex processes, reduce manual input, and enhance the accuracy of document handling (Gergorec, 2020; Vitko, 2020; Shaikh, 2021). AI-powered DMS can also recommend actions, flag anomalies, and continuously improve through user interaction data (EIM International, 2021).

These emerging trends demonstrate that DMSs are no longer mere repositories of digital files but are becoming strategic tools for enabling organisational agility, collaboration, and innovation. As digital ecosystems become more interconnected and dynamic, the role of intelligent, secure, and integrated DMS will become even more critical.

This chapter provided a comprehensive overview of DMS, outlining their definition, historical development, core functionalities, system components, types, and emerging trends. The evolution of DMS from simple document repositories to intelligent, cloud-based platforms has significantly transformed how organisations handle information assets. Through functionalities such as document capture, indexing, storage, workflow automation, and secure access control, DMS contribute to greater efficiency, regulatory compliance, and collaboration. Moreover, integrating artificial intelligence and mobile access reflects the growing strategic importance of DMS in supporting digital transformation. Despite numerous advantages, organisations must also be mindful of potential limitations, such as high initial costs, integration challenges, and user adoption issues. By understanding DMS's structural components and trends, businesses can make informed decisions when selecting, implementing, and scaling these systems as part of their broader information strategy.

In the following chapter, we explore the DMS lifecycle in greater detail and examine how IT governance methodologies, particularly ITIL, can support each phase of its implementation and use.

3 DMS lifecycle based on ITIL methodology

3.1 Lifecycle of DMS as a business information system

Implementing DMS represents a significant organisational undertaking with long-term implications for business efficiency, data governance, and digital transformation. While many organisations view DMS primarily as an archival tool, its value enables the structured, secure, and efficient handling of information assets throughout the enterprise. As Abdulkadhim et al. (2015) emphasised, document-related data are essential for operational support, strategic planning, and market responsiveness.

The lifecycle of a DMS—as with any business information system (BIS)—extends beyond initial deployment. It encompasses interconnected phases, from identifying business needs and system selection through implementation to long-term use, optimisation, and eventual system retirement. According to Adam and Sammon (2004), neglecting any phase of this lifecycle can compromise the effectiveness of the entire solution. They argue that companies often focus excessively on implementation while failing to monitor performance during usage, ultimately determining the return on investment.

The lifecycle of DMS closely aligns with established models of BIS lifecycle management, as synthesised by Huang and Yasuda (2016), Sternad Zabukovšek et al. (2020), and Munkelt and Volker (2013). These models generally consist of three major phases:

1. Selection – In this phase, the organisation identifies its functional, technical, and strategic requirements for a document management solution. It includes stakeholder analysis, business case development, market analysis, and vendor evaluation.
2. Implementation – This phase involves system customisation, process alignment, data migration, training, and go-live. It also includes technical setup and the formalisation of document governance policies.
3. Usage and Optimization – The most extended and impactful phase includes stabilisation, continuous support, user training, upgrades, integration with other systems, and, eventually, the phase-out or replacement of the DMS.

Table 1 illustrates a simplified representation of the DMS lifecycle based on the abovementioned models.

Table 1: Key lifecycle phases of a document management system

Lifecycle Phase	Key Focus Areas	Examples of Activities
Selection	Needs assessment, vendor choice	Requirements gathering, project team setup, request for proposals
Implementation	System deployment and process alignment	Training, migration, pilot testing, go-live, policy development
Usage & Optimization	Continuous use, support, improvement, decommission	

As noted by Yu (2005), the completion of implementation should not be regarded as the final objective but rather as the starting point for system utilisation and value creation. Research by Panorama Consulting (2022) shows that 72% of BIS projects are terminated at the go-live stage, resulting in unrealised potential. Organisations must invest in post-implementation evaluation, advanced usage, and long-term process improvement to fully benefit from a DMS.

Given the strategic role of DMS, its lifecycle must be managed with the same rigour and governance as other enterprise information systems. Therefore, it is essential to adopt a structured lifecycle model supported by an appropriate IT governance methodology. In the following sections, we evaluate relevant IT governance frameworks and justify the selection of ITIL as the most suitable foundation for mapping the DMS lifecycle.

3.2 IT governance methodologies and justification for ITIL

As organisations increasingly depend on information systems to support core business processes, applying standardised governance frameworks becomes crucial for managing complexity, reducing risk, and ensuring strategic alignment. Over the past decades, several well-established methodologies for IT governance have emerged, including COBIT, PRINCE2, TOGAF, and ITIL, each with a distinct focus and scope.

COBIT (Control Objectives for Information and Related Technology), developed by ISACA, is a comprehensive framework designed primarily for auditing, control, and compliance within IT environments. It defines a set of domains, processes, and metrics to assess the performance and maturity of IT governance. COBIT is widely used in large and regulated organisations that require formalised procedures and risk controls (ISACA, 2011).

PRINCE2 (Projects IN Controlled Environments) is a process-based methodology for managing all types of projects, including IT implementations. Originating in the UK, it emphasises business justification, structured project phases, precise role definitions, and risk management (Wideman, 2002). Its strength lies in its versatility and focus on project lifecycle control, making it suitable for managing the introduction of new IT systems such as DMS.

TOGAF (The Open Group Architecture Framework) is an enterprise architecture methodology used to design, plan, implement, and manage information systems architecture. TOGAF supports strategic alignment by integrating business, application, data, and technology architectures and is particularly effective in large organisations undergoing digital transformation (Ferlih, 2016).

Despite the strengths of these frameworks, ITIL (Information Technology Infrastructure Library) stands out as the most appropriate methodology for managing the lifecycle of a Document Management System. Initially developed by the UK's Central Computer and Telecommunications Agency (CCTA), ITIL provides a service-oriented approach to IT management, focusing on the entire lifecycle of IT services—from strategy to continual improvement (Adams, 2009).

Unlike COBIT, which focuses on auditing, or PRINCE2, which centres around project execution, ITIL offers a comprehensive view of the service lifecycle. Its five key phases—Service Strategy, Service Design, Service Transition, Service Operation, and Continual Service Improvement—closely reflect the stages of a DMS implementation and usage process.

As Kern (2009) summarised, ITIL's advantages include improved service quality, reduced long-term costs, better communication and workflows, and enhanced adaptability to change. These benefits align directly with the challenges faced during DMS deployment, especially in ensuring cross-functional integration, standardising document workflows, and maintaining long-term operational stability.

The strategic applicability of ITIL to DMS was further validated through comparative analysis. While PRINCE2 and COBIT cover certain relevant domains—such as planning, control, and compliance—ITIL is the only methodology explicitly addressing post-implementation optimisation and continuous service improvement. As shown in Table 2, ITIL covers all five critical categories necessary for DMS lifecycle governance, while the other frameworks lack coverage in areas such as ongoing enhancement and service design.

Given its comprehensive lifecycle perspective, process orientation, and practical alignment with the DMS implementation and usage phases, ITIL has been selected as the most suitable governance framework for this research. In the following section, we apply the ITIL model to the DMS lifecycle, demonstrating its relevance and effectiveness in supporting strategic, operational, and continuous improvement goals.

Table 2: Comparison of IT governance methodologies for DMS lifecycle

Key Category	COBIT	PRINCE2	ITIL
Project Preparation	✓	✓	✓
Planning and Organization	✓	✓	✓
Strategy and Governance	✓	✓	✓
Service Design and Transition		✓	✓
Continuous Improvement			✓

3.3 DMS lifecycle according to ITIL: model and discussion

Implementing ITIL's service lifecycle model to DMS offers a structured and holistic approach to managing the various stages of DMS implementation and operation. ITIL consists of five interrelated phases—Service Strategy, Service Design, Service Transition, Service Operation, and Continual Service Improvement—each of which can be mapped to specific lifecycle phases of DMS within an enterprise context (Hunnebeck, 2011; Kern, 2009).

Service strategy

The Service Strategy phase plays a fundamental role throughout the entire lifecycle of a DMS. It involves defining the organisational vision, identifying business needs, analysing cost-benefit factors, and developing a strategic plan for the system's introduction and long-term use. In the context of DMS, this phase encompasses both the definition of requirements and the selection of vendors. It ensures that the investment in DMS is aligned with the organisation's goals, regulatory obligations, and digital transformation agenda (Levart, 2012). Strategic planning should include a thorough project charter, timeline, budgeting, and governance structure (Raynes, 2002).

Service design

This phase addresses the architecture, functionality, and processes of the DMS. It includes the design of workflows, classification schemes, metadata models, access control policies, and integration with existing systems. During the requirements and vendor selection phases, organisations must establish detailed service specifications and expectations, ensuring consistency between user needs and the capabilities of the selected system (Sternad Zabukovšek et al., 2020). Service Level Agreements (SLAs), availability planning, information security, and capacity management are key components of this phase (itSMF, 2020).

Service transition

The Service Transition phase focuses on the planning and execution of the implementation. It includes change management, configuration and asset management, release management, and user training. In the DMS lifecycle, this corresponds to system deployment, data migration, pilot testing, and initial training. Organisations must manage risks related to legacy system integration, user resistance, and process gaps (Munkelt & Volker, 2013). Smooth knowledge transfer and stakeholder engagement are essential to ensure a successful go-live.

Service operation

Once the system is live, the focus shifts to ensuring stable operation and responsive user support. The Service Operation phase involves incident and problem management, event monitoring, request fulfilment, and access management. This includes helpdesk support, troubleshooting, change tracking, and user access governance for DMS. Stabilisation is critical at this stage, as users adapt to the new system and any misalignments between expected and actual behaviour are revealed (Rehage, 2006).

Continual service improvement

The final ITIL phase—Continual Service Improvement (CSI)—emphasises the need for regular evaluation and enhancement of DMS functionality and usage. It includes performance monitoring, user feedback collection, process optimisation, and implementing new features or modules. The Deming cycle (Plan–Do–Check–Act) is often used to guide these improvements (Švarc, 2010). Long-term DMS success depends on the organisation's ability to evolve the system in response to changing business needs, regulatory environments, and technological advancements.

Table 3 presents DMS lifecycle phases regarding ITIL phases.

Table 3: Mapping ITIL categories to DMS lifecycle phases

DMS Lifecycle Phase	Service Strategy	Service Design	Service Transition	Service Operation	Continual Improvement
Needs Definition	✓	✓			
Vendor Selection	✓	✓			
Implementation	✓	✓	✓		
Usage	✓			✓	✓

This alignment demonstrates that the ITIL framework provides complete coverage of the DMS lifecycle, offering a consistent and comprehensive structure for governance and management. While other methodologies may emphasise planning or control, ITIL's unique strength is its attention to post-implementation performance, service quality, and continuous value delivery.

From a practical standpoint, ITIL helps organisations avoid common pitfalls in DMS projects, such as short-term focus on deployment, lack of performance monitoring, and insufficient stakeholder involvement. It encourages long-term thinking, clear role assignments, and measurable service outcomes. As such, ITIL supports DMS implementation and ensures that the system evolves as a living, strategic asset integrated with broader business objectives.

This chapter examined the lifecycle of DMS through the lens of IT governance, focusing on the ITIL framework. It highlighted the three fundamental lifecycle phases of DMS—selection, implementation, and usage—while emphasising that post-implementation performance and continuous improvement are often overlooked. Through a comparative analysis of leading methodologies such as COBIT, PRINCE2, and TOGAF, ITIL emerged as the most comprehensive and practical approach for managing DMS across all lifecycle phases. The alignment of ITIL's five stages—Service Strategy, Service Design, Service Transition, Service

Operation, and Continual Service Improvement—with the DMS lifecycle ensures strategic coherence, operational stability, and long-term value realisation. The discussion underscored the importance of adopting a lifecycle-based governance approach to maximise the effectiveness and sustainability of DMS implementations.

In the next chapter, we identify and analyse the critical success factors (CSFs) that influence DMS implementation across these lifecycle stages.

4 Critical success factors in the implementation and use of DMS

4.1 Understanding critical success factors in business information systems

Critical Success Factors (CSFs) originated in the 1960s as a strategic management approach for identifying key areas that require ongoing attention to ensure organisational success. Rockart (1978) defined CSFs as a limited number of key areas where satisfactory results are essential for a business to thrive. This notion was later refined by Bullen and Rockart (1984), who emphasised that these are areas in which "things must go right" for the organisation to achieve its goals. CSFs are viewed as managerial tools that help decision-makers focus on what matters most and proactively steer the organisation toward its objectives (Boynton & Zmud, 1984).

The CSF framework quickly gained popularity across industries for its practical applicability in strategy formulation, performance measurement, and project management. Over time, the concept was extended into the field of information systems (IS), particularly in the context of large-scale implementations such as Enterprise Resource Planning (ERP) systems (Finney & Corbett, 2007; Ifinedo, 2008). Research in this domain sought to identify and classify those factors that most significantly influence the success or failure of ERP initiatives, especially during the selection and implementation stages (Nah et al., 2001).

Despite its broad adoption, the CSF concept has not been without criticism. Researchers have pointed out several limitations related to the subjectivity and variability of CSF identification. For instance, different studies have produced divergent sets of CSFs based on varying methodologies, industry contexts, or researcher perspectives (Karuppusami & Gandhinathan, 2006; Amoako-Gyampah

& Salam, 2004). This inconsistency complicates the development of universally applicable CSF models and raises concerns about the theoretical robustness of the concept.

Moreover, empirical studies have highlighted that many CSFs identified in literature lack a validated causal relationship with system success. Robey et al. (2002) and Sammon and Adam (2007) questioned whether the so-called "critical" factors are genuinely critical, arguing that existing CSF research often provides descriptive lists without theoretical grounding. Some scholars have also noted the absence of established procedures for identifying CSFs, which can reduce their practical utility and lead to decision-making based on intuition rather than evidence (King & Burgess, 2006; Rahmatian, 1999).

Nevertheless, the CSF approach remains a widely used and valuable framework for supporting complex IS initiatives. Its relevance is particularly evident in ERP projects characterised by organisational change, resource intensity, and technological complexity. Numerous studies have demonstrated that identifying the right CSFs can significantly improve the likelihood of successful implementation and long-term system utilisation (Ram et al., 2013; Maguire et al., 2010; Soja & Paliwoda-Pekosz, 2009).

Given the similarities in implementation dynamics, the CSF framework is increasingly being applied to other business information systems, including DMS. Like ERP, introducing DMS often requires adjustments to workflows, user behaviour, IT infrastructure, and organisational culture. As such, a contextualised understanding of CSFs for DMS is essential for managing the complexity of implementation and ensuring value realisation over the system's lifecycle. In the following section, we examine existing research on CSFs specifically related to DMS and categorise them into key thematic areas.

4.2 CSFs for DMS

While the concept of CSFs has been extensively explored in the context of Enterprise Resource Planning (ERP) systems, its application to DMS is increasingly recognised as equally essential. Although DMS projects may be narrower in scope than full-scale ERP implementations, they similarly require organisational transformation, process redesign, and user adaptation. Therefore, identifying the CSFs specific to DMS implementation and use is critical for ensuring project success and maximising return on investment.

Several empirical studies have investigated the factors influencing successful DMS adoption. Beheshti et al. (2014) identified twelve CSFs most relevant to DMS projects. These include top management support, effective project management, user training and education, clear strategy and objectives, internal communication, business process reengineering, a well-defined change management plan, vendor support, minimal system customisation, project team expertise, organisational culture, and active involvement of service providers. This list reflects technical and organisational dimensions, indicating that DMS success depends on structural readiness and human-centred change management.

Alshibly et al. (2016) extended this work by categorising thirty-seven CSFs into six broader domains: (1) technological readiness, (2) top management support, (3) training and engagement, (4) resource availability, (5) system-related factors, and (6) organisational environment and culture. This classification offers a holistic view of the multi-layered nature of DMS implementation. For example, technological readiness includes infrastructure and architecture preparedness, while the system-related category encompasses the DMS's usability, integration, and effectiveness.

User-related factors are also emphasised in the literature. Downing (2006) argues that transparent communication, early user involvement, and realistic expectation setting are crucial for mitigating resistance to change. User buy-in is more likely when the new system's benefits are clearly demonstrated—such as faster access to documents, simplified collaboration, better data protection, and time savings. According to Downing, selecting enthusiastic and credible internal champions to support the implementation can help build momentum and spread acceptance across the organisation.

Another critical theme is process orientation. Since DMS directly affects how documents are created, routed, stored, and retrieved, aligning the system with real-world processes is essential. Engaging users in process redesign ensures that the DMS reflects actual workflows and contributes to operational efficiency. Moreover, user training must go beyond technical instruction and include broader education on the strategic purpose of the DMS and its relevance to organisational goals.

Table 4 presents a synthesised overview of the main categories and examples of DMS-specific CSFs based on the work of Alshibly et al. (2016).

Table 4 Categorization of CSFs for DMS Implementation

Category	Key Factors
Technological Readiness	Architecture, infrastructure, system compatibility, process integration
Top Management Support	Leadership commitment, clear mission, communication, strategic alignment
Training and Engagement	Comprehensive user training, stakeholder involvement, cross-level inclusion
Resource Availability	Financial, technical, and human resources; vendor support
System-related Factors	Usability, system functionality, integration, perceived usefulness
Organisational Environment	Change management, culture, collaboration, alignment with business goals

These findings consistently reinforce the centrality of human and cultural dimensions in DMS implementation. While technical aspects such as system configuration and infrastructure matter, leadership, communication, training, and user inclusion often determine the initiative's overall success. Moreover, the relative importance of individual CSFs may vary depending on the phase of the DMS lifecycle.

In the next section, we examine how these critical success factors relate to the different stages of the DMS lifecycle—selection, implementation, and usage—drawing on the ITIL framework to explore their dynamic roles across the system's evolution.

4.3 CSFs across the DMS lifecycle and key implications

DMS implementation does not occur in a single moment but unfolds across several stages, each with its challenges and requirements. Understanding how Critical Success Factors (CSFs) vary in importance across the DMS lifecycle is essential for effective project planning, risk mitigation, and performance monitoring. The ITIL framework defines service lifecycles in terms of strategy, design, transition, operation, and continual improvement (Hunnebeck, 2011); the DMS lifecycle can be broadly divided into three practical phases: selection, implementation, and usage.

Within each phase, specific CSFs take on greater or lesser significance. For example, leadership support, strategic alignment, and process awareness are critical during the selection phase. These elements ensure that the decision to adopt a DMS is embedded in the broader organisational strategy, with clear expectations about outcomes and scope (Kern, 2009; Raynes, 2002).

In the implementation phase, the focus shifts toward effective project management, training, change management, and technological readiness. This includes setting up infrastructure, configuring the system, migrating data, and preparing users for new processes. Communication, end-user involvement, and the project team's composition play critical roles in ensuring that implementation does not encounter resistance or misalignment (Munkelt & Volker, 2013; Downing, 2006).

The usage phase encompasses the ongoing operation and refinement of the DMS. Here, factors such as organisational culture, user engagement, system usability, and continuous training become central. The system's long-term success depends on its integration into daily workflows, user satisfaction, and adaptability to future changes. Alshibly et al. (2016) emphasise that continued support from management, investment in user competence, and a culture encouraging innovation are all key to sustained DMS effectiveness.

Table 5: Mapping of CSFs Across the DMS Lifecycle (ITIL Perspective)

CSF	Selection (Strategy)	Implementation (Design & Transition)	Usage (Operation & Improvement)
Top Management Support	✓	✓	
Organisational Culture	✓	✓	✓
Time Efficiency	✓	✓	
Cost Efficiency	✓		✓
Process Orientation	✓	✓	✓
Project Team / Support		✓	✓

Table 5 illustrates the mapping of selected CSFs across the DMS lifecycle phases, following the ITIL-aligned structure of service strategy (selection), service design and transition (implementation), and service operation and improvement (usage).

This matrix highlights that while some CSFs—such as organisational culture and process orientation—are relevant throughout the entire lifecycle, others (e.g., cost efficiency) may be more crucial in specific phases. Such differentiation enables more precise resource allocation and targeted interventions by project managers and organisational leaders.

The implications of this lifecycle-based CSF mapping are twofold. First, organisations must avoid the common pitfall of applying a one-size-fits-all approach to success factors. Instead, they should dynamically align CSFs with the maturity and phase of their DMS project. Second, early identification and proactive management of these factors are essential to mitigate risks and maximise the value of the DMS investment.

Furthermore, the influence of CSFs is not isolated from the organisational context. Factors such as enterprise maturity, available competencies, and change readiness can significantly modulate how success factors manifest in practice. Therefore, in the subsequent chapter, we turn to the concept of organisational maturity models, exploring how maturity levels interact with DMS lifecycle phases and CSFs to influence the trajectory and outcomes of implementation efforts.

5 Empirical research on the impact of CSFs on the DMS lifecycle

5.1 Research focus and hypotheses

The previous chapters provided a conceptual and theoretical foundation for understanding the role of CSFs in the implementation and long-term use of DMS. Building on these insights, this chapter presents an empirical study focused specifically on examining the impact of selected CSFs on the various phases of the DMS lifecycle—selection, implementation, and usage. This focus aligns with the ITIL-based lifecycle model introduced earlier and seeks to identify which factors most significantly influence DMS success at different stages.

The empirical part of this monograph is based on the doctoral dissertation by Jordan (2023), which explores the relationships between critical success factors, organisational maturity, and the lifecycle of DMS. In this monograph, we focus specifically on the impact of CSFs on the DMS lifecycle.

The research addresses the hypothesis (H1) that CSFs statistically significantly influence the effectiveness of DMS implementation and usage across the lifecycle. The aim is to operationalise this general hypothesis through a model that captures the relationships between individual CSF categories and each phase of the DMS lifecycle. The structure of the model and the formulation of hypotheses are adapted from Jordan (2023), who proposed an integrated research model addressing multiple dimensions of DMS success.

The following dimensions of CSFs were selected based on the prior literature review (see Chapter 4) and validated constructs in similar studies of ERP and information systems adoption (Beheshti et al., 2014; Alshibly et al., 2016; Ifinedo, 2008). Each dimension was measured using multiple items on a Likert scale in the survey instrument:

- Top Management Support (SUPP)
- Organizational Culture (CULT)
- Time Efficiency (TIME)
- Cost Efficiency (COST)
- Process Orientation (PROC)
- Project Team and Support (TEAM)

Each CSF was hypothesised to influence at least one of the three DMS lifecycle stages, namely:

- Selection (SEL)
- Implementation (IMPL)
- Usage (USE)

This led to the formulation of the following sub-hypotheses:

H1a: CSFs significantly impact the selection phase of the DMS lifecycle.

H1b: CSFs significantly impact the implementation phase of the DMS lifecycle.

H1c: CSFs significantly impact the usage phase of the DMS lifecycle.

The research model and hypotheses were tested using partial least squares structural equation modelling (PLS-SEM), which is well suited for exploratory studies with relatively complex models and moderate sample sizes (Hair et al., 2017). The goal of this empirical analysis is not only to validate the theoretical assumptions but also to derive practical recommendations for organisations planning to adopt or optimise DMS.

In the following section, the methodological approach used in the study is explained in greater detail, including the design of the survey instrument, data collection process, and sample characteristics.

5.2 Research Methodology

The empirical study was a quantitative research project using a structured online questionnaire to collect data on perceptions of critical success factors (CSFs) and their impact on different phases of the Document Management System (DMS) lifecycle. Given the objective of testing a structural model and the need to identify statistically significant relationships among latent constructs, a positivist research paradigm was applied.

The survey instrument was developed based on validated items from previous studies focused on ERP, EDMS, and information system success factors (Beheshti et al., 2014; Alshibly et al., 2016; Ifinedo, 2008). It included items measuring six CSF dimensions—top management support, organisational culture, time efficiency, cost efficiency, process orientation, and project team/support—and three outcome constructs representing the DMS lifecycle phases: selection, implementation, and usage.

Each item was measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was pre-tested with a small group of experts to ensure clarity and content validity. Minor linguistic and layout modifications were made before full deployment.

The data was collected using the 1KA online survey platform (1KA, 2023), enabling efficient distribution and data capture. The target population consisted of employees in Slovenian organisations that had implemented or were in the process of implementing a DMS. Respondents included IT professionals, project managers, administrative personnel, and business users with direct experience using or managing DMS solutions.

A total of 146 valid responses were obtained, providing a sufficient sample size for exploratory factor analysis (EFA) and partial least squares structural equation modelling (PLS-SEM), both of which are robust to moderate sample sizes (Hair et al., 2017). Descriptive statistics of the sample show a balanced representation of organisation sizes, sectors, and respondent roles, supporting the generalizability of the results within the studied context.

The data analysis proceeded in two stages. First, exploratory factor analysis (EFA) was conducted to examine the dimensionality and internal consistency of the measurement scales. Factors with eigenvalues greater than one and factor loadings above 0.6 were retained. The reliability of each construct was assessed using Cronbach's alpha and composite reliability (CR), with thresholds of 0.7 indicating acceptable reliability.

Second, PLS-SEM was used to test the structural model and evaluate the relationships between CSFs and the lifecycle phases of DMS. The method was chosen due to its suitability for predictive modelling, tolerance of non-normal data, and ability to handle reflective constructs with limited indicators (Hair et al., 2017; Henseler et al., 2009). The bootstrapping technique (5,000 resamples) was applied to assess the statistical significance of the path coefficients, and model fit was evaluated using standard PLS criteria such as R^2 values, average variance extracted (AVE), and the Fornell-Larcker criterion for discriminant validity.

The following section presents the results of the measurement and structural model assessment, highlighting which CSFs had statistically significant effects on the different phases of the DMS lifecycle.

5.3 Measurement and structural model assessment

The evaluation of the empirical model proceeded in two phases: first, by assessing the quality of the measurement model (i.e., the reliability and validity of the constructs), and second, by estimating the structural model to test the hypothesised relationships between CSFs and the phases of the DMS lifecycle.

The measurement model was evaluated using several established criteria based on recommendations by Hair et al. (2017). All latent constructs were specified as reflective and assessed through multiple indicators derived from the survey.

Internal consistency reliability was confirmed through Cronbach's alpha and composite reliability (CR). All constructs exceeded the minimum threshold of 0.7, indicating acceptable reliability. Convergent validity was evaluated using average variance extracted (AVE), with all AVE values above the recommended 0.5 threshold, indicating that the constructs adequately explained the variance of their indicators.

Discriminant validity was assessed using the Fornell–Larcker criterion, which requires that each construct's AVE's square root be more significant than its correlations with other constructs. This condition was met for all constructs, supporting the discriminant validity of the measurement model.

Following the confirmation of measurement quality, the structural model was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM). Path coefficients between CSF constructs and the three DMS lifecycle stages (selection, implementation, and usage) were estimated, and statistical significance was determined through bootstrapping with 5,000 subsamples.

The results partially confirmed the overarching hypothesis (H1), showing that certain CSFs had statistically significant effects on specific phases of the DMS lifecycle while others did not. Key findings include:

- Top management support (SUPP) and organisational culture (CULT) significantly positively affected the selection phase.
- Process orientation (PROC) and project team/support (TEAM) were strongly associated with successful implementation.
- Cost efficiency (COST) was found to significantly influence the usage phase, while time efficiency (TIME) showed no significant effect across phases.

The explained variance (R^2) was moderate across the three dependent constructs: R^2 for Selection: 0.37, R^2 for Implementation: 0.41, and R^2 for Usage: 0.29.

These values indicate that the model explains a substantial proportion of the variance in DMS lifecycle outcomes, especially during the implementation phase. The effect sizes (f^2) of significant paths ranged from small to medium, further supporting the relevance of selected CSFs.

Table 6 summarises the structural path results for hypothesis H1 and its subcomponents.

Table 6: Summary of structural model results for hypothesis H1

Path	β Coefficient	p-Value	Significance
SUPP → Selection	0.218	0.014	✓
CULT → Selection	0.194	0.027	✓
PROC → Implementation	0.256	0.004	✓
TEAM → Implementation	0.241	0.011	✓
COST → Usage	0.213	0.019	✓
TIME → All Phases	n.s.	> 0.05	✗

These findings confirm the context-dependent nature of CSFs, illustrating that their influence varies across different lifecycle stages. The following section discusses these results in more detail, comparing them with insights from previous literature and highlighting practical implications for organisations planning DMS implementations.

6 Discussion

The results of this study provide strong empirical support for the notion that CSFs play different roles across the phases of the DMS lifecycle. As hypothesised, several CSFs had statistically significant effects on the success of the selection, implementation, and usage phases. This reinforces the importance of adopting a dynamic and lifecycle-sensitive perspective when planning, deploying, and sustaining DMS solutions.

In the selection phase, the significance of top management support (SUPP) and organisational culture (CULT) underlines the strategic nature of the early decision-making process. Similar to findings in ERP literature (e.g., Ifinedo, 2008; Finney & Corbett, 2007), leadership commitment and a supportive culture are necessary to ensure that the chosen system aligns with the organisation's values, needs, and long-term goals. The culture factor is particularly relevant in environments where hierarchical communication, digital readiness, and openness to change vary widely between departments or user groups.

Process orientation (PROC) and project team/support (TEAM) were critical in the implementation phase. These findings align with Beheshti et al. (2014), who argue that process-based thinking and competent, interdisciplinary teams are fundamental for configuring systems to reflect actual workflows. Organisations that invest in training, coordination, and internal support networks tend to experience smoother transitions and fewer post-implementation issues.

The usage phase was primarily influenced by cost efficiency (COST). This suggests that once the system becomes operational, perceptions of ongoing value—mainly related to cost savings and performance—become key to sustained usage. These findings support Sprehe's (2004) view that long-term adoption is contingent on demonstrable benefits, which must be periodically communicated to users. Interestingly, time efficiency (TIME) did not have a statistically significant impact on any lifecycle phase. This contradicts prior assumptions and warrants further investigation. One explanation may be that perceived time savings are often intangible or difficult to attribute directly to the DMS, especially in complex or multi-system environments.

These results emphasise the need for a phase-aware CSF strategy. It is insufficient to adopt a static checklist approach to success factors. Instead, CSFs should be continuously reassessed and prioritised based on the evolving phase of the project and the organisation's maturity. For example, strategic alignment may be essential in the early stages, while user empowerment and performance monitoring gain importance during operational use.

This study contributes to the theoretical advancement of DMS research by linking CSFs to lifecycle phases using a structured model inspired by the ITIL framework. Applying PLS-SEM allows for a more nuanced understanding of causal relationships and offers a replicable approach for future researchers. The findings also provide practical guidelines for project managers, system integrators, and organisational leaders seeking to improve DMS adoption outcomes by identifying which factors matter most—and when—organisations can allocate resources more effectively and avoid common implementation pitfalls.

As with any empirical study, several limitations should be acknowledged. The sample was limited to organisations in Slovenia, which may influence generalizability due to cultural, legal, or technological differences. Furthermore, the model did not include potential mediating or moderating variables, such as organisational size, digital maturity, or system complexity. Future research could expand on these findings by integrating maturity models (e.g., CMMI, BPMM) and sustainability dimensions, thereby exploring how readiness levels influence the strength or presence of CSFs over time.

In conclusion, the study confirms that CSFs should not be viewed as static or universally applicable. Their influence depends on the timing, context, and alignment with the organisation’s goals and capacities. The next chapter further explores this dynamic by introducing a maturity-based view of DMS implementation, providing an additional lens for understanding outcome variability.

7 Conclusion

This chapter concludes the monograph's empirical part by summarising the research's key findings and contributions, highlighting its theoretical and practical implications, and outlining limitations and future research directions.

The study explored the relationship between CSFs and the lifecycle phases of DMS, focusing on hypothesis H1. Using a PLS-SEM approach on a sample of 146 respondents, the analysis confirmed that the influence of CSFs is not uniform across the DMS lifecycle. Specifically, top management support and organisational culture significantly affected the selection phase; process orientation and project team competence influenced implementation, and cost efficiency was a key factor during system usage.

These findings support the central assumption of the research—that CSFs must be evaluated and managed in a phase-specific manner. The mapping of CSFs to the DMS lifecycle using the ITIL framework provided a structured approach to identifying which factors are most critical at each stage. This has important implications for organisations seeking to optimise DMS planning, deployment, and long-term adoption.

From a theoretical perspective, the study contributes to the growing literature on DMS implementation by offering an integrated model that links CSFs with lifecycle phases, a topic that has received limited attention compared to ERP systems. It demonstrates the value of combining insights from CSF research, lifecycle management, and IT governance frameworks such as ITIL. Moreover, it validates the utility of PLS-SEM in capturing the complexity of IS success dynamics in mid-sized organisational samples.

Nevertheless, the study has certain limitations. The sample was drawn exclusively from Slovenian organisations, which may limit the generalizability of the findings to other national or cultural contexts. In addition, the model did not account for potential moderating variables such as organisational size, digital maturity, or DMS type. Finally, only one dimension of the broader research model was examined (H1), while other factors—such as sustainability orientation or maturity level—were left for future research.

Future studies could expand the model by incorporating and testing these additional dimensions in cross-cultural settings. Longitudinal studies may also offer more profound insights into how the impact of CSFs evolves and interacts with organisational learning and system maturity.

In conclusion, this study highlights the importance of contextual and lifecycle-based approaches to DMS implementation success. By recognising that different CSFs matter at various stages, organisations can tailor their strategies, allocate resources more effectively, and increase the likelihood of achieving operational efficiency and strategic alignment through their DMS initiatives.

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IX. Research on the Influence of Pilot Free Trade Zone on the Economic Development of Shandong Province

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The Shanghai Pilot Free Trade Zone was China's first of its kind, initiating the broader development of pilot free trade zones across the country. By 2023, China had established 21 such zones. 2019 Shandong Province launched its free trade area, encompassing Qingdao, Yantai, and Jinan. This region has prioritised innovation-driven development and strengthened risk prevention mechanisms to support economic growth. This paper examines the impact of the Shandong Pilot Free Trade Zone on regional economic development, focusing on gross domestic product, trade, and investment. The findings indicate that the zone has positively influenced foreign trade by expanding its volume and fostering industrial agglomeration. It has also enhanced the efficiency of foreign investment through improved investment structures and diversified financing channels. Additionally, the zone contributes to balancing the roles of the market and government and improving the tax system.

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1 Introduction

With the continuous development of economic globalisation, regional cooperation has deepened, and new organisational forms have emerged. The Shanghai Pilot Free Trade Zone is China's first pilot free trade zone, which also opened the prelude to the vigorous development of China's pilot free trade zones. By 2023, China had set up 21 pilot free trade zones, forming a "wild goose array" structure with Shanghai as the leading goose, coordinating east, west, north, south, and central China and the coordinated development of land and sea. Establishing a free trade zone is significant in promoting the high-quality development of the regional and even national economies. It is an integral part of China's strategy of deepening reform and opening up. Therefore, evaluating the economic effect brought by the establishment of the free trade zone is one of the hot spots in the current academic circle.

Similarly, this paper studies the free trade zone under the definition of FTZ in China. Therefore, the relevant research literature is mainly completed by Chinese scholars. Tan (2015), through research, found that establishing the free trade zone has effectively stimulated Shanghai's total import and export value and industrial added value (Tan, Zhou, & Lin, 2015). Zheng (2018), through research, proved that establishing the Fujian Free Trade Zone has a positive significance for stimulating the local economy, especially the policy effect of macroeconomic indicators is more significant (Zheng, 2018). Through research, Wang (2020) found that the free trade zone has a positive impact on the regional economy to different degrees. Still, the degree of influence varies from place to place and according to the indicators (Wang, 2020). To sum up, the impact of the establishment of free trade zones on the local economy is generally a positive promoting effect.

2019 Shandong Province set up a pilot free trade zone, including three Qingdao, Yantai, and Jinan districts. Since establishing these three zones, it has been adhering to the innovation-driven development strategy. In 2021, the international arbitration courtyard households were established in the Yantai area, and in 2022, the digital warehouse was launched in the Qingdao area. The main tasks of the three areas are to accelerate the transformation of government functions, improve investment, vigorously develop the marine economy, and further deepen the cooperation between China, Japan, and the ROK. At the same time, the Shandong Pilot Free Trade Zone should establish risk awareness, improve the risk prevention and control and disposal mechanism, escort the high-quality development of the regional economy, improve production efficiency, and better meet the consumer needs of the people (Wang et al., 2022).

Understanding the development status of the Shandong Free Trade Zone mainly involves four aspects: spatial layout, industrial characteristics, development orientation, and system composition. Understanding the changes in the economic development of Shandong Province after the establishment of the Pilot Free Trade Zone requires analysing national economic growth rates, foreign trade, industrial structure, and the degree of investment facilitation in Shandong Province. This will further promote the development of the Shandong Provincial Pilot Free Trade Zone.

The study of the development of Qingdao, Yantai, and Jinan will put forward new ideas for promoting the coordinated development of the regional economy. Analysing the existing problems of the Shandong Pilot Free Trade Zone and putting forward corresponding suggestions will help improve its development level (Zhou, Kang, & Tian, 2022). The study also provides a reference for developing other pilot free trade zones. As an essential part of China's maritime power strategy, Shandong Province's experience in export-oriented economic development can be used as a reference in other coastal areas. This paper will devote itself to studying the impact of the establishment of the Shandong Pilot Free Trade Zone on the economic development of Shandong Province, analysing the factors that have a greater driving force for economic growth, and summarising the development characteristics of the three pilot zones of Shandong Province to provide a reference for the construction of other pilot free trade zones.

2 Development status of Shandong pilot free trade zone and its influence on the economic development of Shandong province

In 2019, Shandong Province established a pilot free trade zone consisting of two coastal areas of Qingdao and Yantai and three inland areas of Jinan, covering 119.98 square kilometres. These three areas drive the development of surrounding cities and promote the economic development of Shandong Province.

2.1 Development status of Shandong Province Pilot Free Trade Zone

Shandong Pilot Free Trade Zone comprises two coastal areas of Qingdao and Yantai and inland areas of Jinan. The three districts have reasonable layouts, characteristic industries, and transparent development directions, which are of great significance in promoting the economic development of Shandong Province.

General Overview of Shandong Pilot Free Trade Zone

To accelerate the supply-side structural reform, strengthen China's opening up to the outside world, accelerate the transformation of government functions, optimise the domestic market environment, and promote the development of foreign trade, the Shanghai Pilot Free Trade Zone was established in 2013. The successful Shanghai Free Trade Zone experiment also opened the prelude to the vigorous development of China's pilot free trade zones. 2015 Guangzhou, Fujian, and Tianjin Pilot Free Trade Zones were established, and the Shandong Pilot Free Trade Zone was officially established in 2019. The free trade area covers an area of 119.98 square kilometres, with three regions—Qingdao, Jinan, and Yantai—distributed in the east, central, and west of Shandong Province, covering an area of 52 square kilometres, 37.99 square kilometres, and 29.99 square kilometres, respectively. These three large areas have their respective advantages, creating a balanced approach to promoting economic development across Shandong Province.

By 2022, the development tasks of the Shandong Pilot Free Trade Zone mainly included the following.

We will accelerate the transformation of government functions. In the free trade zone, the government will delegate some of its powers, which will help simplify procedures, improve efficiency, and enhance the business environment in Shandong Province. With the development of science and technology, the examination and approval system is being implemented in engineering construction. Artificial intelligence is replacing inefficient labour, which contributes to reducing costs, shortening enterprise work cycles, and improving efficiency (Wang, 2023).

Improve the investment climate. Implementing the negative list management system will increase transparency for foreign direct investment and avoid the restrictions of some potential treaties, which are conducive to foreign direct investment. At the same time, we will promote the facilitation and liberalisation of foreign investment in the free trade zone and improve the management system of foreign investment. In addition, the construction of a two-way investment service platform for enterprises should be strengthened to promote various forms of mortgage loans for export enterprises, combine "bringing in" and "going out," and promote balanced economic development (Wu, 2023).

We will vigorously develop the marine economy. Shandong Province is located in Bohai Bay, which should leverage its geographical advantages and actively create a marine economy. Establishing the Shandong Pilot Free Trade Zone will help promote the creation of an aquatic products processing and trade centre in Northeast Asia, optimise seafood import procedures, maximise port advantages, and encourage qualified financial institutions in the free trade zone to provide maritime financial services for related enterprises. In terms of sea transportation, we will build a comprehensive information platform for maritime big data, strengthen the linkage between pilot free trade zones and seaports, and promote the steady economic development of Shandong Province.

Deepen the cooperation between China, Japan, and the ROK. We will promote the construction of the China-South Korea Industrial Park in the Yantai area, further optimise the cooperation model, and expand overseas business to support RMB internationalisation.

Spatial Layout of Shandong Province Free Trade Zone

Although the three areas of the Shandong Pilot Free Trade Zone are relatively scattered, they are located in the top three prefecture-level cities in terms of GDP and optimising economic development within the province.

Jinan area. It covers an area of about 37.99 square kilometres, accounting for 31.7% of the free trade area. The Jinan area mainly includes the Financial International City, Jinan High-Tech Zone Core and East, and Tang Ye Core Area. The first batch of enterprises and entity projects in the Jinan area includes five significant investments, with a total investment reaching 25.3 billion yuan. The area also houses approximately 36 fund companies with a combined scale of 140 billion yuan and ten banking institutions. Unlike the Qingdao and Yantai areas, which are located along the coast, the Jinan area is inland but has a strategic geographical position. To the north, it connects with the Beijing-Tianjin-Hebei region; to the south, it links to the Yangtze River Delta region; and to the west, it connects with Heze, Binzhou, and Liaocheng—economically underdeveloped cities—enhancing economic spillover effects and promoting balanced economic development (Li, 2023).

Yantai area. It covers an area of about 29.99 square kilometres, accounting for 25.0% of the total free trade zone. The Yantai area includes two national-level parks: the China-South Korea (Yantai) Industrial Park and the western section of the Yantai Bonded Port. Upon its establishment, the area housed approximately 3,000 industrial enterprises and 124 financial institutions, with a total investment exceeding 130 billion yuan. Yantai's coastal location provides a geographical advantage, facilitating trade with Japan and South Korea while connecting to the Qingdao area in the south. It also helps alleviate economic pressure on the Qingdao area and serves as a financial hub for promoting the development of neighbouring Weifang and Dongying cities (Li, 2024).

Qingdao area. Covering an area of about 52 square kilometres, it accounts for 43.3% of the total free trade zone, making it the largest of the three regions. The Qingdao area comprises four functional zones: the Qingdao Qianwan Bonded Port Area, the West Coast Comprehensive Bonded Zone, the Qingdao Economic and Technological Development Zone, and the International Economic Cooperation Zone (Sino-German Ecological Park). Within just two weeks of its establishment, the registered capital of enterprises in the Qingdao area increased by 856.5 million yuan, with a total new investment of 86.9 billion yuan. Qingdao's strategic coastal position is key in fostering economic development in Shandong Province (Tong et al., 2024).

The Jinan, Yantai, and Qingdao areas of the Shandong Pilot Free Trade Zone all contribute to the economic development of Shandong Province by leveraging their unique advantages. However, each location has different industry focuses, promoting diversified economic growth within the province.

2.2 Performance of the impact of the establishment of the pilot free trade zone on the economic development of Shandong province

Shandong Province benefits from its superior geographical position, so international trade is an essential focus of its economic growth. The establishment of the Shandong Pilot Free Trade Zone not only promotes the foreign cooperation of Shandong Province, the development of the national economy, and the supply-side structural reform of Shandong Province.

The GDP growth rate was stable.

Shandong Free Trade Zone in 2019 was officially established. To study its impact on economic growth in Shandong Province, data from the six years from 2017 to 2022 are selected for comparison and explanation. The comparative results are shown in Table 1.

Table 1: Gross National Product of Shandong Province from 2017 to 2022(pricing in RMB)

Age (year)	2022	2021	2020	2019	2018	2017
GNP (billion)	8743.51	8309.59	7279.82	7054.05	6664.89	63012.1
Year-on-year growth(%)	3.9	8.3	3.6	5.5	6.4	7.4
National growth rate(%)	3.0	8.1	2.2	6.0	6.7	6.9

Note: The original data are from the National Development and Reform Commission of the People's Republic of China.

As seen from the above table, the GNP of Shandong Province has been on an upward trend from 2017 to 2022, with the growth rate fluctuating slightly, increasing from 6301.21 billion yuan in 2017 to 8743.51 billion yuan in 2022. In terms of growth rate, the growth rate of GNP in 2018 was slightly lower than the national growth rate in 2019. From 2020 to 2022, the growth rate of GNP in Shandong Province is significantly higher than the national growth rate. At the end of 2019, the COVID-19 epidemic began to spread worldwide, especially in the service and manufacturing industries facing large-scale shutdowns. Many shopping malls and stores are closed, which is also a massive challenge for Shandong Province.

The foreign trade situation has gradually improved

Regarding import and export trade, the Shandong Provincial Pilot Free Trade Zone also plays a positive role, and the data for the six years from 2017 to 2022 are selected here. Analysis of the influence of the Shandong pilot free trade zone on foreign trade, and then reflection on its impact on the economic development of Shandong Province. The finishing results are shown in Table 2.

Table 2 Foreign Trade of Shandong Province from 2017 to 2022

Age (year)	TIE (billion yuan)	TI (billion yuan)	TE (billion yuan)	ED (%)	ID (%)
2022	33 32.49	1296.91	2035.58	61	39
2021	29 30.41	1172.14	1758.27	60	40
2020	22 00.94	8 95.46	1305.48	59	41
2019	20 42.09	9 29.06	1113.04	55	45
2018	19 30.25	8 73.29	1056.96	55	45
2017	17 82.39	7 85.85	9 96.54	56	44

Note: TIE means Total imports and exports; TI means Total imports; TE means Total exports; ED means Export dependence; ID means Import dependence. Data are obtained from the Shandong Provincial Bureau of Statistics.

Table 2 since 2017, Shandong Province has increased year by year; 2019, total import and exports in Shandong Province rose 5.8% year on year, and the total import and export of RMB 200 million yuan since then, the total import and export growth trend, in 2020 in Shandong Province must grow 7.5%, late outbreak, especially in 2021, the performance of economic development is very outstanding, in 2021 in Shandong Province total import and export growth of 32.4%.

In 2021, the total import and export of Jinan, Qingdao, and Yantai accounted for 50%, among which Qingdao topped the Province's total import and export of 849.84 billion yuan, and Yantai ranked second. Qingdao's outstanding performance not only in the foreign economic development strategy but also with its diversified trade pattern and high-level trade platform; for example, Qingdao has a national economic and technological development zone, bonded port area, comprehensive bonded zone, export processing zone, and other national customs supervision zone, a micro become food, fruit, edible aquatic animals, ice aquatic products, meat and other seven kinds of goods designated import port.

In terms of foreign trade dependence, Shandong Province's export trade dependence is increasing. By the end of 2021, the survival rate of Shandong Province's foreign trade has reached 60%. Export-oriented final economic development degree is higher. In 2020, after the outbreak of international form development of global trade, Shandong Province's import and export growth slowed but still maintained a specific rate of growth from the foreign trade performance of Qingdao, Yantai, the establishment of the free trade area in Shandong Province added strong impetus to the economic development of Shandong Province, after the outbreak era, improving foreign trade in Shandong Province, also actively looking for new economic growth point.

The adjustment situation of industrial structure in the province

The establishment of the free trade area in Shandong Province and the development of the three major industries in Shandong Province have a particular influence; to explore the impact of the free trade area in the Province, we also chose the data from 2019 to 2022, to assist free trade area in Shandong Province after the change of the proportion of the three industries in Table 3.

Table 3 Shandong Province industrial structure ratio

Age (year)	Total primary industry (100 million)	Growth rate (%)	Total secondary industry (100 M)	Growth rate (%)	Total tertiary industry (100 M)	Growth rate (%)
2022	6298.6	4.3	35014.2	4.2	46122.3	3.6
2021	5363.76	7.5	28612.19	7.2	39153.05	9.2
2020	5116.99	2.7	28171.78	3.3	37251.71	3.9
2019	4950.52	1.1	27523.67	2.6	34174.68	8.7

Note: Data are obtained from the Shandong Provincial Bureau of Statistics.

Vertically, since 2019, the growth rate of the total primary industry in Shandong Province has continued to accelerate, and the output value has also increased from 495052 million yuan in 2019 to 511699 million yuan in 2020 and continued to increase to 62986 million yuan in 2022. In terms of the construction of the first industry, the free trade area in Shandong Province has always put the development of the Marine economy in a prominent position; for example, in the free trade test zone will "enterprise social science" quartet linkage mechanism introduced proliferation discharge system, advocating Marine creatures "big maintenance" pattern, improve the proliferation of discharge precision, scientific, effectiveness, development with the characteristic of Shandong biological maintenance industry. The growth rate of the total secondary industry in Shandong Province has maintained a rapid growth trend, with the output value increasing from 2,752367 million yuan in 2019 to 3,50142 million yuan in 2022. The construction of a total second industry constantly attracts outstanding foreign enterprises to the park. The growth of the total third industry in Shandong Province is more significant; it can be seen that in 2020, the tourism industry, the total third industry in Shandong Province, increased by 8.7% in 2019 to 3.9% in 2020,2021 ling the new champions league outbreak, the total third industry in Shandong Province growth to 9.2%, the island area depends on Qingdao rich tourism resources, its role in the third industry will be more and more apparent.

Horizontally, since 2019, the development of Shandong Province has focused on the secondary and tertiary industries, but the growth rate of the tertiary sector has shown a shrinking trend. The proportion of the tertiary industry fell slightly, and the overall development of the primary sector remained stable. In 2021, the Shandong Provincial Pilot Free Trade Zone will cooperate with the Yunnan Provincial Pilot Free Trade Zone, To further deepen the dialogue and cooperation between the Shandong Provincial Pilot Free Trade Zone and the RCEP member states, Strengthen collaboration in food, agricultural products and other aspects, And in the textile, chemical, new energy and other industries to achieve specific communication results, Promote the development of the primary industry in Shandong Province, At the same time, to strengthen the weak links, To promote the coordinated development of the three major sectors, Taking the Shandong Pilot Free Trade Zone as the demonstration pilot zone in the Province, Then, the successful experience of the Shandong Pilot Free Trade Zone in the development of the three major industries was extended to other prefecture-level cities in the Province, "Coordinated development from point to surface", Further shorten the development gap within the Province, Create a good atmosphere for benign development, We will improve the quality of economic development.

Changes in trade and investment facilitation degree

According to the 2022 edition of China's Annual Report on Trade Facilitation, China's trade facilitation index from 2020 to 2021 was 78.6 points (100 per cent system), up 0.9% yearly, with the overall environment improving. Since establishing the Shandong Provincial Pilot Free Trade Zone in 2019, it has continuously attracted foreign investment and given foreign investment plus pre-establishment national treatment in the pilot free trade zone.

3 Conclusion

The pilot free trade zone has had a positive impact on the economic development of Shandong Province. The pilot free trade zone can promote foreign trade by expanding the volume of foreign exchange and fostering industrial agglomeration. It can also enhance the efficiency of foreign investment utilisation by improving the structure of foreign investment and broadening enterprises' financing channels, thereby increasing the attraction of foreign investment. In addition, the pilot free trade zones balance the relationship between the market and the government and improve the tax system.

First, due to the trade creation effect and tax incentives for goods in the free trade zone, production enterprises will substitute low-efficiency, high-cost domestic production with more efficient and lower-cost imported goods. This shift allows enterprises to focus on developing industries within the free trade zone, improving production efficiency, optimising production factors, and reducing overall production costs. Additionally, it attracts foreign enterprises to import related products from the free trade zone, thereby expanding trade between countries and promoting international trade.

Secondly, due to the trade transfer effect, enterprises in the pilot zone benefit from preferential tax policies, high-standard talent introduction measures, and a convenient business environment. For example, the zone reduces remittance and foreign exchange settlement fees to facilitate fund management. Regarding talent recruitment, the Shandong Provincial Pilot Free Trade Zone has also made notable achievements. Yantai took the lead in implementing a talent housing security system, adopting a "leasing + property rights" model. In 2021, Yantai secured more than 1,000 housing units to meet the needs of skilled professionals. The free trade zone also facilitates international cooperation, enabling enterprises to import goods at lower prices from other countries or regions. The extensive international trade network within the zone increases exports and allows external enterprises to use the free trade zone as a gateway to seek foreign partners. This, in turn, fosters product exports, secures low-cost cooperation opportunities, improves profit margins, and promotes economic development at a higher level.

Finally, improving the economic benefits within the free trade zone also contributes to economic spillover effects, integrating resources across Shandong Province, increasing resource utilisation efficiency, and attracting more enterprises to join the free trade area. This expansion diversifies Shandong's product offerings, enhances product quality, increases trade, improves technical efficiency, and broadens the range of trading partners, contributing to regional economic growth. Industrial agglomeration within the free trade zone helps enterprises strengthen inter-industry linkages, deepen industrial cooperation, and reduce production costs through shared infrastructure. This maximises the use of limited financial resources, enhances specialisation in production, and fosters innovation. Moreover, through the diffusion effect, the free trade zone drives the economic growth of surrounding cities, helping to bridge regional economic disparities.

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X. Study on the Influence Mechanism of Digital Economy Development on China's Service Trade Exports–Based on Countries Along the "Belt and Road"

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The digital economy has injected a strong impetus into developing service trade along the "Belt and Road" between China and other countries. Based on the countries along the "Belt and Road", this paper analyses the impact mechanism of the digital economy on China's service trade exports, focusing on cost reduction and market expansion, and puts forward corresponding policy recommendations.

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1 Introduction

In light of the current global situation, a wave of anti-globalisation is rising, and trade protectionism is increasing. However, economic globalisation remains the dominant trend at the time. Since the 1980s, international trade has developed rapidly, and the proportion of global trade in total output has shown a rising trend. As an indispensable part of foreign trade, service trade has become increasingly important in the world economy and international trade. It has also become a new engine of economic growth for all countries (Ding, 2007).

At the same time, the world is gradually entering the era of the digital economy, benefiting from the development dividends it provides. Countries worldwide have begun to recognise the importance of the digital economy for service trade exports. Securing a leading position in the digital economy is crucial for gaining an advantage in future international trade competition. Consequently, numerous countries have introduced policies and measures to support the digital economy (Bukht & Heeks, 2018). The digital economy has become a driving force for economic growth, facilitating trade globalisation and profoundly transforming international capital flows, goods trade, and services. In 2015, China introduced the "Internet+" strategy, which accelerated digital transformation and promoted the upgrading of the service industry (He, 2021).

Many factors influence China's service trade exports. In the information era, information and communication technology (ICT) plays an increasingly significant role in shaping China's service trade (Jing & Sun, 2019). Since the introduction of the "Belt and Road" initiative, service trade transactions between China and participating countries have intensified. These countries have enormous potential for digital economic growth, aligning with global digital development trends. By leveraging the digital economy's rapid advancement, China can reduce its longstanding trade deficit in services and expand its service trade export volume (Miao, 2022). Taking advantage of digital economic expansion can contribute to a more balanced service trade between imports and exports, fostering the overall development of China's service trade sector (Gao & Wang, 2022).

Theoretically, the rapid expansion of international trade has gained considerable attention from scholars. As the share of trade in services within global trade continues to rise, many academics have begun to study service trade. In the era of the digital economy, many previously non-tradable services have become marketable, enhancing the role of digitalisation in service trade development. However, most academic research on service trade exports focuses on cultural, institutional, and competitive aspects. There is little direct research on the theoretical relationship between the digital economy, China's trade in services, and its impact mechanisms (Xu, Zhang, & Ma, 2018). Investigating how the digital economy influences China's service trade exports will contribute to a better understanding of this relationship and further enhance research on China's digital economy and service trade exports.

Practically speaking, under the current wave of anti-globalisation, the global trade environment is deteriorating. Many countries are implementing trade protectionist measures against China, making service trade exports increasingly challenging. As a result, China's service trade has faced persistent imbalances in import and export volumes. In the digital era, however, the digital economy has emerged as a new engine for global economic development. The growing application of digital technology in international trade has facilitated economic and trade integration, leading to more efficient and convenient transactions (Zhang & Jiang, 2021). By analysing the development of the digital economy and China's service trade exports to the countries along the "Belt and Road," this study aims to provide new insights into reducing China's long-standing trade deficit. The findings can help formulate constructive policy recommendations for developing China's service trade exports and contribute to constructing a more substantial digital Silk Road (Zheng, 2009).

2 Literature review

The digital economy is a new economic form that has emerged with the development of information technology and is closely related to the information economy, network economy, and knowledge economy, serving as a core element in all three. The digital economy is characterised by binary coding and can be understood as a form of the Internet economy. The concept of the "digital economy" was first introduced as early as 1996 by American economist Don Tapscott in his book The Digital Economy: Promise and Peril in the Age of Networked Intelligence (Tapscott, 1996). However, it has only been in recent years that the concept of the "digital economy" has been gradually enriched. Despite its growing importance, there is no unified definition of the digital economy within the academic community.

Foreign scholars Bukht and Heeks (2018) argue that the digital economy can be categorised into three levels: the core layer, which consists of information and communication-related industries; the middle layer, which includes business models that leverage digital technology; and the outermost layer, which encompasses economic activities carried out through digital technology (Bukht & Heeks, 2018). Meanwhile, domestic scholars such as Pang (2013) and Zhao (2016) emphasise the role of digitisation, defining the digital economy as an economic activity that utilises digital technology and trades digitised products (Pang & Zhu, 2013). Other scholars, such as He (2021), place greater importance on big data, arguing that the digital economy is closely linked to data analytics (He, 2021). Overall, the digital economy is defined from multiple perspectives, but most scholars agree it is fundamentally based on digital technology.

The development of trade in services has long been a topic of academic interest, and research on its influencing factors is abundant. Most scholars analyse this subject through the lens of "the impact of multiple factors on the export of trade in services." Using econometric analysis, Ding (2007) found that the number of employees in the service industry, the degree of market openness, the utilisation of foreign direct investment, and the volume of trade in goods all have a significant positive correlation with service exports (Ding, 2007). Xu (2018) examined the factors affecting service trade competitiveness from the global value chain perspective, using Porter's theory of competitive advantage as the foundation (Xu, Zhang, & Ma, 2018). Similarly, Jiang (2021) employed the principal factor method to analyse the influence of seven indicators, including GDP per capita, goods trade exports, and total education expenditure, on the technological content of China's service exports (Jiang, 2017).

Scholars increasingly focus on the relationship between the digital economy and service trade exports. The digital economy, which is rooted in digital technology, plays a vital role in nations' economic and trade development. At the same time, many scholars have empirically examined the impact of openness to foreign markets, per capita GDP, and other factors on service trade exports. With the continuous evolution of the global economic structure, the digital economy will inevitably influence service trade. However, the mechanisms through which the digital economy affects service trade exports and the intrinsic connection between the two remain underexplored. Therefore, this paper analyses the impact mechanism of the digital economy on China's service trade exports based on countries along the "Belt and Road." This research aims to support China's efforts in building the Digital Silk Road by providing more practical policy recommendations.

3 Analysis of the impact of the digital economy on China's service trade exports

3.1 Theoretical foundation

Traceability of services

The traceability of services has long been one of the key research priorities in trade. Some scholars initially argued that services were not tradable due to their inability to be stored. However, this view's limitations have become increasingly evident with the digital economy's continuous development. A review of relevant literature indicates that the key factors affecting the traceability of services primarily include the intrinsic characteristics of services, national regulations, and the level of technological development. Time and space constraints, along with government regulations, influence the degree of traceability of services. At the same time, technological advances have enabled certain services to be delivered in ways that separate the service provider from the consumer (Zhang & Jiang, 2021).

The recognition that services are tradable is now well-established in theory and practice. Limited traceability has historically constrained the growth of international trade in services, and enhancing the traceability of services can serve as a fundamental driver of its expansion (Zheng, 2009). Therefore, one of the key pathways to promoting the development of international trade in services is to improve the tradability of services.

Transaction cost theory

The digital economy has penetrated all aspects of society and has become one of the key elements in promoting social and economic development. The advancement of the digital economy has encouraged countries to increase investment in digital infrastructure, artificial intelligence, the Internet, and other large-scale digital infrastructure projects. The widespread use of the Internet and computers has positively impacted China's service trade exports. Trade partner countries that have developed digital economies can effectively reduce trade costs, including information, communication, and transaction costs (Jing & Sun, 2019).

Traditional transaction cost theory posits that enterprise coordination replaces market coordination, thereby reducing costs incurred in the transaction process. However, the nature of these costs has gradually evolved in the era of the digital economy. Blockchain technology, a distributed shared database ledger, represents a transformative "information transfer" technology in the Internet age. It ensures that transaction information is open, transparent, and tamper-proof, significantly addressing the problem of "information asymmetry" and effectively reducing information costs in transactions.

Furthermore, the Internet environment provides a more open and transparent transaction system, where most current transactions rely on network platforms to reach final agreements. The entire supply chain process—from product transportation to final delivery–can be fully recorded, tracked in real-time, and accessed at any moment, significantly reducing communication and transaction costs and mitigating associated risks.

The theory of economies of scale

The economy of scale refers to the phenomenon where an increase in enterprise production within a specific range of production leads to a decrease in average costs. Economies of scale can be categorised into internal and external economies of scale. Generally speaking, as market consumer demand increasingly diversifies and orders grow to a certain level, enterprises often struggle to balance production scale with the need to meet individual consumer demands. The development of the digital economy can effectively alleviate this contradiction.

Communication between buyers and sellers is more direct in the digital economy, and international trade's supply and demand dynamics are more precise (Miao, 2022). For domestic exporters, a larger export scale enables enterprises to expand their trade reach and accumulate vast amounts of raw data through trade activities. By leveraging big data technology, businesses can accurately assess foreign consumer demand and market trends, thereby facilitating the formation of economies of scale.

For foreign consumers, market information becomes more open and transparent in a trading environment dominated by network platforms. Small product price, quality, or turnover advantages among leading enterprises become key criteria for consumer selection. This, in turn, drives an expansion of consumption and contributes to the formation of economies of scale on the demand side of trade.

3.2 Analysis of Impact Mechanisms

Cost reduction effect

First, it reduces information costs. In traditional trade models, information exchange between trading parties often incurs high costs. In the era of the digital economy, the widespread application of the Internet, trade platforms, and big data has eliminated many information barriers in service trade across countries. The speed of information transfer, sharing, and collection has significantly increased, improving efficiency and reducing information costs (Gao & Wang, 2022).

On the one hand, service trade-exporting countries find it more challenging to understand international markets than domestic ones. However, with the advancement of digital technology, Chinese export enterprises can more easily access relevant information about countries along the Belt and Road, reducing the difficulty of obtaining information and mitigating the problem of information asymmetry. On the other hand, enhanced and optimised information technology enables data disclosure and sharing. As a service trade exporter, China can use digital technology to disseminate trade-related information quickly. This allows potential buyers in other countries to understand Chinese enterprises comprehensively, facilitating one-to-many trade cooperation and improving the matching efficiency between China and Belt and Road countries regarding product demand and supply.

Second, it reduces communication costs. The rise of Internet-based e-commerce and digitalisation has had a transformative effect on the traditional model of international trade. The negotiation process between trade partners has shifted from offline, in-person meetings to online, remote communications. Digital technology in Belt and Road countries has seen substantial advancements in recent years, with continuous improvements in digital infrastructure and platform applications. These developments provide enterprises with various online communication platforms that bridge time and space constraints. The digitisation of information and the adoption of information communication technology have strengthened support for online communication in service trade. The immediacy of online interactions significantly shortens waiting times for cross-border negotiations, reducing the adverse effects of geographic distance. Consequently, China and its trade partners along the Belt and Road can use email and other online communication platforms to facilitate timely feedback and cross-border negotiations, thereby reducing communication costs and minimising the waste of human, material, and financial resources.

Third, it reduces transaction costs. The application of the digital economy minimises the costs associated with production, transportation, and sales in the fulfilment process for both trading parties. In the digital economy, service products from different countries can be replicated at lower costs without compromising quality. The development of the digital economy in China and Belt and Road countries has accelerated the adoption of the Internet of Things (IoT), leading to digitalisation and automation in processes such as order processing, goods sorting, warehousing, and transportation. This reduces errors caused by human negligence, enhances transportation efficiency, and lowers costs in service trade exports.

Furthermore, the digital economy enables direct transactions between producers and importers, eliminating intermediaries and reducing trade costs at multiple levels. Additionally, the rise of mobile e-payments and e-banking has encouraged more enterprises to adopt digital payment methods when exporting, significantly lowering document processing costs. Third-party payment platforms offer transaction security guarantees, effectively reducing transaction risk costs.

Market expansion effect

Firstly, diluting market boundaries. In traditional service trade exports, Chinese exporters have often been constrained by time and space, making it relatively difficult to trade services with countries along the Belt and Road. However, in the era of the digital economy, the rapid expansion of the Internet of Things has enabled the widespread dissemination of data and information across borders. As a result, various entities involved in service trade are no longer restricted by geographic distance (Tadesse & White, 2010). The emergence of diverse Internet trading platforms has further provided a more open environment for economic innovation and the evolution of innovative business models. In addition, with the expansion of the digital economy, Internet applications have blurred traditional market boundaries. Even if the two parties in a service trade transaction are located in different regions, they can conduct real-time virtual meetings, exchange data, and communicate effectively online. This enables service trade enterprises to tap into potential markets without physical visits entirely (Han et al., 2022).

Secondly, expanding the scale of user demand. With continuous improvements in digital economic infrastructure in Belt and Road countries and the widespread adoption of mobile Internet, the demand for diversified service products has grown, and digitalisation has been increasingly integrated into trade activities. Various digital platforms have been developed, allowing enterprises to showcase their offerings comprehensively. Consumers can now use digital platforms to perform simple searches and quickly find the services they need at competitive prices. As a result, service products that were previously unknown to consumers have entered the market, offering buyers more choices while expanding sales channels for sellers. Furthermore, through Internet-based data collection, China can capitalise on potential market opportunities in Belt and Road countries, enabling a more precise understanding of service market demands. This enhances China's ability to expand its service trade export markets.

Finally, expanding transaction varieties. Digital technology has penetrated various industries regarding service transaction types, facilitating the creation of new service products. These new service forms are increasingly important in China's service trade exports, contributing to the diversification and expansion of China's service trade offerings. In traditional international trade, most transactions have been concentrated on goods produced by the manufacturing sector. However, as Internet information technology continues to integrate with service trade, the production speed of service products has significantly accelerated, productivity has improved, and the export value of services has increased annually. The adoption of digitalisation has given rise to new business models in service industries, allowing China to provide a more diverse range of services to Belt and Road countries. This also ensures higher quality service offerings, further strengthening China's position in global service trade.

The digital economy enhances China's service trade exports by reducing information, communication, and transaction costs. Additionally, it promotes service trade exports by breaking market boundaries, expanding user demand, generating new market opportunities, supporting the emergence of new industries, and diversifying service trade exports (Wang, 2023). Based on the Belt and Road countries, the impact mechanism of digital economy development on China's service trade exports can be summarised, as illustrated in Figure 1.

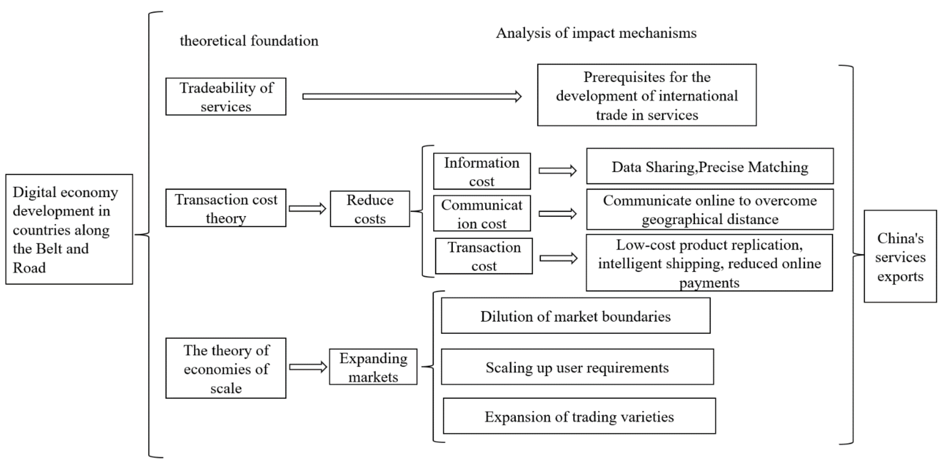

Figure 1: The Mechanism of the Digital Economy's Impact on China's Service Trade Exports China's Services Trade Exports

4 Status of China's services trade exports with countries along the Belt and Road route

4.1 Overview of the current status of China's trade in services exports

The Scale of China's Trade In Services Exports Maintains Relatively Rapid Growth, and the Growth Rate Continues to Rise

In recent years, China has further opened up to the outside world and increased its support for service trade. From 2010 to 2019, the proportion of service trade to GDP showed an upward trend. In 2020, due to the pandemic's impact, the proportion of service trade exports decreased significantly. In 2021, China's service trade maintained a rapid growth trend, with a total service trade volume of 12.2%. In 2022, it also steadily increased, reaching 13.4%. Among them, the growth rate of knowledge-intensive exports reached 18%, and the growth rate of intellectual property usage fees far exceeded 30%. The export value of China's transportation services is 820.55 billion yuan, with a growth rate of 110.2%, making it the fastest-growing sector in service trade.

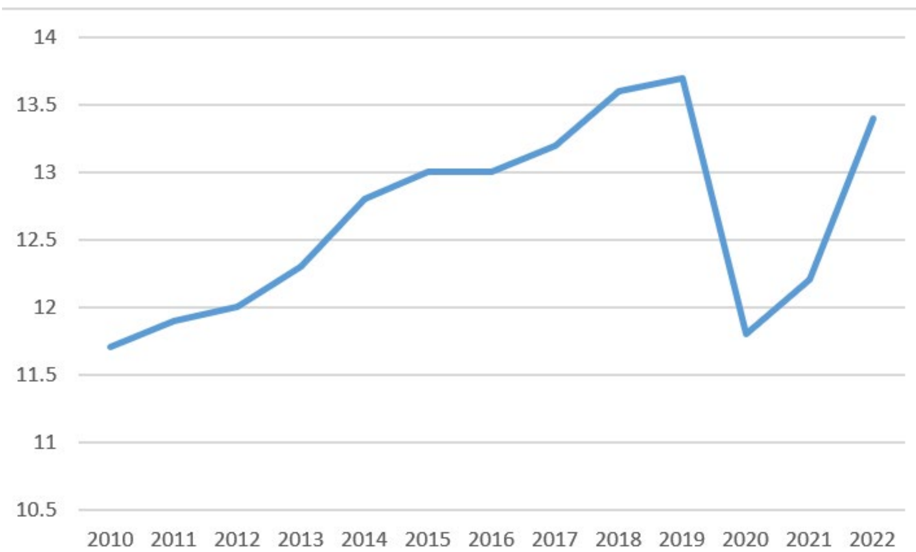

Figure 2: The proportion of export trade volume to GDP
Data source: World Bank

Trade deficit in services narrows but remains in trade deficit

In 2021, China's total service trade imports amounted to $427 billion. Service trade exports reached $394.2 billion, narrowing the service trade deficit to $32.75 billion, which is the lowest in the past decade.2022, in the first half of the year, the service trade deficit was further shrunk to $12.2 billion, which fully reveals that China's measures such as continuously optimising the structure of trade in services and constantly promoting the export of emerging services have achieved specific results. From a general point of view, China's advantages in construction engineering, international transportation and other aspects are more significant in IT services, finance and tourism and developed countries; if there is a certain distance, China's trade in services will still be in deficit.

Trade structure is further optimized, but the level of development still falls short of that of developed countries

Since China acceded to the WTO, the open fields of service trade have been increasing, relevant trade measures have been continuously launched, and the structure of China's service trade has been further optimised.2022 From January to October, the export of knowledge-intensive services was 1,149.92 billion yuan, with an increase of 14.3%, and the competitiveness of China's knowledge-intensive services has significantly improved, and the trade in knowledge-intensive services has become a driving force for promoting the innovation of high-quality development of China's services. Knowledge-intensive service trade has become an innovative driving force for the high-quality development of China's services. The proportion of high-quality service exports represented by knowledge-intensive service exports has been increasing, which profoundly shows the further optimisation of China's service export structure. Although China's service trade is now ranked second in the world, the value-added of the tertiary industry accounts for 53.3% of GDP, which is still lower than the global average and even lower than the proportion of service trade in the GDP of the Western developed countries. Although the proportion of knowledge-intensive service exports in China's service trade exports has been rising, it has not yet reached 50%, still lower than traditional service trade exports. In contrast, the high-tech service exports of developed countries such as the United Kingdom and the United States are much higher than the proportion of traditional service trade exports. Overall, although the level of development of China's trade in services exports has continued to rise, it will still take some time to catch up with the developed countries.

4.2 Analysis of the current situation of China's trade in services exports to countries along the Belt and Road

The Scale of Trade in Services Exports is Growing Steadily, but Overall Development is Lagging Behind That of Trade in Goods

In 2020, due to the impact of the epidemic, China's service trade exports to countries along the "Belt and Road" amounted to $37.73 billion, a year-on-year decline of 0.9%, and the service trade exports to countries along the route accounted for 13.4% of China's total service trade exports (Table 3). In 2021, China's service trade exports to countries along the route amounted to $56.33 billion, an increase of 49.3% year-on-year. In 2021, China's service trade exports to countries along the routes will amount to 56.33 billion U.S. dollars, with a year-on-year growth of 49.3%. From 2020 to 2021, China's service trade exports to countries along the routes will grow from 37.73 billion U.S. dollars to 56.33 billion U.S. dollars, compared with 2020, China's service trade exports to countries along the routes will increase significantly, and for the first time, China will realise a significant increase in service trade exports to countries along the Belt and Road. "China's service trade exports to countries along the Belt and Road have increased significantly compared to 2020, and for the first time, it has realised a trade surplus in services with countries along the Belt and Road. However, compared to trade in goods, although China's exports of services to the countries along the Belt and Road have increased significantly, they are still lagging compared with trade in goods. In 2021, China's trade in goods with the countries along the Belt and Road amounted to 700.5, the highest total trade in goods in the past eight years.

Table 3 Development of service trade between China and countries along the Belt and Road

Year	Export volume of service trade	Proportion
2020	$37.73 billion	13.4%
2021	$56.33 billion	20%
2022	$70.5 billion	29.7%

Data source: National Bureau of Statistics

In 2021, China's trade in goods with countries along the Belt and Road will total RMB 11.6 trillion, the highest in the past eight years, and will account for 29.7% of China's total trade in goods, much higher than its share in China's total trade in services.

The export structure of trade in services has been optimized, but the development potential of high-tech industries can be further explored

In 2020, due to the impact of the new coronary pneumonia epidemic, the export value of the traditional services trade represented by the tourism industry dropped significantly, and its development was seriously hampered. At this time, knowledge-intensive services defined by the digital economy show their prominence, and knowledge-intensive services represented by information and software services, service outsourcing, and digital service exports have significantly increased their status in China's service trade exports to countries along the route. According to statistics from China's Ministry of Commerce, in 2020, China's execution of services contracted out from abroad increased by 8.9% year-on-year, and in 2021, China's contracted services from the countries along the route amounted to 226.1 billion yuan, an increase of 25.7% year-on-year. At the same time, however, trade in services serving trade in goods and trade in productive services is expanding rapidly. During the epidemic, the export value of logistics and transportation service trade continued to grow. China's productive services accounted for 80% of the total, with China's export value of transportation services at 820.55 billion yuan in 2021, a growth rate of 110.2%. At the same time, driven by the China-EU liner, the amount of goods transported and the number of cities that arrived have increased significantly, and the export value of logistics and transportation services will further increase. In contrast, the traditional transportation and construction industries still dominate China's service trade exports to the countries along the route. With the lifting of the sealing control in various countries, tourism services will be revitalised again. The potential for cooperation in high-tech and high-value-added fields such as digital services, medical and health care, technology and intellectual property rights has yet to be further explored.

Services exports are closely traded, but the country structure needs to be further optimized and balanced

Since the Belt and Road Initiative was put forward, China has continued to develop the Belt and Road market. In the era of digitalisation, General Secretary Xi has even proposed building a sound digital Silk Road to further realise the connectivity between China and the countries along the route. However, China's service trade exports along the "Belt and Road" have been more concentrated in a few countries or regions in recent years. East Asia, West Asia, South Asia, and other areas are the central regions of China's service trade exports. According to the data on China's service trade exports in 2021, China's service trade exports with the top ten countries, such as Singapore, Russia, the United Arab Emirates, Malaysia, Vietnam, India, etc., accounted for nearly 80%. As a major global financial centre, shipping centre and trade centre, Singapore accounts for a relatively large share of China's service trade exports to Singapore. In the future, China can further develop the markets of other countries along the route without limiting itself to individual countries, realise the diversification of service trade export markets, explore countries with service export potential, and optimise the country composition of China's service trade exports.

5 Apocalypse and policy recommendations

At present, China's trade in services is still in deficit. In the context of the digital economy, developing the digital economy in trade partner countries has become an essential factor for China's service trade exports. In recent years, the digital economy of the countries along the "Belt and Road" has been developing rapidly, and after the analysis of the above theories and influence mechanisms, it can be seen that China can take advantage of the momentum of the development of the digital economy of the countries along the route, on the one hand, by reducing the cost of information, communication and the transaction process, and on the other hand, with the dilution of the market boundary, further expand the market in terms of increasing the scale of demand On the other hand, as market borders are diluted, China can further expand the market by increasing the scale of demand and transaction varieties, so as to strengthen the service trade cooperation with the countries along the route, in order to narrow the existing service trade deficit, expand the scale of China's service trade exports, promote the further growth of service trade exports, and achieve the relative balance of the import and export volume of the service trade.

Based on this, in the following three aspects, I will put forward corresponding policy recommendations for China’s service trade exports with the countries along the Belt and Road under the digital economy.

5.1 Accelerating digital economy policies to achieve balanced digitalization

China's digital economy has been steadily advancing in recent years, but some problems still need to be solved. China's Internet penetration rate is not high compared with developed countries, and there is an imbalance between the east and west of China in terms of digital development, with some economically disadvantaged regions not entering the digital era, which indicates that there is still much room for digital growth in China to be tapped. Suppose China wants to achieve further cooperation with the countries along the "Belt and Road" regarding the digital economy. In that case, we need to improve the construction of the digital economy in our trading partners and synchronise the progress of China's digital economy. The development of the digital economy in the central and western regions of China is lagging behind that of the eastern areas. The western and central regions need to refer to the advanced experience of the eastern areas and combine it with their advantages, vigorously build and develop the whole chain of the digital service industry, improve the construction of relevant information industry infrastructure in the western regions as soon as possible, and expand the channels of the digital economy in the field of service trade, logistics, information transmission and other aspects. China's "14th Five-Year Plan" has put the digital economy at the top design level. Then, we need the provincial and municipal governments to better implement the national digital economy policy to provide a more stable, perfect, and sound environment for developing the digital economy to export service trade to Chinese enterprises.

5.2 Expanding services market openness and optimizing the structure of services exports

The problem of unbalanced development of China's service industry still exists. Although China is continuously expanding the degree of opening up to the outside world, the degree of opening up is insufficient, and the areas of opening up are concentrated in the service market, thus restricting the improvement of the scale and efficiency of the development of China's service industry. China should further promote the "going out" of Chinese services, reduce trade and export restrictions in related sectors, promote Chinese service trade exports in an orderly manner, and create a more relaxed market business environment. At the same time, China should, according to the actual situation of the countries along the "Belt and Road", broaden the development channels of high-tech industries, increase the export scale of high-tech industry services, and continuously promote the integration of digital information technology with financial, cultural and other sectors, to promote the innovative development of China's industries. Development of China's industries. In addition, we will continue to improve the quality-of-service exports, deepen bilateral and multilateral cooperation, optimise the industrial structure of China's service exports based on better quality service products, and promote the development of China's service exports with higher quality.

5.3 Contributing to the construction of digital infrastructure in countries along the route and promoting the construction of the digital Silk Road

In the digital era, the precondition for digital technology to promote economic development is the construction of a sound digital infrastructure. However, the development of the digital economy of the countries along the route is not balanced; the development level of each country has a large gap, and most of the countries along the "Belt and Road" are developing countries with a relatively backward level of economic development, so it is difficult for these countries to complete the construction of digital economy infrastructure alone. Therefore, to realise better connectivity between China and the countries along the Belt and Road, China should provide technical and financial support to the countries along the Belt and Road while continuously developing its digital economy. It should make full use of China's advantages in digital information technology, strengthen the cooperation between

China and the countries along the routes in terms of the three major network operators, encourage enterprises with technological advantages and much experience in digital infrastructure construction to go out of the country, and continuously increase the investment in the infrastructure of trade partner countries, to help the countries along the routes to build and improve their digital infrastructure, improve their network coverage, and promote the development of digital infrastructure. Infrastructure development. The idea of the Digital Silk Road will further contribute to developing the regional and world economies. Therefore, China should further promote the Digital Silk Road construction process and push forward the construction of big data, cloud computing and smart cities to bridge the digital divide between countries. It should further reduce the transaction costs of service trade participants, enhance the tradability of services, and stimulate the development potential of China's service exports.

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XI. Opportunities and Challenges of Digital Payment Development in Southeast Asia for China's Cross-Border E-commerce Companies

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Digital payment services subvert the characteristics of the past large single, low-frequency trade transactions, help enterprises to deal with the traditional payment business model that is difficult to match, the payment cost is high, the overseas market coverage is not high enough and other constraints to improve the payment security and protection capabilities and transaction operational efficiency, empowering global trade activities. In recent years, the rapid development of digital payment in Southeast Asian countries, this paper first defines the relevant concepts, and then studies and analyses the current situation of the development of digital payment in Southeast Asian countries, and discusses the development of digital payment in Southeast Asia on China's cross-border e-commerce opportunities and challenges.

Keywords:
digital payments,
payment business model,
cross-border e-commerce,
opportunities and
challenges,
China

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1 Introduction

With the rapid development of new digital technologies such as big data, cloud computing, artificial intelligence, blockchain, and so on, digital technology significantly impacts international trade and national development. Digital technologies such as big data, cloud computing, artificial intelligence, blockchain, and other new digital technologies have a disruptive impact on international trade, investment, and global production layout (Luo, 2022).

International trade, international investment, and global production layout have had a disruptive impact. According to the Digital Trade Development and Co-operation Report 2022 released at TIS 2022, the scale of global cross-border digital trade in services will exceed USD 3.8 trillion in 2021, with a year-on-year growth of 14.3 per cent, accounting for 63.6 per cent of trade in services. Among them, the total import and export value of China's digital services reached USD 359.69 billion, up 22.3% year-on-year, accounting for 43.2% of services import and export (Mogo's Digital Payments Subsidiary Carta Worldwide Ups Payments Volume in 2023, 2024). China's digital trade is developing rapidly, ranking among the world's top in terms of scale and growth rate. Against this background, China's trade with economies along the "Belt and Road" has been growing rapidly, with the scale and growth rate among the highest in the world.

In this context, China and the economies along the "One Belt and One Road" have continued to deepen international cooperation in the digital field, establishing the "Digital Silk Road" cooperation mechanism and the "Silk Road E-commerce" bilateral cooperation mechanism. At the same time, it has completed the construction of several international submarine fibre-optic cables and cross-border land cables. Meanwhile, several international submarine fibre-optic cables and transboundary land cables were constructed. Digital trade has become a key factor in resolving capacity shortages and accumulating new international competitive advantages in economies along the Belt and Road (WSPN Aligns with Fireblocks to Advance Digital Payments Ecosystem, 2024).

Digital trade has become an essential tool for resolving the capacity shortage of economies along the Belt and Road, accumulating a new type of international competitive advantage and realising leapfrog development (Behera & Kumra, 2023).

Existing research shows that in terms of digital infrastructure in Southeast Asian countries, the level of digital infrastructure in Southeast Asian countries is relatively good, and a digital economic governance system has been initially constructed. In terms of digital trade cooperation between China and Southeast Asian countries, the digital economy between China and Southeast Asian countries has a high degree of complementarity and a more sound cooperation system. Although there are typical constraints, such as a lagging governance system, overall digital trade cooperation between the two is gradually deepening (Ibrahim & I. R., 2023).

In recent years, the level of digital infrastructure in Southeast Asia has been constantly improving, especially in the digital payment sector. However, the impact of China's and Southeast Asia's trade on digital payments has been explored less in the literature. Accordingly, this paper examines Southeast Asia's current digital payment level situation. Further, it explores the opportunities and challenges for China's cross-border e-commerce to promote the development of China's cross-border e-commerce enterprises and provide insights for other cross-border e-commerce enterprises (Obe Survey: Digital Payments Offer Environmentally Conscious Utility Customers a Better Choice, 2023).

1.1 Definition of relevant concepts

Digital payment

Digital payment, also known as electronic payment, is a payment method based on digital technology, including electronic bank transfers, third-party payments, mobile payments, and so on (Sinha, 2024). Among them, third-party payment is a relatively common digital payment method which completes the clearing and settlement of funds through a third-party payment platform. On the other hand, mobile payment is a digital payment method based on mobile terminals, allowing users to complete payment operations through mobile devices such as mobile phones. Digital payment has the advantages of convenience, speed, efficiency, and security and has become an essential part of the modern payment system.

GMV

GMV (Gross Merchandise Volume), the total amount of commodity transactions, is the total amount of transactions within a certain period. It is mainly used in the e-commerce industry and generally includes the number of unpaid orders placed (Worldline and Google forge strategic partnership for cloud-based digital payments innovation, 2024). As an e-commerce platform metric, GMV is a core indicator for measuring platform competitiveness (market share). The general e-commerce platform GMV formula is:

GMV=sales+cancelled orders+rejected orders+returned orders

That is, GMV is the sum of paid and unpaid orders.

GTV

GTV, also known as the total transaction value, refers to the platform's total transaction amount. GTV does not deduct income reductions such as returns but represents the total value of the original transaction. The key difference between GTV and GMV is that GTV accounts for deductions such as refunds and cancellations, representing the total value at the original transaction price (Shanu, Anu, & V., 2024). The difference in actual use depends on platform attributes. For instance, GTV is used for platforms like Shell, Meituan, and Bixin, which primarily provide intermediary transaction services and involve fewer returns and cancellations. Meanwhile, GMV is more relevant for platforms like Taobao and JD.com, where merchandise transactions often include unpaid orders.

2 Status of digital payment development in Southeast Asia

The low penetration of banks and credit cards in Southeast Asia compared to many developed countries poses a significant barrier to the use of digital payments. Like many developing countries, consumer financial services in Southeast Asia are poorly designed, and consumers have difficulty obtaining credit cards from banks due to a lack of credit data. At the same time, opening a bank account requires submitting many documents, a series of cumbersome processes that discourage many people. In addition, due to the insufficient size of the card acceptance market in Southeast

Asia, the widespread acceptance of bank cards has not yet been fully realised, directly affecting cardholders' incentive to use their cards. The basis for the development of bank cards is their good universality. When the number of specialised bank card merchants in a country is below a specific number, cardholders will feel inconvenienced using bank cards and ultimately return to cash payments. As a result, Southeast Asia is still a "cash is king" society, and many people still rely on cash for offline purchases.

However, Southeast Asia's reliance on cash has declined in recent years. According to the Southeast Asia Internet Economy Report 2021, the proportion of money in Southeast Asia's payment GTV is expected to decrease from 60 per cent in 2019 to 47 per cent in 2025.

2.1 Rising share of digital payments in Southeast Asia

On 1 November 2023, Google, Temasek and Bain & Company jointly released the latest version of the Southeast Asia Digital Economy Report 2023 (Economy SEA 2023, hereinafter referred to as the "Report"). According to the Report, Southeast Asia's digital economy GMV is expected to grow by 11 per cent to US$218 billion in 2023. By 2025, Southeast Asia's digital economy GMV is expected to grow at a CAGR of 16% to US$295 billion.

As shown in Figure 1 below, compared with other regions, Southeast Asia has withstood global macroeconomic challenges with strong resilience; the GDP growth rate of the six countries in Southeast Asia has remained above 4%, and the inflation rate has dropped to 3%, which shows that the region is still entire of unlimited business opportunities. Trade enterprises that have already laid out their business plans or are on the lookout for them can also find valuable information through this report on how to cut into Southeast Asia successfully.

According to the report's statistics on the development of the digital economy in Southeast Asian countries, Indonesia remains the most prominent digital economy in Southeast Asia, with GMV reaching about $82 billion in 2023 and is expected to exceed the $100 billion mark by 2025.

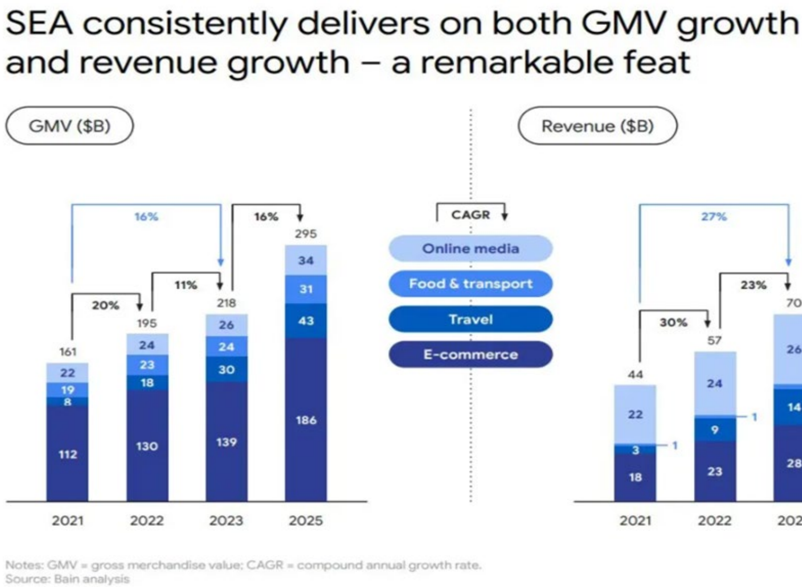

Figure 1 Economic development in the countries of South-East Asia
Data source: economy SEA 2023

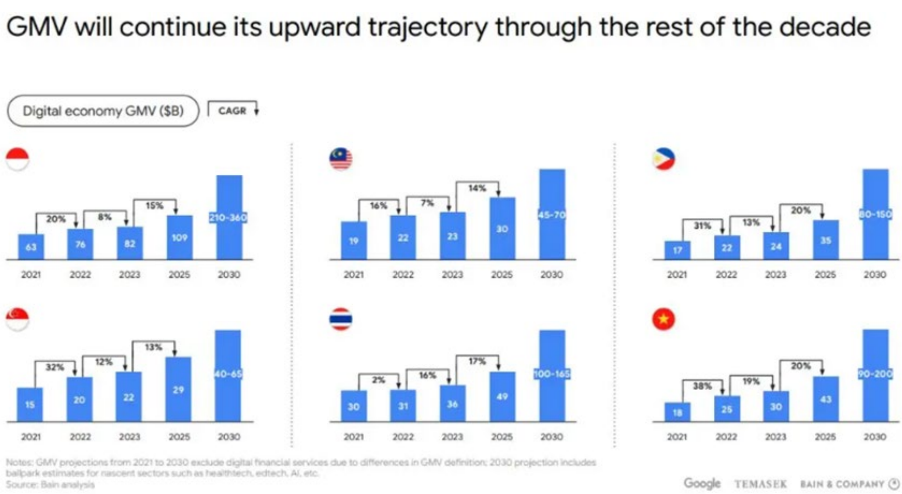

Figure 2 Development of the digital economy in South-East Asian countries
Data source: economy SEA 2023

In addition, regarding the compound annual growth rate of digital economy GMV by country from 2023-2025, the top three countries are Vietnam, the Philippines and Thailand. Among them, Vietnam and the Philippines topped the list with a growth rate of 20%; Vietnam's digital economy GMV grew from $30 billion to $43 billion, and the Philippines from $24 billion to $35 billion, followed by Thailand with a growth rate of 17%, the digital economy GMV grew from $36 billion to $49 billion. At the same time, the volume ranked second in Southeast Asia.

2.2 E-wallets in Southeast Asia

E-wallets are the most central category in digital payments in Southeast Asia. An e-wallet is a virtual wallet that allows users to transfer, receive, and save money and pay fees on their mobile phones. According to the Mobile Wallet Report 2021, a collaboration between London-based financial firm Boku and digital technology analyst firm Juniper Research, e-wallets overtook credit cards as the most widely used payment method globally in 2019, with penetration increasing further during the epidemic.

In general, many e-wallets require a bank or credit card to be tied to top-up. However, some e-wallets can be topped up in cash in Southeast Asia at convenience stores and selected offline outlets. This brings convenience to Southeast Asia, where bank and credit card penetration is low, and unbanked Southeast Asian consumers can use e-wallets to shop online and use other digital services. For example, Singapore's e-wallet Singtel Dash can be topped up from bank accounts and credit cards, in addition to cash top-ups at convenience stores such as Singtel and 7-11. Other Southeast Asian e-wallets that can also accept offline cash top-ups include e-commerce platform Lazada's Lazada Wallet, Malaysia's Touch 'n Go, Philippine e-wallets PayMaya and GCash, and Indonesian e-wallets OVO and GoPay. Only 13 per cent of Southeast Asia's unbanked urban population uses e-wallets. Still, e-wallet penetration among Southeast Asia's unbanked population is expected to soar to 58 per cent by 2025, according to a BCG survey released in 2020.

From a broader perspective, there are two types of mobile wallets worldwide. One is card-based mobile wallets, such as Apple Pay and Google Pay, which are more prevalent in developed markets. The other is top-up mobile wallets, such as China's Alipay and Grab's GrabPay, which are popular in emerging markets with low credit card usage. Due to the fragmented nature of the Southeast Asian market, e-wallet players have also blossomed (Table 1). Each country is represented by multiple e-wallet players, ranging from mobile wallets owned by banking institutions to those launched by non-banking organisations. From a more segmented perspective, Southeast Asian e-wallets can be broadly categorised into three more groups: telecom operator-based, internet company-based, bank-based, etc.

Table 1 South-East Asian e-wallets

Telecom operator-based e-wallets	Internet company-based e-wallets	Bank-based e-wallets
Singtel Dash LinkAja Gcash True Money Viettel Pay	GrabPay GoPay ShopePay FavePay Zalo Pay RabbitLINE Pay OVO DANA PayMaya Momo Boost	DBS PayLah！ Pay Anyone JakOne Mobile DiskarTech Diskar Tech K PLUS（K+）

3 Opportunities

3.1 Southeast Asian governments' support for digital payments

In recent years, Southeast Asian governments have also attached importance to the development of digital payments. To keep up with the trend of digitalisation, Singapore, Malaysia, and the Philippines have issued several digital banking licenses in recent years to facilitate the development of digital payments by further improving the local financial network (Table 2).

Unlike traditional banks, digital banking no longer relies on a network of physical branches. Instead, it uses the digital network as the bank's core, providing services such as bank reconciliation, cash withdrawals, managing cheques, mobile banking, bill payments, finance and monitoring transactions. Among these, virtual bank cards, e-wallets, and mobile banking are digital payment products of digital banks. In the case of Tonik, which is licensed as a digital bank in the Philippines, by using the Tonik mobile app, a user can open a bank account within five minutes using an ID and a selfie. Additionally, users with a Tonik bank account can top up their account through their bank, debit card, or cash at nearly 10,000 retail agents nationwide.

Table 2 Relevant Policies in South-East Asia

Months and year	Policy
2020.12	The Monetary Authority of Singapore (MAS) has announced the list of successful applicants for this year's digital banking licences: a consortium of Grab and SingTel, as well as Southeast Asian tech giant Sea Group (Winterhaven Group), were awarded a complete digital banking licence (Digital Full Bank); and a consortium led by Ant Group and Greenland Financial Investment Holding Group were awarded a wholesale digital banking licence (Digital Wholesale Bank).
2021.9	The BSP, the central bank of the Philippines, awarded its sixth digital banking licence to local fintech firm Voyager Innovations. The other five Philippine digital banking licence holders are GOtyme, UnionDigital, Overseas Filipino Bank, UNOBANK and Tonik Digital Bank.
2022.4	Five digital banking licences were issued in Malaysia, with successful applicants being a consortium represented by Grab, a consortium represented by the Dung Hai Group, a consortium represented by RHB, Malaysia's fourth largest bank, a consortium represented by Aeon Financial Services, and a consortium led by KAF Investment Bank Sdn Bhd.

Digital banking has been particularly beneficial for users in rural areas. Traditional banks tend not to set up branches in rural areas of Southeast Asia because of the high cost of building infrastructure, as opposed to conducting financial services in densely populated, high-traffic cities. Digital banking, on the other hand, can be a good way to meet the needs of rural users who want to use digital payments to make simple digital transactions at the touch of a mobile phone button. Digital banks will play an essential role in the digital financial ecosystem," said Benjamin E. Diokno, governor of the Bank of the Philippines. These additional partners can further improve market efficiency and expand Filipinos' access to a wide range of financial services, enabling us to more quickly achieve the stated financial inclusion goals of shifting at least 50 per cent of total retail payment transactions to digital by 2030, as well as about 70 per cent of adult Filipinos having a transaction account." In an environment of financial inclusion, Southeast Asian users are more likely to be exposed to and increase the frequency of digital payments, boosting the industry's growth.

3.2 Epidemic spurs users to embrace digital payments

The epidemic has fueled popular demand for digital consumption, and the continued use of digital services has become a new way of life in Southeast Asia, with the Southeast Asia Internet Economy Report 2021 showing that 90 per cent of those who used digital services in 2020 will continue to do so in 2021. The growth of digital consumers in Southeast Asia is even more promising when compared with the epidemic as a cut-off point. The report notes that 60 million new digital consumers have been added in Southeast Asia since the start of the epidemic, with 20 million becoming new digital consumers in the first half of 2021 alone.

In many areas of digital consumption, digital payments have become an essential vehicle for completing online transactions. This is because, during the height of the epidemic, Southeast Asian country's home segregation measures were taken one after another. Along with the shutdown of offline activities, many consumer activities have shifted to online, and payment methods have also moved to online. During such a special period, the acceptance of digital payments has been growing among both C- and B-end users.

Consumer e-wallet usage is up 45 per cent compared to the pre-epidemic period, and the value of transactions generated is expected to double by 2025. The convenience of e-wallets and incentives from e-commerce platforms are the main reasons consumers opt for digital payments. Additionally, the contactless feel of digital payments to meet the needs of Southeast Asian consumers during times of outbreaks is also driving consumers to opt for digital payments. According to Fintech News, in April 2021, Prompt Pay, an instant payment provider in Thailand, saw a year-on-year increase of around 80 per cent in the value of transactions. In Singapore, instant payments grew 58 per cent from last year.

As consumers' use of digital payments increases, it has also fueled merchants' acceptance of digital payments. According to the Southeast Asia Internet Economy 2021 report, over 90 per cent of merchants accept digital payments, citing digital financial services as an essential factor in ensuring their business can grow. In addition, another 75% of merchants find digital payments more convenient, and 72% of merchants say they will continue to increase the frequency of digital payments in the next 1-2 years. In the Indonesian market, merchants' adoption of digital payments has also increased significantly. From December 2020 to October 2021, the number of merchants adopting the QRIS system in Indonesia increased from 5.8 million to 12 million.

Even though the epidemic's peak has passed and offline activities in Southeast Asian countries have returned to normal, many local users still insist on using digital payments. According to a BCG research study, 60 per cent of urban Southeast Asian users said they would continue to use e-wallets even without incentives such as cashback and discounts. Just like getting used to e-commerce shopping, many Southeast Asian consumers also developed the habit of using digital payments during the outbreak, and merchants continued to support digital payments to cater to consumer preferences.

4 Challenges

4.1 Lack of mobility of innovation factors

Under the "Belt and Road" framework, there is a lack of fluidity in the flow of innovation factors among the countries along the route. There are barriers to the inter-regional mobility of capital, talent, technology and other factors, and inter-regional and inter-country communication lacks the support of service platforms. Due to information asymmetry, physical distance and other natural barriers, as well as factors such as the difficulty of capital intervention, the slow flow of talent, the lack of technology and other factors leading to the development of the digital economy within the region, there are specific difficulties. The synergistic efficiency of traditional industries is low, and there are many obstacles to starting a new industry.

4.2 Limited trade protection

The gap in the regional legal agreement on digital security between Southeast Asian countries and China has led to the failure of trade protection, cyber fraud, and frequent personal privacy data leakage incidents. As China and the "One Belt, One Road" agreement countries have in-depth cooperation in infrastructure construction, especially in transport and energy, the improper protection of data and business secrets can directly endanger national security. Therefore, the lack of a legal mechanism for data security will quickly lead to ineffective regulation.

4.3 Lack of relevant talents

Countries along the "Belt and Road" are constrained by their economies, cultures, and education levels, and they lack professional talents and talent training systems that match the current international digital development. With China's "Belt and Road" countries signed an agreement, West Asia, North Africa, South Asia, and Southeast Asia, part of the country generally exists in people's low level of education, the overall economic development of the region lagging behind and so on. The number of talents in the region and the ability to innovate are relatively scarce, and talents and innovation are critical engines for improving digital informatisation and economic development.

4.4 Infrastructure remains relatively underdeveloped

Southeast Asian countries are lagging in developing traditional and new infrastructure, which limits the development of digital technology and commerce. The countries' economies along the "Belt and Road" are mainly in the developing stage, and the construction of traditional infrastructures, such as highways, ports, airports and energy sources, is relatively weak. Due to the poor economic foundation, low education penetration rate and a significant gap between the level of informatisation and the international average level, this difference makes China face significant challenges in the development of the digital economy in Southeast Asian countries.

5 Conclusions

Digital payments are a good business for both entrepreneurs and investors. Scott Krivokopich, co-founder of Southeast Asian venture capital firm 1982 Ventures, which focuses on investing in fintech projects, has said that payments are an industry with a powerful network effect. In the first few years of payment, companies getting financing is straightforward; many companies are crazy expanding at the expense of all kinds of subsidies to grab market share. The payment market in the last two years has gradually returned to rationality, mainly due to the impact of this epidemic, which may accelerate the industry reshuffle. With the development of e-commerce, digital payments in Southeast Asia are also developing rapidly. However, the pattern of its development is still very fragmented and immature, and there are still many opportunities, such as the reconciliation and clearing of payment systems. In Indonesia, there are still many companies that are used to paying with banks. Still, digital payments are much more convenient, with faster and more efficient operation of income and expenditure flows. Therefore, the Chinese government and companies can seize the opportunity to work to overcome the challenges of taking advantage of the digital economy and developing trade with Southeast Asian countries.

This paper attempts to study the current status of digital payments in Southeast Asia. The study found that the proportion of digital payments in Southeast Asia is increasing. Indonesia is still the most significant digital economy in Southeast Asia. As the core of digital payment e-wallets, the penetration rate of e-wallets in Southeast Asia is increasing and is expected to reach 58% in 2025. Southeast Asian government policy supports the digital economy; the epidemic makes more users accept digital payments, which will give cross-border e-commerce enterprises opportunities. However, they must pay attention to overcoming the lack of mobility of innovative elements, limited trade protection, and other challenges. Therefore, the Chinese government and enterprises can seize the opportunities and overcome the challenges of taking advantage of the digital economy and developing more trade with Southeast Asian countries.

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XII. The Impact of Digital Economy Development of Countries Along "The Belt and Road" on China's Economic Cooperation

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Since the launch of the "Belt and Road" initiative in 2013, the digital economy has become a vital driver of its high-quality development. This study explores how the development of the digital economy in countries along the route influences China's economic cooperation, particularly in terms of foreign direct investment (FDI). By analysing existing data and constructing a theoretical framework, the paper reveals that countries with higher digital economy development attract more Chinese FDI. This effect is especially significant for private firms, companies engaged in digital industries, and those with prior international experience. The findings highlight the strategic importance of digital connectivity in promoting cross-border investment and cooperation.

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1 Introduction

The Digital Silk Road is an organic combination of global digital economic development and the initiative of jointly building "The Belt and Road." In October 2023, the third "The Belt and Road" International Cooperation Summit Forum was held in Beijing. Accelerating the digital construction of "The Belt and Road" and building the Digital Silk Road are emerging topics and tasks in "The Belt and Road" construction. They represent a core component of promoting its high-quality development.

As one of the core characteristics of the future globalisation process, the "digitalisation" trend of international economic cooperation is accelerating and profoundly affecting the patterns and paths of foreign trade among countries. The 14th Five-Year Plan for the Development of Digital Economy in China also proposes to expand international cooperation in the digital economy effectively, accelerate the digital development of trade, promote the deepening of the Digital Silk Road, and actively build a favourable international cooperation environment (Chen, Xu, & Lan, 2020).

There are two main reasons for the formation of this proposition. On the one hand, the current world economic growth is weak, and there is an urgent need for the digital economy to become a new driving force for global economic growth. Countries worldwide should build an open digital trade pattern, create digital free trade zones, deepen cooperation and dialogue mechanisms, promote the cross-border flow of data, technology, and talent, and achieve global sharing of digital dividends (Huang & Duan, 2021). On the other hand, thanks to the vast scale of the digital economy market and well-established infrastructure, China is in the first tier of global digital economy development, enabling it to provide experience for the world's digital transformation and contribute to developing the world's digital economy.

Therefore, adhering to deepening international cooperation in the digital economy is an important manifestation of China as a supporter and promoter of multilateralism and a necessary channel for China to achieve high-quality economic development (Sinha, 2024). Exploring the development of the digital economy in countries along The Belt and Road and China's outward direct investment is thus of practical significance.

2 Global digital economy development pattern

The role of the digital economy in global economic development is increasingly prominent, yet its development remains highly unbalanced.

Firstly, according to relevant data from the Global Digital Economy White Paper of the China Academy of Information and Communications Technology from 2019 to 2022, the scale of the digital economy in 47 countries worldwide increased from 30.2 trillion USD in 2018 to 38.1 trillion USD in 2021, with an average annual growth rate of 6.5%, which is twice the average GDP growth rate of 3.2% in these countries during the same period. Meanwhile, the proportion of the digital economy relative to GDP has increased from 40.3% in 2018 to 45% in 2021, with an average annual growth rate of 3% (Table 1).

With the increasing proportion of the digital economy in the global economy, the world is entering the digital economy era, with industrial digitisation serving as the main driving force for this growth. The proportion of industrial digitisation in the global digital economy has remained stable at around 85%. In contrast, the digital transformation of industries follows a pattern where the tertiary sector surpasses the secondary sector, surpassing the primary sector (Hou & Xiong, 2023).

Table 1: The scale and proportion of the digital economy of major global economies in GDP in 2018-2021

Time Data	2018	2019	2020	2021
The scale of the digital economy (one trillion dollars)	30.2	31.8	32.6	38.1
Contributing to GDP (%)	40.3	41.5	43.7	45.0

Secondly, data from 47 countries calculated by the China Academy of Information and Communications Technology shows that, in terms of economic development levels, the digital economy scale of 20 developed countries reached 27.6 trillion USD in 2021, accounting for 72.5% of the total global digital economy and 55.7% of GDP, all of which are far higher than those of developing countries.

From the perspective of income levels, the scale of the digital economy in high-income countries has reached 28.6 trillion USD, which is approximately three times that of middle- and high-income countries and 32 times that of middle- and low-income countries. The proportion of the digital economy relative to GDP in high-income countries has reached 52%, significantly surpassing the 34.4% in middle- and high-income countries and 18.5% in middle- and low-income countries, as shown in Table 2 below.

Therefore, a significant digital divide exists in the development of the global digital economy. Developed countries lead in digital economy development compared to developing countries; however, the growth rate of the digital economy in developing countries, middle- and high-income countries, and middle- and low-income countries is considerable (Ou & Hou, 2023). In 2021, the growth rate of the digital economy in these groups exceeded 20%, whereas the growth rate in developed and high-income countries during the same period was around 10%.

Table 2: Digital economy development in different types of countries around the world in 2021

Classify	The scale of the digital economy (one trillion dollars)	Share of the scale of the global digital economy	Their proportion of GDP
Developed countries	27.6	72.5%	55.7%
Developing countries	10.5	27.5%	29.8%
High-income countries	28.6	75.2%	52%
Middle - and high-income countries	8.6	22.6%	34.4%
Low - and middle-income countries	0.9	2.2%	18.5%

From a national perspective, the United States has the largest digital economy in the world, with a scale of 15.3 trillion USD. China ranks second globally, with a digital economy valued at 7.1 trillion USD. Germany, Japan, the United Kingdom, and France rank third to sixth, respectively. The digital economies of these six countries all exceed one trillion USD, with a combined total of 31.4 trillion USD, accounting for 82.4% of the global digital economy. Leading economies have established a dominant position in the digital economy, shaping a global digital economy competition pattern between the United States and Europe.

Regional differences in digital infrastructure and digital technology are the main causes of the "digital divide." The "digital divide" between developing and developed countries is primarily due to disparities in digital infrastructure and digital technology application capabilities, leading to a knowledge acquisition gap.

Firstly, digital infrastructure serves as a crucial enabler of data-driven economies, providing foundational support for next-generation digital technologies such as artificial intelligence. Through connectivity and network effects, it drives the comprehensive development of the digital economy, ultimately transforming economic and social productivity as well as production methods. In recent years, global capital investment in digital infrastructure has accelerated. However, due to the economic disruptions caused by the COVID-19 pandemic and the Ukrainian crisis, the financial conditions of major economies have deteriorated. Consequently, public capital from governments is insufficient to meet the scale and operational demands of global digital infrastructure investment (Pei, Ni, & Li, 2018).

Currently, private capital plays a key role in sustaining global digital infrastructure development. In 2021, global private capital investment in digital infrastructure increased by 109% year-on-year, with a significant portion coming from developed countries. These nations benefit from advanced technology, strong capital reserves, and a robust industrial foundation, giving them a first-mover advantage in digital infrastructure expansion. With comprehensive industrial systems and established digital infrastructure, developed countries can integrate digital technologies into traditional industries, potentially upgrading productivity or exacerbating geopolitical digital disparities, further widening the digital economic gap between developed and developing nations.

Furthermore, while 66% of the world's population has Internet access, penetration rates vary significantly by region: 80% to 90% of people in Europe and the Americas have access to the Internet, whereas only 40% of Africa's population is online. In technical terms, nearly 88% of the global population had access to 4G networks in 2022, yet in many developing nations, 3G networks remain the primary means of connectivity (Shi, Nie, & Qi, 2023). Thus, the gap in digital infrastructure and Internet access between developing and developed countries continues to widen.

On the other hand, there are substantial regional disparities in digital infrastructure development, with well-established digital infrastructure and efficient digital communication channels serving as prerequisites for effective international digital economic cooperation. According to the World Internet Development Report 2022, Singapore, Norway, South Korea, the United States, and China lead in information infrastructure scores (Sun, 2023). These nations excel in average network download speeds, broadband subscription rates, and IPv6 adoption. Conversely, underdeveloped countries such as Kenya, Ethiopia, and Nigeria struggle with slow network speeds, high service costs, and low Internet penetration rates, highlighting the need for improved digital infrastructure. This regional imbalance hampers data flow and global digital economic cooperation, making it difficult for digital infrastructure to facilitate international trade while increasing the cost of utilising data and digital technology in commerce, thereby reducing cooperation efficiency.

Secondly, digital technology is the driving force behind the deep integration of the digital economy with the real economy. Key challenges include advancing core technologies and leveraging next-generation digital solutions to empower industries through digital transformation. Historically, every major information technology revolution has been closely tied to advancements in computing power, which is fundamentally supported by integrated circuits. The global integrated circuit industry has undergone three phases of industrial relocation, resulting in a highly specialised, spatially clustered, and monopolised sector.

Six core regions dominate the global semiconductor industry: the United States, South Korea, Japan, mainland China, Taiwan, and Europe. In 2021, the global semiconductor market was valued at 556 billion USD, with market shares distributed as follows: the United States (46%), South Korea (19%), Japan (9%), Europe (9%), Taiwan (8%), and mainland China (7%) (The State Internet Information Office, 2023).

Moreover, the development of next-generation digital technologies remains highly uneven worldwide. The Frontier Technology Readiness Index evaluates the overall development level of 11 cutting-edge technologies, including artificial intelligence and the Internet of Things. The top five countries—the United States, Sweden, Singapore, Switzerland, and the Netherlands—lead in these advancements, while developing nations generally rank lower (White Paper, 2023). The rapid evolution of new technologies may further exacerbate inequalities in development, widen income distribution gaps, and even accelerate global economic divergence. Consequently, while digital technology transformation holds great potential, it has also intensified the disparities between developing and developed countries.

2.1 China's economic cooperation

In recent years, unilateralism and trade protectionism have continued to rise, and the "nationalisation" and "politicisation" of digital technology have become increasingly prominent in the process of anti-globalisation as leaders in the global digital economy, China and the United States are influenced by geopolitics and so-called strategic goals. The United States frequently provokes friction with China regarding digital technology, which has gradually extended into foreign trade.

As the foundation for the development and international cooperation of the digital economy, the digital industry relies heavily on domestic digital technology. Unlike traditional industries, it lacks upstream and downstream international partners, leading to significant exclusivity and mutual exclusion in the sector. This exclusivity results in competition among countries with similar industrial chains, often forming a "zero-sum game" (White Paper, 2023). Generally speaking, the more a country relies on a certain industry, the stronger its tendency to protect that industry. In the international environment, this protectionism often leads to competition rather than cooperation with similar countries. This competitive dynamic is widely observed in the field of digital trade. Since 2018, China's export growth rate in digitally deliverable services, including telecommunications, computer, and information services, has fluctuated and generally declined (Xing, 2022).

Faced with the enormous development potential of the digital economy, China is advancing global digital economic development through international cooperation rather than unilateral efforts, actively helping developing countries bridge the "digital divide." The 14th Five-Year Plan for the Development of Digital Economy also provides specific guidance and arrangements for fostering international digital economy cooperation. Additionally, in contrast to the United States and Europe, China maintains closer digital economy partnerships with developing countries.

Among these initiatives, the Digital Silk Road is a product of the deep integration of global digital economic development and The Belt and Road initiative. It serves as China's strategic approach to promoting new economic globalisation cooperation through high-quality co-construction of The Belt and Road in the digital economy era. China actively pursues digital economic collaboration along The Belt and Road, deepens digital infrastructure connectivity, enhances Internet penetration, assists industries in their digital transformation, supports domestic leading digital economy enterprises in expanding globally, and cultivates new areas of cooperation to drive the high-quality development of The Belt and Road.

Given these efforts, it is crucial to further leverage the role and potential of international cooperation in the digital economy to strengthen high-quality development along The Belt and Road. Since The Belt and Road spans a diverse set of countries, a deep understanding of the digital economy's development characteristics in different regions is essential. By tailoring international digital economy cooperation strategies, China can facilitate high-quality economic development along The Belt and Road, ultimately enabling participating countries to share in the dividends of digital economic growth.

2.2 Mechanism analysis of the impact of digital economy development in host countries on the efficiency of China's foreign direct investment

As a new economic form driven by the new generation of information technology revolution, the digital economy has disrupted the traditional spatial organisation of economic factors. Its advantages in reshaping the global production network model are becoming increasingly evident, making it a crucial driver of cross-border economic cooperation.

Based on the structural characteristics of China's current outward foreign direct investment, which primarily focuses on the service industry and developing economies, this article argues that the internal mechanisms through which the development of the host country's digital economy impacts the efficiency of China's outward foreign direct investment include at least two key aspects: reducing trade costs and improving government efficiency (Xiao & Liang, n.d.).

2.3 Improving enterprise management level to reduce trade costs

From the industry distribution of Chinese enterprises' outward foreign direct investment, trade service-oriented investment is more significant and prevalent than overseas production-oriented investment. Essentially, it represents a form of vertical direct investment that supports imports and exports, maintaining a complementary relationship with trade flows. The robust development of the host country's digital economy can significantly enhance the speed and frequency of information flow, thereby reducing trade costs faced by China in foreign direct investment—particularly in trade service-oriented investment. This includes improvements in cross-border search matching and communication coordination, effectively mitigating the efficiency losses in cross-border cooperation caused by information asymmetry, expanding intermediate goods trade, strengthening production linkages between enterprises, and encouraging Chinese enterprises to engage in foreign direct investment.

Additionally, as the digital economy's development level improves, the host country's domestic logistics service industry will increasingly enhance its ability to leverage digital infrastructure and technology (Zhao, 2021). The intelligence of order processing, warehouse regulation, and customs clearance can significantly boost logistics efficiency while reducing operational costs associated with warehousing and transportation for trade service-oriented investments.

At the same time, new business models, such as digital trade and digital platforms, will continue to emerge in the host country, facilitating better alignment between China's competitive industries and targeted international markets. This promotes cross-border digital investment cooperation, further unlocking the advantages and potential of Chinese enterprises in outward direct investment and enhancing investment efficiency.

2.4 Improving government efficiency

Government efficiency refers to the speed and quality of processing public services, administrative approvals, information disclosure, and other matters managed by the government. It is a crucial factor influencing the location selection of international direct investment. Higher government efficiency in a host country leads to lower institutional transaction costs for newly established enterprises, making the country more attractive for international direct investment.

The primary destinations of China's outward foreign direct investment are developing economies, where government efficiency still has significant room for improvement compared to developed nations. The robust development of the digital economy in a host country can first effectively promote the digital transformation of traditional government frameworks, simplifying and accelerating administrative approval processes. Secondly, digital governance enhances transparency, facilitating better information flow between governments and enterprises. By leveraging digital technology, governments can more accurately identify the investment policy needs of foreign investors, optimise the investment environment and service quality, and reduce investment uncertainty risks.

Additionally, the strong development of the digital economy enables foreign investors to access policy information more conveniently and participate in public policy formulation through various digital channels, such as e-government platforms and government portal websites. This continuous engagement enhances their participation in e-governance, helping to overcome the disadvantages and trust deficits that foreign investors may face due to information asymmetry. As a result, digital governance supports foreign investors in forming efficient and precise investment decision-making and operational systems, ultimately improving investment efficiency.

The development of the digital economy along The Belt and Road positively impacts the location selection of Chinese enterprises' foreign direct investment. Companies are more inclined to invest in regions along The Belt and Road where the digital economy is more advanced. Well-developed digital economies in these regions are particularly effective in attracting investment flows from private enterprises, businesses with overseas operations, and firms in digital economy-related industries

(Zhang & Li, 2021). Moreover, the digital transformation of host countries along The Belt and Road significantly influences enterprise location decisions by enhancing technological innovation and alleviating financing constraints. The theoretical framework is illustrated in Figure 1.

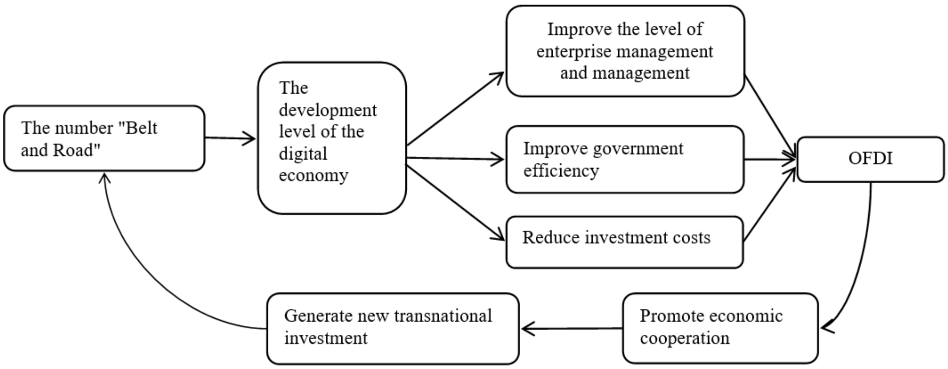

Figure 1: Theoretical framework affecting the efficiency of China's OFDI

3 Conclusion

The international cooperation in the digital economy led by China is creating new opportunities for countries and regions along The Belt and Road to bridge the "digital divide" and foster economic and social development (Zhao, 2023). Firstly, the digital economy along The Belt and Road has entered a period of rapid growth. Secondly, from a regional perspective, variations in digital economy development among The Belt and Road countries are mainly influenced by a combination of factors, including the digital governance environment, digital infrastructure construction, and digital technology applications, all of which exhibit spatial agglomeration characteristics.

On one hand, the development of the digital economy is closely linked to a country's overall strength. A thriving digital economy requires a well-established digital ecosystem and robust digital infrastructure, which necessitate an industrial foundation and widespread digital technology application. On the other hand, a favourable political, economic, and innovation environment enhances digital governance capabilities in host countries along The Belt and Road, providing a stronger foundation for digital economic development.

Attach great importance to the role of Southeast Asia in advancing digital economic cooperation along the Belt and Road

In this study, West Asia, the Middle East, and Southeast Asia demonstrate the highest levels of digital economy development. However, Southeast Asia exhibits greater political and economic integration compared to West Asia and the Middle East. In the future, the scale and diffusion effects of the digital economy in Southeast Asia are expected to be more pronounced.

In recent years, the digital economy in Southeast Asia has grown rapidly, benefiting from several key advantages.

1. Policy Advantages: Governments in Southeast Asia actively embrace opportunities presented by the global technological revolution and industrial transformation, incorporating digital economy development into their economic reform strategies. For instance, since 2016, the Indonesian government has implemented policies focusing on e-government, e-commerce, digital transformation in manufacturing, artificial intelligence, and comprehensive digital economy growth (Zhao, 2023). The launch of the Digital Indonesia 2021-2024 Roadmap has laid the groundwork for Indonesia's digital economy development, emphasising digital infrastructure, digital governance, and digital services.
2. Geographical Advantage: Southeast Asia's proximity to China, Japan, and South Korea fosters deep integration with their digital economies. The short transportation distances facilitate industrial transfers within the region, enabling Southeast Asia to adopt and learn from digital industrialisation models pioneered by China, Japan, and South Korea. Moreover, leading digital economy enterprises from these countries—such as Alibaba, Tencent, JD.com, and ByteDance—have entered the Southeast Asian market, driving industry development. This has led to the formation of a regional digital economic cooperation model, often referred to as the China-Southeast Asia Wild Goose Formation Model.

3. Demographic Advantage: The young and growing population in Southeast Asia presents strong potential for digital economy expansion. In 2021, the region's population surpassed 650 million, with individuals under the age of 30 accounting for more than 50% of the total population, highlighting significant demand for digital services.
4. Business Advantage: Southeast Asia has a high concentration of small and medium-sized enterprises (SMEs), which contribute significantly to GDP and employment. The development of the digital economy lowers barriers to information access and financing for SMEs, expanding market opportunities and stimulating further demand for digital services.
5. Technological Advantage: The artificial intelligence (AI) market in Southeast Asia is attracting increasing global investment. Between 2010 and 2021, AI companies from six Southeast Asian nations—Singapore, Malaysia, Indonesia, Thailand, Vietnam, and the Philippines—secured over 7.3 billion USD in funding across 658 transactions, with a record-high 2.4 billion USD in investments in 2021. Foreign investment accounted for more than 60% of AI-related transactions in the region.

To maximise these opportunities, deeper cooperation between China and Southeast Asia's digital economies should be prioritised.

1. Enhancing Trade Integration: Strengthening digital trade and cross-border e-commerce will allow China to efficiently match its supply capabilities with Southeast Asia's growing consumer market. This will enable better responsiveness to local demand while reinforcing The Belt and Road's role in global trade integration.
2. Leveraging Geographical Proximity: China and Southeast Asia share geographical and cultural similarities, which can facilitate industrial digital transformation. Southeast Asian countries can adopt China's digital transformation models, replicating successful business strategies from leading Chinese technology firms. Strengthening economic ties will enhance regional digital economic cooperation and long-term stability.
3. Focusing on AI Development: The rise of AI technologies, including generative AI applications such as ChatGPT, is reshaping global industries. Observing policy trends and market developments—especially in AI-driven economies such as Singapore—will be critical. While AI adoption is met

with both high expectations and regulatory concerns, its transformative impact is expected to expand economic potential in Southeast Asia.

By deepening digital economic collaboration, China and Southeast Asia can establish a more resilient and interconnected regional digital economy, driving sustainable development and long-term prosperity.

Consolidate the foundation of digital infrastructure connectivity along "the Belt and Road"

Since "the Belt and Road" initiative was put forward ten years ago, the connectivity of traditional infrastructure such as roads, railways, ports and airports has been constantly improved. We should further deepen the construction of digital infrastructure and continue to improve the production end costs of jointly building "the Belt and Road". According to literature research, the large difference in the development of digital infrastructure along "the Belt and Road" is one of the main reasons for the unbalanced development of the digital economy. Most countries along the line have a huge demand for telecommunications base stations, transmission networks, optical cables, submarine cables, iron towers, data centres and cloud computing.

Secondly, "the Belt and Road" digital economic cooperation should be based on achieving mutual benefit and win-win results. It should not only help the host countries along "the Belt and Road" to bridge the "digital divide", but also achieve high-quality and sustainable development. Therefore, it is necessary to focus on key locations and industries for digital infrastructure construction. Focus on the layout of data centres in Southeast Asia, the interconnection of optical cables between neighbouring countries such as China Myanmar and China Pakistan, the interconnection of power plants and transmission and distribution network infrastructure in Central Asia, and cross-border submarine cable investment from China to Southeast Asia, South Asia, West Asia, and the Middle East.

In addition, the scale of investment in digital infrastructure is large, and the payback period of investment is long, but the return on investment is stable. Traditional credit is difficult to support the financial needs of such assets for a long time. Therefore, comprehensive finance should be fully used to support the construction of digital infrastructure in countries and regions along "the Belt and Road".

Promote more enterprises in the digital economy sector to " go global"

In recent years, it has become increasingly challenging for China to invest in technology and digital economy-related fields in developed countries. The scrutiny of foreign investment in these nations has intensified, with stricter regulatory, compliance, and information disclosure requirements. As a result, Chinese enterprises—especially state-owned enterprises—face significant obstacles when seeking investment opportunities in the digital economy sector.

Given these constraints, greater support should be provided to enterprises in the digital economy sector to expand their presence along The Belt and Road. Based on the findings of this study, Southeast Asia, West Asia, and the Middle East have well-developed digital economies, making them high-potential locations for digital economic cooperation (Zhao, 2021). Additionally, Central Asia is experiencing rapid digital economy development, with significant growth potential and ample opportunities for bilateral and multilateral enterprise cooperation.

For Chinese digital economy enterprises to successfully "go global," they should adopt market-oriented and internationalised business models when operating in host countries. Expanding market share, introducing advanced Chinese technologies and digital products, and fostering collaborative technical standards with The Belt and Road countries will be essential steps in strengthening China's role in the global digital economy.

Improve the quality of external investment

Improving the quality of outward foreign direct investment is not only a crucial lever for accelerating China's transition from a major outward investor to a strong global investor but also a key driver in shaping a new development pattern of comprehensive openness. The 14th Five-Year Plan for Business Development emphasises the need to significantly enhance the level of outward investment, continuously improving both the quality and efficiency of investments as primary economic and social development objectives during the 14th Five-Year Plan period.

Furthermore, the report of the 20th National Congress of the Communist Party of China explicitly highlights the necessity to "improve the quality and level of trade and investment cooperation" and to "promote high-level opening up to the outside world."

Although China ranks among the top globally in outward foreign direct investment (FDI) volume, there remains a substantial gap in the quality and efficiency of its FDI compared to developed countries. This challenge is further compounded by the ongoing anti-globalisation trend, which has led to a rise in restrictive investment policies worldwide, a deteriorating global investment environment, and increasing downward pressure on global investment flows. Many countries, particularly developing nations, are grappling with significant challenges in outward investment cooperation.

While ensuring a stable and sustainable scale of foreign investment in this challenging environment, China is now prioritising the urgent need to enhance investment efficiency. This effort aligns with the overarching economic and social development goals outlined in the 14th Five-Year Plan and the pursuit of high-quality foreign investment development.

The rapid expansion of the global digital economy continues to spur the emergence of new industries and business models, driving the global value chain toward digitalisation and intelligence. Traditional international labour division and production models are being reshaped, prompting multinational enterprises to reassess their investment strategies, adjust capital structures, and optimise location patterns. Given that the digital economy has become a pivotal factor in attracting foreign investment, countries worldwide are placing increasing emphasis on digital infrastructure development, digital technology innovation, and digital governance policy coordination. These trends are expected to significantly influence international investment flows and patterns in the coming years (Xiao & Liang, n.d.).

The joint construction of "the Belt and Road" has gone through ten years of development and is moving steadily towards high-quality development. In the face of a digital economy era full of opportunities but more complex and challenging, it is necessary to have a deeper understanding and comprehension of the global digital economy landscape. The digital economy resets the existing global resource allocation mode. China should actively grasp the initiative of the new round of scientific and technological revolution and industrial reform, vigorously promote "the Belt and Road" digital economy cooperation, share the dividends of digital economy development with countries, and achieve mutual benefit and win-win results.

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XIII. Blockchain Technology Implementation for Traceability in the Food Supply Chain – Case Research

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Food supply chains are evolving into coordinated systems, prompting competition between companies and entire supply networks. In this context, Short Food Supply Chains (SFSCs) have emerged as a response to public concerns about food sourcing and handling. Defined by the EU as systems involving few economic actors committed to local development and close producer-consumer relations, SFSCs present both opportunities and challenges. Among key challenges are identity management, transparency, and security. Blockchain technology, introduced shortly after SFSCs gained attention, offers promising solutions by enhancing traceability and linking product information with physical flows. This chapter explores the role of blockchain in addressing traceability challenges and presents a practical case of its application in SFSCs.

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1 Introduction

The globalisation of markets is leading to an increasing need for food traceability. The ability to track and verify the movement of food products along the supply chain has become essential for ensuring food safety, quality, and transparency. Consumers benefit significantly from this development, as they can access food products from various parts of the world in their local markets (Behnke & Janssen, 2020). The demand for diverse food products, especially fresh produce, has altered traditional food consumption patterns. Nowadays, consumers buy food, particularly fruits and vegetables, regardless of the season, often resulting in increased reliance on imported foodstuffs. As Behnke and Janssen (2020) stated, food supply chains are becoming increasingly global and dependent on a growing number of actors, adding complexity to the distribution and logistical processes.

These shifts in consumer behaviour and global trade have led to an increasing need to exchange high-quality information between all actors along the supply chain. Transparency is paramount in modern supply chains, and businesses are expected to provide accurate data on the sourcing, processing, and distribution of food products. To meet these expectations, stakeholders must have full traceability of each product or ingredient in the final product (Behnke & Janssen, 2020). This capability enhances food safety, minimises the risk of contamination or fraud, and ensures compliance with regulatory requirements. Moreover, the ability to collect and analyse traceability data in real-time provides tangible benefits for all actors in the supply chain, allowing for efficient risk management, product recalls, and improved operational efficiencies. A robust traceability system is essential for providing comprehensive information about a food product's origin, processing, sale, and destination (Bertolini et al., 2006).

Traceability is a highly complex process that requires extensive data collection throughout the supply chain. Historically, this process relied on manual data recording, which was prone to errors, inefficiencies, and limitations in scalability. Manually recorded information was later transferred to computer systems or maintained in paper-based records, making data retrieval and verification cumbersome. This manual approach posed several risks, including inaccurate data entry, incomplete records, and inefficient resource allocation. The rapid advancement of automation, digitalisation, and communication technologies has revolutionised traceability systems in recent decades. The emergence of the Internet of Things (IoT) paradigm has played a crucial role in transforming traceability practices. The rapid growth of IoT, sensor technology, and real-time data analytics has enabled fast and efficient data collection through reliable methods such as product identification, transport and storage tracking, component analysis, and system integration (Demestichas et al., 2020). IoT-based solutions enhance real-time monitoring, enabling stakeholders to track food products at every stage of the supply chain, from production to final consumption.

Additionally, blockchain technology has emerged as a transformative solution for traceability, offering secure, immutable, and decentralised data storage. Blockchain enables all supply chain participants to access a transparent and tamper-proof ledger, reducing the risks of fraud and mislabeling. While blockchain technology presents new opportunities for improving food traceability, it also introduces challenges such as data integration, interoperability, scalability, and regulatory considerations (Demestichas et al., 2020). As digital solutions continue to evolve, the integration of IoT, artificial intelligence, and blockchain is expected to shape the future of traceability in the food industry.

The transformation of food supply chains has extended beyond traceability to include structural changes in agribusiness systems. In general, food supply chains and agribusiness systems are evolving into coordinated food networks, fostering competition between individual companies and entire supply chains and networks. These changes have prompted research into new business models for food markets. In the 1980s, a shift in global business practices encouraged agribusiness companies to prioritise strategic partnerships and collaborative supply chain models (Kähkönen, 2012). This transformation led companies to move beyond individual competition and instead operate as integrated entities within broader supply chain networks. As a result, competition within supply chains has intensified, and businesses increasingly view their ability to integrate into efficient networks as a key performance indicator. This shift has also led to the emergence of new collaborative arrangements among stakeholders, fostering resilience and efficiency in the food supply chain (Thomé et al., 2021).

One significant development in modern food supply chains is the rise of Short Food Supply Chains (SFSCs), which emerged in response to public concerns regarding the sourcing, transportation, and handling of food. The EU Rural Development Regulation (1305/2013) defines short supply chains as networks involving a limited number of economic operators committed to working together to enhance local economic development while simultaneously fostering close geographical and social relationships between food producers, processors, and consumers (Official Journal of the EU, 2013). SFSCs are characterised by direct interactions between producers and consumers, often reducing the need for intermediaries and logistical complexities.

In recent years, the prevalence of short supply chains and local markets has increased significantly across the European Union. This trend has facilitated the sale of locally produced agricultural products in community markets, where producers engage directly with consumers, bypassing conventional intermediaries. As a result, the number of intermediaries involved in SFSCs is minimal, allowing producers to capture a larger share of the economic value generated by their products (Vespia, 2021). In contrast, conventional long supply chains involve multiple intermediaries, often leading to a lack of transparency, price distortions, and reduced bargaining power for small farmers. In long chains, consumers also tend to have limited knowledge about the origin and production methods of their food. Notably, approximately 15% of farmers in the EU sell more than half of their production directly to consumers, reflecting a growing demand for local and traceable food sources. These trends are supported by research highlighting the benefits of SFSCs, including fairer pricing for farmers, consumer access to fresh and seasonal produce, reduced environmental impact, and enhanced social cohesion at the local level (Jarzebowski, 2020).

The environmental benefits of SFSCs are well-documented. Most locally sold products are produced sustainably, with lower reliance on pesticides, synthetic fertilisers, and extensive irrigation. Additionally, the reduced need for extensive packaging, refrigeration, and long-distance transportation decreases energy consumption and overall carbon emissions (European Parliament, 2016). By shortening the supply chain, food producers contribute to sustainability by minimising the environmental footprint associated with food distribution.

Beyond environmental considerations, SFSCs also yield significant social and economic advantages. Consumers increasingly prioritise ethical and sustainable food consumption, placing greater value on direct interactions with food producers. This shift has encouraged the growth of small-scale and organic farming, where producers emphasise quality, transparency, and sustainability. SFSCs foster stronger community ties, reinforcing trust between farmers and consumers. Moreover, research suggests that short supply chains contribute to domestic production growth, increased supply volumes, and greater affordability for consumers (Jarzebowski, 2020).

Despite their numerous advantages, SFSCs are not without challenges. The scalability of local food networks remains a concern, particularly in urbanised areas where demand may surpass local production capacity. Additionally, logistical complexities associated with distribution, storage, and regulatory compliance can pose barriers to widespread SFSC adoption. Nevertheless, policymakers and industry stakeholders recognise the potential of SFSCs to promote sustainability, resilience, and economic inclusivity in food supply chains.

As food supply chains continue to evolve, technological advancements, policy frameworks, and consumer awareness will shape the future of food traceability and distribution models. The integration of digital tools, including blockchain and IoT, offers promising solutions for enhancing transparency and efficiency. Meanwhile, SFSCs will likely continue gaining traction as consumers and producers seek viable alternatives to conventional supply chain models. These transformations underscore the growing importance of research and innovation in food traceability and sustainable supply chain management.

2 Traceability in supply chains

Traceability is defined as the ability to identify the past or current locations of items and ascertain their history (GS1, 2007). In the context of supply chains, traceability refers to the process of identifying and documenting the movement of a product or service from its point of origin through all stages of production, processing, distribution, and delivery to the final customer or user. This process also involves collecting and storing relevant information, including details such as time, location, processes, raw materials used, and the responsible actors in the supply chain.

The ability to trace items throughout a supply chain ensures transparency, product safety, and quality control while enabling a rapid response to potential issues. In cases of foodborne illness outbreaks, contamination, or product defects, a robust traceability system allows stakeholders to swiftly identify the source of the problem and remove affected products from the market (Behnke & Janssen, 2020). Moreover, governments and regulatory bodies worldwide impose stringent compliance requirements on supply chain participants, necessitating robust traceability frameworks to mitigate risks associated with counterfeit goods, fraud, and non-compliance.

2.1 Definitions and key concepts of traceability

A review of the literature reveals various definitions of traceability. Wilson and Clarke (1998) describe traceability as the information required to document a product's history, including its transformation processes from the point of origin to the consumer. In broader supply chain contexts, traceability extends beyond physical goods and encompasses services, data, and information flows, ensuring that all aspects of a product's journey are recorded and verifiable.

Two key terms are commonly associated with traceability within supply chains:

- Tracing: The ability to reconstruct a product's history, including the identification of inputs, production procedures, and processing details. Tamayo et al. (2009) define tracing as the capacity to track raw materials through the distribution chain using product serial numbers or batch identifiers. Manos and Manikas (2010) further elaborate that tracing enables stakeholders to verify product origins, assess production conditions, and ensure compliance with quality standards.
- Tracking: The real-time monitoring of a product's movement across the supply chain. Opara (2003) describes tracking as the capability to oversee past and future events, identify potential locations of products, and monitor key supply chain inputs. Tracking systems leverage barcode scanning, RFID (Radio Frequency Identification), GPS tracking, and blockchain technology to enable seamless product monitoring from manufacturing to final delivery.

Thakur and Donnelly (2011) further differentiate monitoring, which refers specifically to food and animal feed traceability across production, processing, and distribution stages. Monitoring ensures that perishable goods adhere to safety and quality requirements, reducing risks associated with contamination and spoilage.

2.2 The role of traceability in supply chain management

A supply chain is a complex and dynamic system involving the coordination of multiple elements, including products, services, information, financial transactions, and knowledge-sharing networks (Lewis, 2022). In the food supply chain, traceability encompasses various industries such as agriculture, horticulture, fisheries, and aquaculture, which contribute to the sourcing and production of food products. The supply chain consists of three main stages (Hayes, 2023):

1. Primary production – Encompasses the agricultural, horticultural, and aquaculture sectors, where raw food materials are cultivated or harvested.
2. Processing and distribution – Include food processing facilities, packaging, storage, and logistics operations to ensure the safe transportation of food products.
3. Retail and consumption – The final stage is where products reach consumers through supermarkets, restaurants, or direct sales channels.

Each stage in the food supply chain plays a critical role in maintaining food quality, safety, and compliance with regulations. Caro et al. (2018) outline the following key phases in food traceability:

- Production: The starting point where agricultural products are cultivated, livestock is raised, or fish is harvested.
- Quality assurance and regulation: Compliance with food safety standards, appearance specifications, and legal requirements.
- Processing: Convert raw materials into consumable food products, ensuring consistency, hygiene, and regulatory adherence.
- Packaging: Protection and presentation of food products, with labelling that conveys essential details such as origin, nutritional content, and expiration dates.

- Distribution and transportation: A critical step in which food products are shipped to retailers or wholesalers. Cold chain logistics play a crucial role in preserving perishable goods.
- Retail: The stage where food products become available to consumers in markets, supermarkets, or restaurants.
- Consumption: The final step is when consumers purchase and consume food, with traceability information ensuring they can verify product authenticity, quality, and safety.

2.3 The importance of traceability in ensuring food safety and quality

The significance of traceability in supply chains extends beyond compliance and transparency—it serves as a fundamental tool for risk management, fraud prevention, and consumer protection. Bertolini et al. (2006) define a traceability system as "the documented identification of operations leading from the production to the sale of a product." The main benefits of traceability include:

- Enhanced food safety: Enables rapid product recalls in case of contamination.
- Fraud prevention: Protects against counterfeiting and food mislabeling.
- Sustainability: Supports responsible sourcing and minimises environmental impacts.
- Consumer confidence: Ensures that consumers receive accurate, verifiable, and ethical information about their food.

2.4 Blockchain technology and traceability

Recent technological advancements have introduced blockchain technology as a powerful solution for enhancing traceability. Blockchain provides an immutable, decentralised ledger that records every transaction within the supply chain, ensuring data integrity, security, and transparency (Boson & Gebresenbet, 2013). The adoption of blockchain in food traceability presents several advantages:

- Real-time visibility: Stakeholders can access tamper-proof food production and distribution records.
- Decentralized verification: Prevents fraud by ensuring all transactions are recorded in an immutable ledger.

- Automation through smart contracts: Facilitates seamless tracking, reducing paperwork and manual errors.

2.5 Standardization in traceability systems

To achieve global consistency in traceability practices, international standards have been developed:

- ISO 22005:2007 – Traceability in the Feed and Food Chain
  - Establishes a structured framework for tracking food from production to consumption.
  - Ensures compliance with food safety regulations.
  - Encourages the use of barcodes, RFID, and other identification methods.
- GS1 – Global Barcode Standards
- Provides unique identification numbers (e.g., GTIN, EAN/UPC, DataMatrix).
- Enhances supply chain efficiency and accuracy.
- Widely adopted for processed foods, retail products, and logistics tracking.

These standards facilitate seamless data exchange among stakeholders, fostering trust, efficiency, and sustainability in modern supply chains.

2.6 Challenges and future directions in supply chain traceability

Despite its advantages, implementing traceability systems presents several challenges:

- High costs: Small producers may struggle with the financial burden of adopting advanced tracking technologies.
- Data integration: Many supply chains still rely on fragmented legacy systems, making seamless data exchange difficult.
- Regulatory inconsistencies: Varying laws across countries pose compliance challenges for global supply chains.
- Cybersecurity risks: Digital traceability systems are vulnerable to cyber threats and data breaches.

Future research and technological innovations—such as artificial intelligence, IoT sensors, and big data analytics—are expected to enhance traceability capabilities further. Governments and private entities are actively exploring strategies to standardise, regulate, and optimise traceability frameworks, ensuring global supply chains' continued safety, efficiency, and sustainability.

3 Traceability technologies in supply chains

3.1 Understanding the technological background of traceability: blockchain

To fully grasp the potential of blockchain technology in enabling traceability, it is essential to understand blockchain's technological background and evolution. Blockchain technology has gained increasing recognition as a revolutionary tool for ensuring data integrity, transparency, and security across various sectors. Originally developed as the underlying technology behind Bitcoin, blockchain has since evolved beyond cryptocurrency applications and is now widely utilised in supply chain management, finance, healthcare, and government operations (Knut et al., 2017).

The development of blockchain technology can be classified into three distinct generations, each expanding the scope and capabilities of the technology:

- First Generation (Bitcoin Era): The initial blockchain development phase focused on Bitcoin and its use as a decentralised digital currency. Bitcoin's primary function was to provide secure, peer-to-peer transactions without requiring an intermediary like a bank.
- Second Generation (Ethereum and Smart Contracts): Ethereum introduced the concept of smart contracts, allowing automated, self-executing agreements encoded on the blockchain. This advancement expanded blockchain’s application beyond financial transactions and enabled programmable, trustless execution of agreements (Knut et al., 2017).
- Third Generation (Beyond Traditional Blockchain): The latest phase in blockchain evolution incorporates various techniques and protocols, addressing issues such as scalability, interoperability, and energy efficiency. These

improvements allow blockchain to cater to diverse user needs, integrating emerging technologies like artificial intelligence (AI), the Internet of Things (IoT), and decentralised finance (DeFi).

Blockchain's flexibility and security have made it an invaluable tool in the banking, healthcare, agriculture, and logistics industries. In the context of supply chain management, blockchain facilitates seamless product tracking, digital authentication, and fraud prevention (Tayeb et al., 2018). Some of its notable applications include (Kamilaris et al., 2019):

- Verification of Intellectual Property (IP) and Patent Rights
- Managing Health Records and Medical Supply Chains
- E-Governance and Electronic Voting Systems
- Real Estate Transactions and Land Registries
- Authentication and Tracking of Agricultural and Consumer Goods.

Blockchain's impact extends beyond technological innovation, reshaping societal structures, economic models, and business paradigms (Ivanuša-Bezjak, 2018). By decentralising trust and removing intermediaries, blockchain fosters more transparent, efficient, and secure global trade ecosystems.

3.2 Blockchain as a distributed and immutable ledger

At its core, blockchain is a decentralised and immutable ledger that records transactions in a secure and transparent manner (Antonucci et al., 2019). Every transaction is stored chronologically in encrypted data blocks to form an unalterable chain. This public ledger is shared across multiple participants (nodes), ensuring data consistency and security.

Each new transaction added to the blockchain must be verified through a consensus mechanism, which requires the approval of the majority of network participants. Once recorded, the information cannot be altered or removed, ensuring tamper-proof data integrity.

The three key characteristics that make blockchain ideal for traceability include:

1. Reliability: Transactions are verified through cryptographic algorithms, eliminating errors and fraudulent activities.
2. Transparency: All supply chain participants can view real-time transactions, increasing accountability.
3. Immutability: Once data is recorded, it is permanently stored and cannot be manipulated (Gradišnik et al., 2022).

In food supply chains, blockchain does not replace internal information systems but rather enhances existing traceability mechanisms by providing a single source of truth. By integrating blockchain, food producers, distributors, and retailers can track each stage of a product's journey—from farm to fork.

3.3 Blockchain's role in supply chain traceability

Cryptographic signatures and decentralised data storage enable the traceability of products using blockchain. Each transaction in a supply chain—such as production, packaging, transportation, and retail—is recorded as a time-stamped event on the blockchain (Sunny et al., 2020). This process ensures full visibility and traceability of products, helping to:

- Prevent fraud by ensuring accurate documentation of product origin and handling.
- Enhance consumer trust by providing verifiable data on food sourcing and quality.
- Improve recall efficiency in case of contamination or safety concerns.
- Facilitate regulatory compliance by maintaining tamper-proof records.

Blockchain technology ensures that a transaction cannot be modified once it is recorded—only new information can be appended. This guarantees an audit trail for every product in the supply chain.

Blockchain also provides real-time visibility of transactions. Each stakeholder—including farmers, suppliers, manufacturers, logistics providers, and retailers—has equal access to the blockchain, ensuring complete transparency.

Decentralisation and security in supply chains

Unlike centralised databases, blockchain operates as a peer-to-peer network with no single point of failure. Each node in the network (e.g., routers, servers, or computers) stores a complete copy of the blockchain, making the system highly resilient (BUILTIN, 2022).

Smart contracts in blockchain-based supply chains

Smart contracts are self-executing agreements programmed into the blockchain. They automate transactions by defining specific conditions that must be met before execution. In supply chains, smart contracts (Curto & Gaspar, 2021):

– Reduce manual errors by automating data entry and compliance checks.
– Speed up transactions by eliminating paperwork and intermediaries.
– Enhance security through encryption, digital signatures, and audit trail.

Before deployment, smart contracts must be rigorously tested to ensure security, reliability, and full functionality (LinkedIn, 2023).

Integrating blockchain with other traceability technologies

Blockchain alone is not sufficient for comprehensive traceability. Its effectiveness is significantly enhanced when combined with other modern technologies.

Radiofrequency identification (RFID) tags

RFID is a wireless technology that enables real-time product tracking. Compared to QR codes and barcodes, RFID offers (Hoogenraad, 2018):

– Faster scanning without direct line-of-sight.

- Higher efficiency in inventory management.
- Seamless integration with blockchain for automated data logging.

Near-field communication (NFC) for secure data exchange

NFC is an extension of RFID technology, allowing two-way communication between objects. NFC technology supports real-time tracking, making it particularly useful for (Ledbetter, 2023):

- Contactless payments and product authentication.
- Tamper-proof verification of supply chain records.

QR codes and digital tracking

QR codes provide a cost-effective, user-friendly solution for tracking product origin and quality. Combined with blockchain, QR codes (Scantrust, 2023):

- Enhance transparency by allowing consumers to scan and verify product details.
- Support sustainability efforts by promoting ethical sourcing.
- Improve recall accuracy by linking each product to verified supply chain data.

3.5 Challenges and prospects of blockchain in traceability

Despite its advantages, blockchain adoption in supply chain traceability faces several challenges:

- Scalability issues: The increasing volume of data transactions may slow down processing times.
- Regulatory uncertainty: Different countries have varying legal frameworks for blockchain implementation.
- Integration complexity: Businesses must invest in interoperability solutions to connect blockchain with existing ERP systems.
- Cybersecurity risks: Although blockchain itself is secure, external vulnerabilities (e.g., hacking of private keys) must be addressed.

Future Trends are:

- Hybrid blockchain models combining public and private blockchains for scalability.
- AI-driven automation to improve supply chain analytics.
- Wider adoption in sustainable agriculture, pharmaceuticals, and logistics.

Blockchain technology is transforming traceability systems by ensuring secure, transparent, and tamper-proof tracking of products across supply chains. When combined with RFID, NFC, and QR codes, blockchain enhances efficiency, consumer trust, and regulatory compliance. Although challenges remain, the future of blockchain in traceability is promising, with advancements in AI, IoT, and decentralised applications driving further innovation.

4 Traceability in food supply chains

4.1 Introduction to short supply chains

Short supply chains encompass various models designed to streamline food distribution while promoting local production, sustainability, and direct relationships between producers and consumers. The core objective of short food supply chains (SFSCs) is to reduce the number of intermediaries, thus ensuring greater transparency, fairer pricing for producers, and improved product traceability (EUFIC, 2021). Common models of short supply chains include (EUFIC, 2021):

- Direct sales between farmer and consumer: This model includes farm sales, market sales, and home delivery, enabling producers to sell directly to consumers without middlemen.
- Community-Supported Agriculture (CSA): Consumers pre-order and pre-pay for farm produce, securing seasonal, locally grown food while supporting farmers' financial stability.
- Collective sales to institutions: This model focuses on supplying food to schools, hospitals, and public institutions, emphasising local sourcing and sustainability.
- Distance selling: Farmers and producers use digital platforms to sell products directly to consumers, facilitating wider accessibility of local produce.

The establishment of joint sales networks and short supply chains offers an optimal approach to increasing efficiency, improving distribution channels, and ensuring consistent product quality. Stakeholders can leverage collective resources to expand sales networks and enhance supply chain effectiveness by cooperating within existing producer groups. Agricultural cooperatives and regional producer organisations serve as a foundation for developing sustainable short-supply chains that strengthen relationships between farmers, retailers, and public institutions (CZR Murska Sobota, 2018).

4.2 The role of blockchain in food supply chains

Blockchain technology is rapidly gaining prominence in areas beyond cryptocurrencies, particularly in agriculture and food supply chains. The globalisation of food markets has led to increasingly complex supply chains, requiring enhanced transparency, safety, and traceability. In addition, shifting demographics and evolving consumer preferences—such as increased demand for organic, fresh, and minimally processed foods—necessitate more sophisticated traceability solutions.

Consumers today, especially in Europe and North America, are willing to pay a premium for high-quality food products that provide detailed information about their origin, production methods, and safety certifications. This has prompted food industry stakeholders to explore new, innovative traceability technologies, with blockchain emerging as one of the most promising solutions (Tribis et al., 2018).

Blockchain technology was integrated into short supply chains soon after its emergence, offering significant benefits in tracking, data security, and transaction verification. Studies indicate that 40% of companies implementing blockchain technology operate in the agriculture and food production sectors (Vadgama et al., 2021).

4.3 Challenges in traditional short supply chains

Short food supply chains, while beneficial, face significant challenges in identity management, data integrity, and operational efficiency. Many transactions within these supply chains remain manual, involving multiple independent stakeholders who maintain separate databases. This fragmented approach creates bottlenecks, errors, and a lack of transparency, leading to issues such as (Pavlović, 2017):

- Data inconsistencies due to manual record-keeping.
- Limited trust among stakeholders due to a lack of verifiable data.
- Inefficient information sharing, leading to delays and potential fraud.
- Slow transaction processing, increasing operational costs.

Blockchain as a standardised solution for short-supply chains

Replacing fragmented and outdated systems with a standardised blockchain-based solution can significantly enhance the efficiency and reliability of short supply chains. Blockchain technology offers key advantages, including (Lovrec, 2019):

- Management of digital identities for all supply chain participants.
- Real-time tracking of transactions among all stakeholders.
- Verification of product origin, material flows, and financial transactions.
- Creation of an immutable, tamper-proof ledger with verifiable transaction records.
- Reduction in transaction time and overall operational inefficiencies.
- Increased trust among stakeholders by ensuring data integrity and transparency.

Consumer engagement through digital traceability

The digital transformation of short supply chains enables greater consumer involvement. Consumers can now directly interact with farmers and food producers, gaining valuable insights into where and how their food is produced. This fosters increased trust, brand loyalty, and a preference for locally sourced food (Collison et al., 2019).

Blockchain technology plays a pivotal role in enhancing efficiency, transparency, and security in short-food supply chains by:

- Providing real-time verification of product origin and production conditions.

- Ensuring food safety compliance through immutable records.
- Reducing fraud and mislabeling by preventing tampering with product information.
- Enabling rapid product recalls in case of contamination.

4.4 The structure of food supply chains and blockchain integration

The food supply chain consists of three primary layers, each of which plays a critical role in ensuring traceability and data accuracy (Ehsan et al., 2022):

1. Physical Flow (Top Layer)

- Represents the actual movement of food through the supply chain.
- Includes harvesting, processing, packaging, distribution, and retail.

2. Digital Stream (Middle Layer) encompasses digital tracking technologies, such as:

- QR codes for product authentication.
- RFID (Radio Frequency Identification) for inventory tracking.
- NFC (Near Field Communication) for secure product verification.
- Online certification and digital signatures to verify food safety compliance.
- IoT sensors and mobile apps for real-time monitoring of food conditions.

3. Internet and Web Infrastructure (Bottom Layer)

- Serves as the backbone for data sharing and blockchain connectivity.
- Enables cloud-based traceability platforms that store encrypted records accessible to all stakeholders.

Blockchain's Role in Each Layer (Kamilaris et al., 2019):

- Physical Flow: Each product's origin, production conditions, and handling are logged in the blockchain.

- Digital Stream: Technologies such as RFID, QR codes, and NFC tags feed real-time data into the blockchain.
- Internet & Web: Decentralized storage and verification mechanisms ensure permanent, immutable records.

4.5 Future of blockchain in short supply chains

Blockchain integration in short-food supply chains is still evolving, with continuous improvements in efficiency, scalability, and user adoption. Future trends include:

- Artificial Intelligence (AI) and Blockchain Integration
- AI-powered analytics for predicting supply chain disruptions.
- Automated fraud detection and quality assurance systems.
- IoT Sensors for Smart Agriculture
- IoT-enabled devices that monitor soil conditions, temperature, and humidity.
- Real-time updates on harvest schedules and production efficiency.
- Decentralized Finance (DeFi) for Small Farmers
- Blockchain-based microfinance and credit systems for small-scale farmers.
- Improved access to transparent financial transactions.
- Regulatory Standardization and Cross-Border Adoption
- Development of global blockchain standards for interoperability between countries.
- Regulatory compliance frameworks ensuring safe and ethical food production.

Blockchain technology is revolutionising short supply chains by enabling secure, transparent, and verifiable tracking of food products. Blockchain improves efficiency, trust, and compliance across all supply chain stakeholders by integrating digital identity management, smart contracts, and real-time tracking technologies.

While challenges remain, ongoing technological advancements and regulatory developments will further drive the adoption of blockchain in food supply chains, ensuring safer, more sustainable, and consumer-friendly food systems.

5 Implementing a traceability system in a short supply chain – case research

5.1 Introduction to Green Point

Green Point is the largest and most advanced regional short supply chain for food supply in northeastern Slovenia. Established in 2013 by local farmers, Green Point has grown into an extensive network comprising over 100 farmers, food producers, and cooperatives engaged in field, greenhouse, and processed food production. Green Point operates a dedicated logistics centre equipped with storage and refrigeration capacities capable of handling over 80 tons of fresh produce to facilitate efficient logistics.

Green Point is committed to connecting local farmers with end consumers as a distribution hub for short supply chains by promoting high-quality, locally produced, and sustainably sourced food products. The organisation's mission is twofold:

- Ensure consumer safety and satisfaction by providing fresh, traceable food.
- Promote sustainable farming practices and support local economies and communities.

The short supply chain model employed by Green Point significantly reduces the number of intermediaries, thereby ensuring:

- Fairer pricing and improved profitability for farmers.
- Enhanced traceability and food safety for consumers.
- Greater sustainability and reduced environmental impact due to shorter transportation distances.

Through its logistics and distribution network, Green Point supplies fresh fruits, vegetables, and local products to a wide range of public institutions (e.g., schools, kindergartens, elderly care homes) and private institutions (e.g., restaurants, wellness centres, hotels). Additionally, Green Point operates a retail store and an online marketplace, further increasing accessibility to locally sourced, traceable food.

The short supply chain of Green Point consists of several interconnected phases, ensuring the efficient movement of food products from farmers to consumers. Figure 1 includes the main stages (Balaic, 2024):

1. Production: Farmers cultivate crops using sustainable agricultural practices.
2. Harvesting and Collection: Fresh produce is harvested, sorted, and transported to the Green Point distribution centre.
3. Storage and Processing: The produce is stored in cold storage or processed into secondary food products.
4. Logistics and Distribution: The products are prepared for delivery and transported to various public and private institutions, as well as Green Point's retail outlets.
5. Retail and Consumer Access: Products are made available in Green Point stores and online platforms, where consumers can verify their origin and quality.

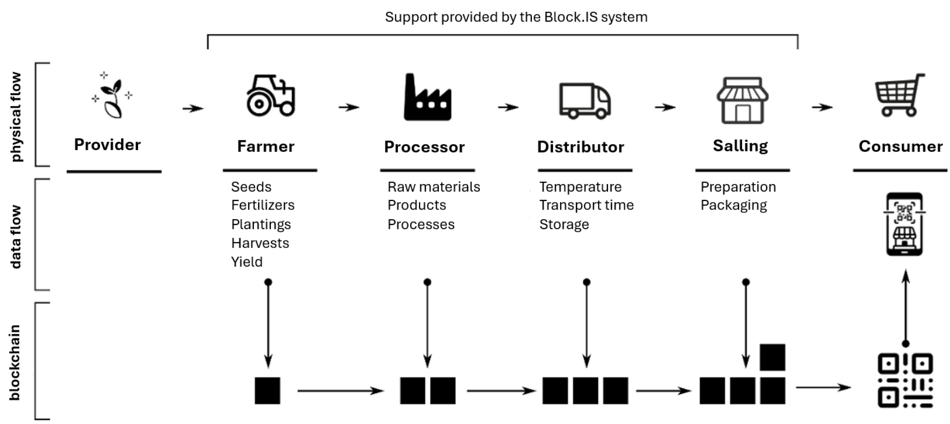

Figure 1: Schematic of the phases and flow of collected data in the short supply chain of the Green Point
Source: (Balaic, 2024)

5.2 The structure and operations of Green Point

The operations of Green Point revolve around several key activities that ensure efficient food production, distribution, and sales while maintaining high traceability standards. The first step in the supply chain is cultivation, where farmers grow more than 20 varieties of vegetables. The outdoor production cycle typically runs from April to October, while greenhouse cultivation extends from February to November, allowing for year-round supply. Most of the vegetables grown by Green Point's farmers are certified under the national quality scheme "integrated production," which emphasises environmentally friendly and sustainable farming methods.

Once the crops are harvested, farmers immediately sort and package the produce before sending it to the Green Point distribution centre. Unlike conventional supply chains, where farmers store large quantities of produce in separate facilities, Green Point centralises storage in its logistics hub. This allows for better quality control and more efficient organisation of inventory. After arriving at the distribution centre, the produce is temporarily stored in cold storage before being prepared for delivery. The logistics team ensures that food products are efficiently transported to customers across the Pomurska region and stocked on the shelves of the Green Point store.

Green Point's retail store plays a crucial role in connecting consumers directly with local food producers. The store is more than just a marketplace—it also serves as an educational hub where consumers can learn about food traceability, sustainable agriculture, and the origins of their food. Green Point enhances trust in locally produced food by promoting consumer awareness and encourages informed purchasing decisions. Additionally, consumers can verify the origin of products using their mobile phones, further reinforcing transparency in the supply chain.

Beyond its commercial activities, Green Point functions as a Living Lab, fostering collaboration among primary producers, food companies, technology providers, consumers, local authorities, and other stakeholders. This multi-partnership approach encourages innovation and the adoption of new technologies that support sustainability, improve efficiency, and strengthen the resilience of local food systems.

5.3 The Role of Blockchain in Green Point's Traceability System

Blockchain technology plays a pivotal role in Green Point's traceability system, ensuring the accurate tracking of food products throughout their lifecycle. In the broader context of food production, reliable traceability is essential for maintaining food safety, quality assurance, and regulatory compliance. Errors, missing information, or inaccessible records can lead to supply chain disruptions, product recalls, and a loss of consumer trust. To address these challenges, digital technologies must be designed to capture and monitor data in real time, providing a verifiable and immutable record of each transaction.

Green Point has adopted blockchain technology to create a unified tracking system for its short supply chain. Blockchain's decentralised nature ensures that all recorded transactions are secure, tamper-proof, and transparent. Unlike conventional databases, where data can be altered or lost, blockchain creates a permanent digital ledger in which transactions are time-stamped and cryptographically signed. Each transaction, whether it involves harvesting, processing, or distribution, is linked to the previous one, forming a continuous chain of verified records. This immutable record-keeping system guarantees that all supply chain participants can access reliable information about food products at any stage of the process.

The use of blockchain in Green Point's traceability system has provided several key benefits. It enables real-time tracking of transactions and material flows, reducing inefficiencies and improving supply chain coordination. Stakeholders can verify the authenticity and movement of food products, which helps prevent fraud and mislabeling. Additionally, blockchain enhances consumer trust by allowing individuals to access product information through QR codes, ensuring greater transparency regarding food origins, quality certifications, and sustainable practices.

5.4 Stakeholders and their roles in the traceability model

Green Point's traceability system relies on a well-defined network of stakeholders, each playing a crucial role in ensuring the safe and efficient passage of food through the supply chain. The key participants include producers, processors, transporters, retailers, and consumers.

The traceability model of Green Point's short supply chain relies on blockchain technology to enhance transparency and security. Each stakeholder in the supply chain has a unique digital identity recorded on the blockchain. The roles of key stakeholders are as follows (Figure 2):

– Producers (Farmers): Responsible for cultivating and harvesting fresh produce.
– Processors: Convert raw agricultural products into processed goods such as juices, pasta, and oils.
– Transporters: Ensure the timely and safe delivery of food products to distribution centres and retailers.
– Retailers: Provide a direct link between the supply chain and consumers, ensuring that products are traceable and meet quality standards.
– Consumers: Can verify product authenticity using QR codes or mobile applications, ensuring transparency and trust.

Figure 2: Illustration of the solution design of the blockchain-based traceability model in the short supply chain Green Dot
Source: (Balaic, 2024)

Blockchain technology records every transaction in real-time, enabling all participants to track the movement of food products through the supply chain. This system reduces fraud, prevents mislabeling, and increases trust between producers and consumers.

Unlike traditional supply chains, Green Point has omitted the role of providers who supply raw materials, such as seeds and fertilisers. The organisation has created a more streamlined supply chain with fewer intermediaries, ensuring that food moves more efficiently from farms to consumers.

Technical implementation of blockchain in Green Point's traceability system

Green Point has implemented a private blockchain network based on the Hyperledger Besu framework to avoid high transaction costs associated with public blockchain networks. This enterprise-friendly blockchain solution ensures that only verified participants have permission to access and record transactions, improving security and scalability.

The blockchain node network used in Green Point's traceability system ensures data security, transparency, and decentralisation. Each node in the network plays a specific role in verifying, storing, and distributing traceability information.

The node network structure includes three main components (Figure 3):

1. Proxies: Manage data exchange between different nodes and enable communication across the blockchain network.
2. Validators: Verify transaction validity and maintain the integrity of recorded data.
3. Peers: Provide read access to blockchain records, ensuring that all stakeholders can access real-time product traceability data.

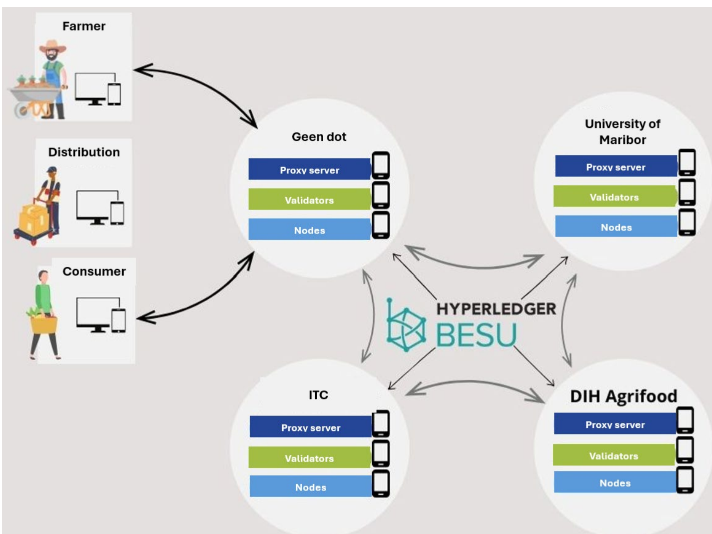

Figure 3: Node network
Source: (Balaic, 2024)

The implementation of a private blockchain network (Hyperledger Besu) allows Green Point to avoid high transaction costs associated with public blockchains. Additionally, the InterPlanetary File System (IPFS) is used for decentralised data storage, ensuring that large files such as images, digital signatures, and certifications are securely stored. At the same time, only references are recorded on the blockchain.

Green Point has integrated the InterPlanetary File System (IPFS), a decentralised file storage network, to optimise data storage and retrieval. Large files, such as images, certifications, and transaction records, are stored off-chain on IPFS, while blockchain stores digital proofs and metadata that point to the original documents. This hybrid approach ensures efficient use of blockchain storage while maintaining data integrity and accessibility.

Green Point's traceability solution is accessible through a mobile application, allowing stakeholders to record relevant data at each stage of the food chain. Farmers, processors, and retailers input production, processing, and logistics information, creating a comprehensive digital record of every product's journey. Consumers can then access this information by scanning QR codes on product packaging, providing full transparency and reinforcing trust in local food production.

Green Point's implementation of blockchain-based traceability represents a significant step toward ensuring transparency, efficiency, and trust in short food supply chains. Green Point has enhanced traceability, food safety, and consumer confidence by leveraging decentralised digital records, real-time tracking, and cryptographic security. The integration of blockchain technology not only optimises supply chain operations but also supports sustainable agriculture and local economic development.

Looking ahead, further advancements in artificial intelligence, IoT, and smart contracts could further enhance blockchain's role in traceability and supply chain optimisation. As Green Point continues to innovate, its model serves as a blueprint for other short supply chains seeking to implement reliable, transparent, and scalable traceability solutions.

6 Conclusion

In recent years, consumer concerns regarding food's origin, safety, and quality have grown significantly. This heightened awareness has increased consumers' willingness to pay a premium for food products that provide proven traceability and transparent information about their origin. Despite advancements in traceability technologies, most existing systems remain centralised and outdated, particularly in terms of data exchange, interoperability, and security. These shortcomings highlight the urgent need for modern digital traceability solutions that leverage information and communication technology (ICT), radio frequency identification (RFID), the Internet of Things (IoT), and blockchain to enhance transparency and trust in food supply chains (Demestichas et al., 2020).

Among the various technological solutions available, distributed ledger technology (DLT), such as blockchain, offers significant potential to address many of the existing challenges in food traceability. By ensuring immutability, decentralisation, and transparency, blockchain enhances trust between stakeholders, prevents fraud, and enables real-time monitoring of food products throughout the supply chain. However, implementing blockchain-based traceability systems presents new challenges for organisations, including technical complexity, cost of adoption, and integration with existing supply chain management systems. Overcoming these challenges requires strategic planning, technical expertise, and collaboration among industry stakeholders.

The growing popularity of short supply chains and local food markets across the European Union reflects a broader shift toward sustainable, transparent, and ethically sourced food production. Unlike conventional long supply chains, where farmers have limited bargaining power, and consumers lack insight into food origins, short supply chains enable direct transactions between producers and consumers, often involving only one intermediary or none (Vespia, 2021). Research has shown that approximately 15% of farmers in the EU sell more than half of their produce directly to consumers, reflecting an increasing demand for alternative, locally sourced food options (Jarzebowski, 2020). The advantages of short supply chains include fairer prices for farmers, improved consumer access to fresh and seasonal produce, a reduced environmental footprint, and stronger social cohesion at the local level.

From an environmental perspective, short supply chains contribute to more sustainable food production by reducing the need for extensive transportation, packaging, and energy consumption. Locally sourced food is typically grown using fewer pesticides, synthetic fertilisers, and water resources, further minimising its ecological impact (European Parliament, 2016). The emphasis on direct transactions between producers and consumers also fosters stronger community ties and trust, reinforcing the importance of ethical and sustainable food systems (EIP-AGRI, 2019).

Despite the potential of blockchain and other digital traceability technologies, their widespread adoption remains hindered by several challenges. Many stakeholders in the food supply chain lack the technical expertise to implement and maintain blockchain-based traceability systems effectively. Additionally, disagreements on standardisation, interoperability, and governance structures have further slowed adoption. For blockchain technology to reach its full potential in food traceability, organisations must develop user-friendly solutions that simplify system integration and enhance accessibility for all stakeholders, from small-scale farmers to large retailers.

The implementation of blockchain-based traceability at Green Point serves as an example of both the opportunities and challenges associated with adopting new technologies in short-supply chains. While blockchain technology provided an effective solution for ensuring food traceability, improving supply chain efficiency, and enhancing consumer trust, the transition required significant effort in training employees and adapting business processes. Employees initially faced difficulties in embracing the new system, as they had to move away from traditional record-keeping methods and adapt to digital solutions. The digitisation process was not immediate, requiring all stakeholders to fully integrate and fully accept the new blockchain-enabled business model.

The successful implementation of blockchain-based traceability in short food supply chains depends on several factors. First, continued investment in digital literacy and employee training is essential to ensure the adoption and utilisation of new technologies effectively. Second, collaborations between food producers, technology providers, and regulatory bodies are necessary to establish standardised traceability frameworks that promote interoperability and compliance with food safety regulations. Lastly, integrating emerging technologies such as AI-powered analytics, IoT-enabled monitoring, and decentralised finance (DeFi) could further optimise supply chain transparency, efficiency, and resilience.

In conclusion, the future of traceability in short-supply chains lies in leveraging advanced digital technologies to create efficient, transparent, and sustainable food ecosystems. Blockchain and other DLT-based traceability solutions hold immense potential in ensuring food safety, fraud prevention, and enhanced consumer trust. However, the road to full adoption requires strategic implementation, overcoming technical barriers, and fostering industry-wide collaboration. As more organisations recognise the value of digital traceability, short-supply chains will continue to evolve, offering greater efficiency, sustainability, and consumer confidence in food production.

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XIV. Customer Perception of Technologies for New-Generation Web Shops – Preliminary Study

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This paper investigates emerging technological trends in web commerce and examines user perceptions through a pilot survey. Key innovations include IoT, AI, ML, chatbots, social and voice commerce, as well as immersive technologies like AR and VR. These tools enhance personalization, automate services, and support better consumer decision-making. The pilot study, based on an online questionnaire, explores user behaviour, expectations, and attitudes toward these developments. Results show that while users are familiar with technologies like chatbots and personalization, awareness of AR and VR remains low. Concerns about security and data privacy significantly influence user trust. The findings highlight the need for seamless technological integration, increased user education, and transparent communication to build trust and improve the digital shopping experience.

Keywords:
web commerce,
e-commerce trends,
internet of things (IoT),
artificial intelligence (AI),
machine learning (ML),
chatbots,
augmented reality (AR),
virtual reality (VR),
voice commerce,
user perception,
digital transformation,
data privacy

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1 Introduction

The advent of the internet has enabled the rise of e-commerce, introducing transformative changes to global goods circulation. Online commerce has broken down time and space constraints, reshaped commercial patterns, and accelerated the flow of goods, capital, and information. These developments have led to increased productivity, enhanced economic efficiency, and lower transaction costs. Moreover, e-commerce has influenced consumer lifestyles and social behaviour, contributing to a shift in how people perceive and interact with the world. Current and emerging trends in online commerce continue to drive innovation and improvement. By leveraging technologies to collect and analyse customer data, e-commerce platforms can now tailor marketing strategies and customize product offerings more effectively.

In recent years, e-commerce has become an integral component of global retail. Like in many other industries, the Internet has fundamentally reshaped the buying and selling of goods. As digitalization continues to penetrate all areas of modern life, consumers across the globe benefit from the convenience and accessibility of online transactions. With the rapid expansion of internet access and usage worldwide, the volume of online purchases continues to rise (Pasquali, 2023). Today, a consumer's first point of contact with a company often occurs online. In Slovenia, for instance, 1,562,370 individuals aged 16 to 74 used the Internet in 2022, representing 74% of the total population (Statistical Office of the Republic of Slovenia, 2023). In the global e-commerce revenue rankings, Slovenia holds the 90th position, with projected earnings of USD 927.9 million for 2023 (ECDB, 2023).

As consumers are presented with an ever-increasing variety of choices, making purchasing decisions has become more complex. Consequently, the influence of emerging information technology trends and developments in online commerce has become more pronounced. These digital trends make it easier and faster to guide consumers toward purchase decisions, thereby reshaping the dynamics of digital consumer behaviour.

2 Web commerce

Electronic commerce (e-commerce), a product of the internet, is one of the most transformative technological and societal advancements of the modern era. It has revolutionized global trade by eliminating the traditional barriers of time and space, reshaping commercial patterns, and significantly improving the flow of goods, capital, and information. E-commerce enables businesses to gain competitive advantages by streamlining operations and reducing production and transaction costs. In essence, it empowers traditional businesses to operate faster, more efficiently, and more cost-effectively (Zheng, 2010).

The influence of online commerce extends far beyond retail. It influences key aspects of society, including employment, industrial production, legal frameworks, education, and public administration. Moreover, it permeates virtually all sectors, including manufacturing, logistics, finance, media, government services, research institutions, and even traditional agriculture (Zheng, 2010).

At its core, e-commerce can be succinctly defined as: "the buying and selling of goods or services over the Internet." These transactions occur electronically, without physical interaction between the buyer and the seller.

The increasing demand for convenience, speed, and privacy is among the primary factors driving consumers toward e-commerce. Technological advancements, particularly in information and communication technologies (ICT), have further reinforced this trend. Additionally, globalization has intensified market competition and heightened consumer expectations, accelerating innovation and adoption in e-commerce. A key driver of this transformation is the widespread availability of mobile internet access through smartphones and tablets. These devices enable consumers to compare prices, read product reviews, and access information instantaneously. Increasingly, shoppers visit physical stores merely to inspect products in person, only to finalize their purchases online where better deals are often available (Santos et al., 2017).

E-commerce platforms serve as the technological backbone of online stores. They facilitate essential functions such as catalogue management, order processing, payment integration, customer support, and logistics coordination. Platforms such as Magento, WooCommerce, Shopify, PrestaShop, and BigCommerce provide comprehensive toolsets that support the efficient management of digital retail environments and enable scalability.

Marketing tools are crucial to the success of e-commerce ventures. As multi-channel strategies become more prevalent, digital marketing in e-commerce has evolved into a complex, data-driven discipline. To maintain competitiveness, businesses must manage diverse sales and communication channels—including social media, email, search engines, and influencer networks—with precision and consistency. Modern marketing tools facilitate automation, real-time analytics, personalization, and targeted advertising, ultimately enhancing campaign effectiveness, customer engagement, and conversion rates.

Looking ahead, e-commerce is set to undergo significant transformation. Its future will be increasingly digital, consumer-centric, and sustainability-oriented. Artificial intelligence (AI) is expected to play a critical role, particularly in areas such as personalization, product recommendations, inventory management, and customer service. By analysing large volumes of user data through machine learning, businesses can deliver tailored experiences that enhance customer satisfaction while improving operational efficiency. This not only increases revenue potential but also optimises resource utilization.

E-commerce businesses that recognize and proactively adapt to these emerging trends will be better positioned for success in an increasingly competitive digital marketplace. The following section will explore key trends shaping the future of online commerce.

3 New developments in web commerce

3.1 Internet of Things (IoT)

The Internet of Things (IoT) refers to billions of physical devices around the world that are connected to the internet, collecting and sharing data (Ranger, 2020). In recent years, IoT has become one of the most transformative technologies of the 21st century. Everyday objects—such as kitchen appliances, cars, thermostats, and baby monitors–can now be embedded with smart technology, enabling seamless communication between people, systems, and things.

By leveraging low-cost computing, cloud infrastructure, big data, analytics, and mobile technologies, physical devices can collect and transmit data with minimal human intervention. The widespread availability of affordable microchips and wireless networks has facilitated the transformation of virtually any object—from small tablets to large aircraft–into a component of the IoT ecosystem. By equipping these objects with sensors and connectivity features they gain a degree of digital intelligence, allowing them to communicate real-time data autonomously. In doing so, IoT bridges the physical and digital worlds, making them more intelligent, efficient, and responsive (Ranger, 2020).

The increasing integration of IoT in e-commerce has significantly altered how both consumers and retailers interact and conduct transactions. Online stores can now send personalized promotions and recommendations based on a customer's location, preferences, or purchasing history–enabled by data collected from smart devices such as smartphones, fitness bands, and smartwatches. Additionally, smart home devices (e.g., thermostats, smart refrigerators, lighting systems, and speakers) contribute to the e-commerce ecosystem by enabling automated replenishment of household goods.

From a business perspective, IoT enhances operations by improving supply chain visibility and enabling real-time order tracking via smart devices. This integration of IoT not only optimizes but also elevates the overall user experience and operational efficiency, changing the way e-commerce functions.

According to Koteshov (2024), the most prominent applications of IoT in online commerce include:

- Eliminating logistical bottlenecks
- Enhancing user experience
- Inventory management
- Troubleshooting and failure detection
- Improving security
- Performance analytics

Eliminating logistical bottlenecks. IoT plays a crucial role in addressing inefficiencies throughout the supply chain. Businesses can monitor, automate, and optimize logistics through connected sensors and tracking devices. Technologies such as autonomous delivery vehicles, automated warehouses, and smart packaging solutions are driven by IoT. Real-time tracking and predictive analytics enable companies to forecast demand more accurately, streamline inventory levels, and minimize costs associated with overstocking or understocking.

Enhancing user experience (UX). IoT facilitates the personalization of the customer journey by collecting behavioural data from connected devices. These insights allow businesses to deliver tailored recommendations, dynamic content, and targeted advertising while refining their service offerings. For example, if IoT sensors detect a product malfunction, the system can automatically notify the customer and initiate a service request, thereby enhancing user satisfaction and retention.

Inventory management. Through IoT-enabled sensors and Radio Frequency Identification (RFID) technology, retailers can monitor inventory in real-time. Inventory databases are automatically updated when items are shipped, received, or sold. This automation supports efficient restocking and ensures better synchronization between e-commerce platforms and supply chain networks. Additionally, direct integration with suppliers enables a more responsive and transparent supply chain, ultimately improving delivery accuracy and fulfilment speed.

Troubleshooting and Problem Detection. IoT facilitates the proactive identification and resolution of common e-commerce, including lost shipments, cart abandonment, high return rates, and low customer engagement. By analysing behavioural patterns and device-generated data, businesses can address potential issues before they escalate, improving customer satisfaction and operational performance.

Improved Security. IoT contributes to enhanced e-commerce security for both retailers and consumers. Smart surveillance systems, motion sensors and access control mechanisms can detect unauthorized activity, security breaches or theft in warehouses and fulfilment centres, allowing businesses to take immediate action.

Performance Analytics. Monitoring key metrics such as goods movement, delivery times, customer location data, and usage patterns provides businesses with valuable performance insights. IoT-generated data helps determine whether key performance indicators (KPIs) are being met and identify areas for improvement or strategic intervention.

In summary, IoT is not only reshaping the technological infrastructure of online commerce but also offering new levels of intelligence, automation, and personalization that benefit businesses and consumers alike.

3.2 Artificial intelligence and machine learning

Artificial Intelligence (AI) has attracted significant attention for decades, yet it remains one of the most transformative emerging technologies. Its full impact on how we live, work, and interact is only beginning to unfold. AI is already recognized for its remarkable capabilities in image and speech recognition, and it is widely used in navigation systems, virtual assistants on smartphones, ride-sharing services, and many other applications (Duggal, 2023).

Recently, AI and its subfield, Machine Learning (ML), have become central to innovation in information technology. Many leading companies implement AI and ML solutions to enhance user experience, streamline operations, reduce production issues, and increase revenue (Sakovich, 2023).

In e-commerce, machine learning plays a key role in utilizing self-learning algorithms to forecast sales trends, optimize marketing strategies, manage inventory and delivery, personalize the shopping experience, and mitigate retail risks (Vekony, 2023).

According to Davidov (2022), ML significantly impacts e-commerce through the following areas:

– Product Recommendations. Machine learning powers advanced recommendation engines by analysing past customer behaviour and interactions on the website. It suggests relevant products likely to interest each user, increasing conversion rates and average cart values. For instance, eBay displays laptops to users who previously browsed similar items.

- Personalization. E-commerce platforms can use ML to tailor the entire shopping experience. This includes customising product displays, special offers, messages, and recommendations based on individual customer interests and purchasing history. (Further explored in Section 3.5.)
- Customer Behaviour Monitoring and Analytics. ML enables tracking and analysis of customer behaviour on e-commerce sites. By understanding browsing patterns, navigation flows, and abandonment points, businesses can make data-driven improvements to the user experience.
- Inventory Management. Machine learning is used to forecast product demand, enabling better inventory planning. Retailers can determine how many products to order or produce to meet customer needs while avoiding overstocking or stockouts.
- Fraud Detection. ML algorithms analyze transaction data and detect unusual or suspicious activities, helping to prevent fraudulent behaviour such as identity theft or credit card misuse.
- Advanced Identity Verification. AI technologies can support robust user authentication through biometric data, facial recognition, voice recognition, and other tools, ensuring that legitimate users carry out transactions.
- Dynamic Pricing. Machine learning enables e-commerce businesses to adjust prices dynamically based on demand, competition, seasonality, and other variables. This approach allows real-time pricing strategies that attract more customers and boost profitability while maintaining competitiveness.
- Content and Ad Customization. AI can analyse user behaviour across websites, social media, and other platforms to tailor content and advertisements more effectively to specific audience segments.
- Product Distribution Optimization. ML supports logistics and distribution optimisation by analysing delivery history to recommend the most effective shipping methods (e.g., free shipping or same-day delivery). It can also improve route planning by factoring in real-time traffic, weather conditions, and driver capacity.
- Demand Forecasting. AI and ML can develop predictive models to estimate future demand for specific products or categories by analysing historical sales

data and external influences. These insights help in planning inventory levels, marketing campaigns, and operational decisions.

– Website and Conversion Optimization. AI and ML can analyze user experience data—such as page load times, navigation flow, and responsiveness—and suggest improvements to boost conversions and reduce cart abandonment rates.

3.3 Chatbots

Chatbots, defined as "web-based conversational systems between humans and computers using natural language" (Cahn, 2017), have become essential in modern e-commerce. These intelligent software agents simulate human conversation and serve as digital assistants, guiding users through various stages of their online shopping journey. In recent years, chatbots have become a key component of modern e-commerce platforms, offering businesses an efficient, scalable way to enhance customer interaction, automate services, and streamline operations.

A key advantage of chatbots in e-commerce is their 24/7 availability, offering instant assistance regardless of time zones. They handle a wide range of inquiries, from answering product-related questions and processing orders to offering support on payment and shipping. This instant availability not only improves customer satisfaction but also reduces the workload of human support agents, allowing businesses to allocate resources more strategically.

Beyond basic customer service, chatbots serve as powerful tools for collecting and analysing valuable customer data. When a visitor lands on an e-commerce website, a chatbot can proactively start a conversation, asking questions about the shopper's preferences, product interests, or preferred communication channels. This interaction generates rich data that companies can use to personalize marketing campaigns, suggest relevant products, and optimize user experiences. Personalized recommendations based on chatbot interactions often lead to increased conversion rates and stronger customer loyalty (Bhargava, 2023).

A significant challenge in e-commerce is the issue of abandoned shopping carts. Many users add products to their cart but leave the site before completing the purchase, resulting in lost sales. Chatbots can address this issue in several proactive ways. For example, if a customer lingers too long on a checkout page, a chatbot can initiate a supportive message, helping or even a small incentive to complete the transaction. These timely interventions often resolve customer concerns or hesitation in the moment. Additionally, if a customer exits the site without completing the purchase, a chatbot integrated with messaging apps or social media platforms can follow up with reminders or exclusive offers. These interactions not only help recover abandoned carts but also provide insights into the reasons behind cart abandonment (Bhargava, 2023).

Another noteworthy advantage of chatbots is their capacity to support multilingual communication. By using natural language processing (NLP) technologies, chatbots can understand and respond in various languages, making them particularly useful for international e-commerce operations. This linguistic flexibility broadens the company's reach and improves customer service for diverse user groups.

Moreover, chatbots are increasingly integrated with AI and machine learning capabilities, allowing them to learn from past interactions and continuously improve their responses. Over time, they become better at understanding customer intent, identifying patterns, and offering more precise support. This adaptability contributes to long-term customer engagement and helps businesses remain competitive in a fast-evolving digital marketplace.

In conclusion, chatbots represent a transformative force in e-commerce. Their ability to personalize the shopping experience, reduce cart abandonment, gather actionable insights, and provide round-the-clock assistance makes them an asset for online retailers. As AI evolves, chatbots are expected to become even more sophisticated, further enhancing their role in shaping the future of digital commerce.

3.4 Web commerce on social media

Today, social media platforms rank among the most powerful digital communication tools, exerting far-reaching influence on the global economy—especially the digital economy. In the modern digital age, simply establishing an online store is no longer sufficient to guarantee success. Businesses must go beyond transactional interactions and actively engage customers, nurture relationships, and cultivate digital communities. This shift has spurred the rapid emergence of social commerce, a growing subfield of e-commerce that blends social media platforms and digital content into the buying and selling process.

Unlike traditional e-commerce, which typically relies on direct website-based transactions, social commerce integrates commercial activity directly into the fabric of social media interactions. This includes features such as customer reviews and ratings, peer recommendations and referrals, shoppable posts, influencer endorsements, livestream shopping events, and online communities built around shared interests (Linda, 2010; LaFleur, 2023). These elements create a more interactive and participatory shopping experience, where consumer behaviour is shaped by trust, engagement, and real-time social interaction.

The rise of social commerce has been fuelled by both technological advancements and evolving consumer behaviour. Chief among these factors is the widespread adoption of smartphones and the ever-increasing popularity of social networks such as Facebook, YouTube, TikTok and Instagram. These platforms have evolved far beyond their original purpose of personal communication and entertainment. Today, they function as hybrid environments where users can discover products, engage with brands, and complete purchases—all without leaving the app.

According to a McKinsey report, global sales through social commerce channels reached approximately $37 billion in 2021 and are projected to nearly double to $80 billion by 2025. This exponential rise is driven by growing consumer demand and continuous platform innovation. Social media companies are investing heavily in commerce-enabling features such as in-app checkouts, AI-powered product recommendations, and integrated payment systems to streamline the shopping journey (LaFleur, 2023).

For businesses, social commerce offers new opportunities to reach target audiences through personalized, data-driven strategies. Retail giants like Amazon combine user data from website visits with insights from social media interactions—such as likes, shares, and comments—to identify trends and tailor product offerings. This information is then used to deliver highly targeted advertisements, including sponsored posts, influencer campaigns, and display ads across search engines and social feeds.

One of the most powerful aspects of social commerce is user-generated content. Shoppers often rely on peer opinions when making purchasing decisions. Reviews, unboxing videos, and product tutorials shared by other users or influencers play a critical role in building trust and influencing prospective buyers. This peer-to-peer dynamic not only boosts brand credibility but also creates a sense of community around products and services.

In conclusion, social commerce represents a fundamental shift in how e-commerce operates. It merges the connectivity of social media with the utility of digital marketplaces, creating a dynamic and engaging shopping experience. As consumer behaviour continues to evolve, and digital platforms become more sophisticated, social commerce is poised to become a dominant force in the future of online retail.

3.5 Voice commerce

Voice commerce, or V-commerce, refers to the interaction between a customer and a computer system through spoken language, eliminating the need for physical interfaces such as a keyboard, touchscreen, or mouse. This interaction is powered by smart speakers and AI-based voice assistants, which interpret human speech to perform tasks (Vozza, 2023). As an emerging channel within digital commerce, voice commerce is redefining how consumers search for products, place orders, and engage with brands in a more convenient, hands-free manner.

Leading voice assistants such as Amazon’s Alexa, Google Assistant, and Apple’s Siri are at the forefront of this development. These AI-driven systems enable users to carry out a variety of everyday tasks—from managing smart homes to making online purchases—using only their voice. While still in its early stages, voice commerce is steadily gaining traction worldwide. Although it accounted for just 0.2% of total e-commerce transactions in 2023, analysts project a sharp increase in both adoption and transaction volume in the coming years as the technology matures and users grow more comfortable with voice interactions (Vozza, 2023).

One of voice commerce's greatest strengths lies in its user-centric design. It enables a frictionless shopping experience, particularly for routine or repeat purchases like groceries or household supplies. A customer can simply say, “Order more coffee,” and the system will place an order based on their previous buying behaviour. This level of automation not only simplifies transactions but also enhances personalization and convenience.

In addition to convenience, voice commerce offers retailers valuable data insights. By analysing customer voice queries, businesses can identify trends in consumer demand, detect frequently requested products, and optimize their inventory accordingly. These insights also allow for more targeted marketing campaigns and personalized product recommendations (Davidov, 2022). In this way, voice commerce supports data-driven decision-making and enhances overall customer engagement.

The scope of voice commerce is rapidly expanding. Originally limited to simple tasks such as placing grocery orders or checking delivery statuses, it now includes more complex transactions like booking travel arrangements, managing finances, and requesting services. Retailers are increasingly investing in developing voice-activated applications, or "skills," to enable users to interact with their online stores through smart speakers. These custom voice applications aim to create a more intuitive and responsive shopping journey.

Smart speakers themselves have evolved into multifunctional devices. Aside from enabling voice shopping, they serve as hubs for managing connected smart home devices such as lighting systems, thermostats, and appliances. They can also provide real-time information like weather updates, news briefings, reminders, and calendar management. As these devices become more integrated into daily life, the potential for voice commerce continues to expand (Davies, 2024).

In conclusion, voice commerce represents a promising frontier in the evolution of e-commerce. It offers convenience, personalisation, and innovation by enabling hands-free, conversational interaction between consumers and digital platforms. As technology advances and consumer trust in voice systems grows is expected to become a standard feature of the online shopping experience

3.6 Augmented reality and virtual reality

Augmented reality (AR) and virtual reality (VR) are emerging as transformative technologies in e-commerce, revolutionizing how customers interact with products and make purchasing decisions. These immersive technologies bridge the gap between online and physical retail by creating dynamic, interactive experiences. (Hanak, 2024).

AR enriches the physical world by overlaying digital elements onto real environments. This allows consumers to visualize how a product will look or function in their actual space—such as seeing furniture in their living room or previewing how a pair of shoes fits with their outfit. In contrast, VR provides a fully simulated environment where users can explore virtual stores or product worlds, offering a unique and engaging online shopping experience (Hanak, 2024).

With AR and VR, customers can browse and purchase products online through highly engaging interfaces that simulate physical settings. Virtual try-ons enable shoppers to assess clothing, accessories, or makeup before deciding. In contrast, virtual showrooms replicate retail environments, allowing consumers to walk through store layouts or view how items would appear in their homes. These innovations provide a solution for one of the key limitations of online shopping—the lack of tactile interaction—and allow businesses to present their products in a more comprehensive, user-friendly manner. As a result, these technologies can significantly boost customer satisfaction, strengthen brand loyalty, and increase conversion rates (Thakkar, 2018).

According to Hanak (2024), AR and VR technologies enable the following advancements in e-commerce:

- Virtual Try-Ons: Customers can try on clothes, accessories, or cosmetics virtually before making a purchase decision.
- Virtual Showrooms: Products can be displayed in virtual spaces that mimic real-life store layouts or home settings.
- Interactive Product Visualization: Shoppers can explore product details from every angle, enhancing product understanding and reducing return rates.

– Virtual Events and Experiences: Retailers can organise online events such as product launches, fashion shows, or immersive brand experiences to engage consumers more deeply.

These technological advancements do not exist in isolation. Modern e-commerce is being reshaped by a broader wave of digital transformation, where AR and VR are joined by other innovations that collectively redefine how e-commerce operates. The Internet of Things (IoT) facilitates seamless connectivity between devices, automating operations and enhancing logistics. Artificial Intelligence (AI) and Machine Learning (ML) enable data-driven personalization, allowing online platforms to recommend products, adjust pricing dynamically, and detect fraud in real-time. These smart technologies also help in forecasting demand, managing inventory, and optimizing the overall supply chain.

Together, these innovations are transforming the digital shopping experience from a static, one-dimensional process into a dynamic, responsive, and user-centric journey. As AR and VR become more accessible and affordable, their adoption across the e-commerce industry is expected to rise, offering retailers a powerful competitive advantage in an increasingly experience-driven marketplace.

4 Pilot research study and its findings

The research data was collected using an online questionnaire designed with the Google Forms platform and distributed via a personal profile on the social media network Facebook. The study follows a cross-sectional design, as participants were contacted only once. It combines both retrospective and prospective elements—participants were asked to reflect on their past online shopping experiences as well as to share their expectations regarding next-generation online stores.

A total of 71 respondents (N = 71) participated in the survey published on Facebook. Of these, 62% (44 respondents) identify as female and 38% (27 respondents) as male.

Respondents were categorized into four age groups: under 18 (1.4%), 18 to 30 (23%), 30 to 50 (45%), and over 50 years (31%).

In the next section of the questionnaire, participants were asked to reflect on their previous experience with online shopping and identify what they considered the most important feature of an online store. The response options included:

- better access to information across multiple pages,
- the ability to place orders 24/7,
- access to customer feedback,
- discount codes,
- the ability to order without geographical limitations and
- a wide selection of products and services.

Figure 1 shows that the majority of respondents (32%) considered a wide selection of products and services to be the most important feature. This finding indicates that consumers highly value diversity and choice when shopping online. Other notable features included the ability to place orders at any time (24/7), selected by 20% of participants, highlighting the need for accessibility and flexibility. Another notable feature was better access to information across websites, chosen by 18%, which highlights the importance of clear, detailed, and easily accessible product information.

Discount codes, selected by 16% of respondents, reflect a desire for favourable pricing and promotional offers, while only 10% valued the ability to place orders without geographic restrictions. The least valued feature was access to customer feedback, which was selected by just 4% of participants as the most important.

These results suggest that when choosing online stores, consumers prioritize the variety of products and services offered, which may indicate a preference for more personalized and versatile shopping experiences.

Figure 2 presents the results of the survey question: “How do you most often find the products you order?”, providing insight into participants' shopping habits and preferences when searching for products online. Respondents could choose among several options: via social media platforms (Facebook, Instagram, TikTok, etc.), through search engines and websites, using voice assistants such as Siri or Alexa, or via email messages.

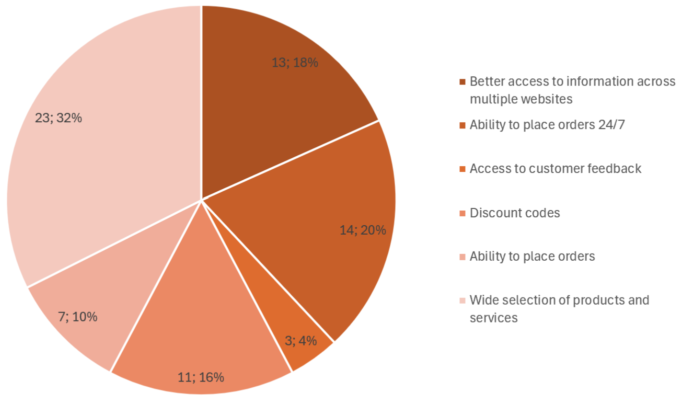


Figure 1: Most Important Features of Online Stores

The results indicate that consumers most frequently (54%) use search engines to independently browse websites and find the products they intend to purchase. Additionally, 45% of respondents reported that they typically order products discovered on social media platforms such as Facebook, TikTok, and Instagram. Only 1% of participants stated that they most often find products through promotional emails, while none of the respondents indicated using voice commerce via Siri or Alexa to discover products.

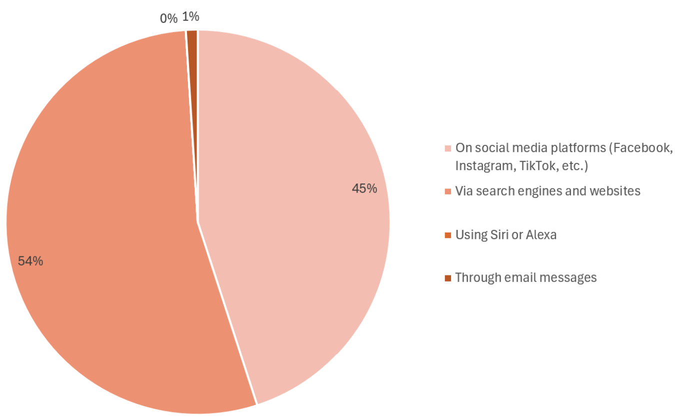


Figure 2: A most common method for finding products ordered online

Figure 3 presents the results of the survey question: "What is the main reason you most often do not complete an online purchase?" Respondents were able to choose from a range of reasons, such as high delivery costs, a complicated payment process, lack of trust in website security, insufficient product information, long estimated delivery times, or unclear return policies. The purpose of this question was to identify the main obstacles consumers face when shopping online and to understand which factors online retailers should improve to increase their cart completion rates.

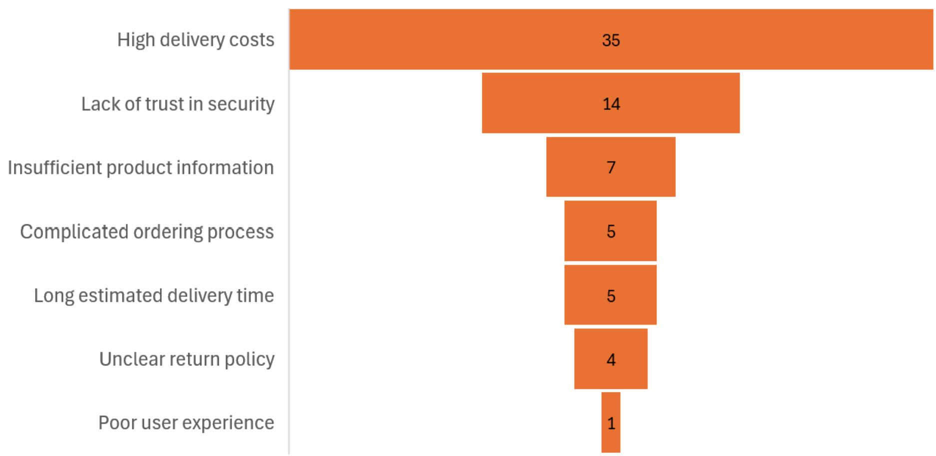


Figure 3: Reasons for Incomplete Online Purchases

The data reveals that the most common reason for abandoning an online purchase is high delivery costs, selected by more than half of the respondents (35). This was followed by a lack of trust in the security of online transactions, chosen by 14 respondents. On the other hand, the factor with the least influence on purchase abandonment appears to be a poor user experience, with only one respondent indicating this as their primary reason for not completing a transaction.

Figure 4 displays the results of the survey question: "Do you check multiple websites offering the same product before completing an online purchase?" The objective of this question was to determine the extent to which consumers compare prices and offers across different online platforms. Such behaviour may reflect a desire to find the best deal, compare service quality, evaluate delivery options, or assess the trustworthiness of sellers.

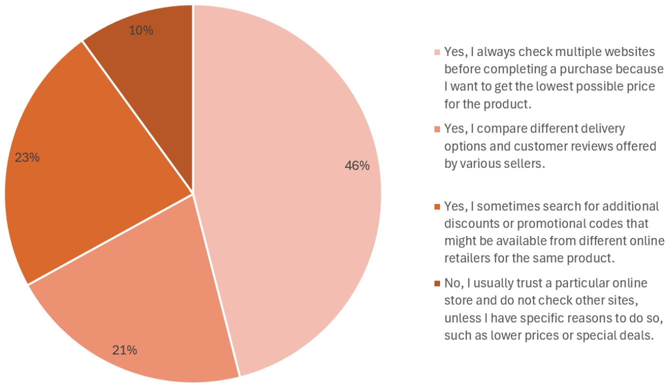


Figure 4: Comparison of Multiple Websites Before Completing an Online Purchase

The results provide insights into how consumers conduct pre-purchase research and the key factors influencing their decision-making process. As shown, 46% of respondents reported that they check multiple websites to ensure they get the lowest possible price for a given product. Additionally, 23% search for discounts or promotional codes across different websites. Another 21% compare various delivery options and read customer reviews from different retailers before making a purchase decision. Only 10% of respondents reported that they do not compare websites, indicating a high level of trust in a single, preferred online store.

Figure 5 presents the trends in web commerce and the number of respondents who have already encountered them.

As shown, the most common trend experienced by 73% of participants (52 respondents) is the use of website cookies. Additionally, 45% (32 respondents) reported having interacted with a chatbot during online shopping. The third most recognized trend is personalization, which was encountered by 18% of the respondents (13). Furthermore, 17% (12 respondents) answered negatively, indicating they had not knowingly encountered any of the listed trends.

Other trends appeared to be less familiar to the respondents; however, it is likely that many of them have, at some point, experienced multichannel web commerce or augmented and virtual reality without being fully aware of it. To address this, the following section of the survey assessed whether participants actually recognize and distinguish between the concepts of augmented reality and virtual reality.

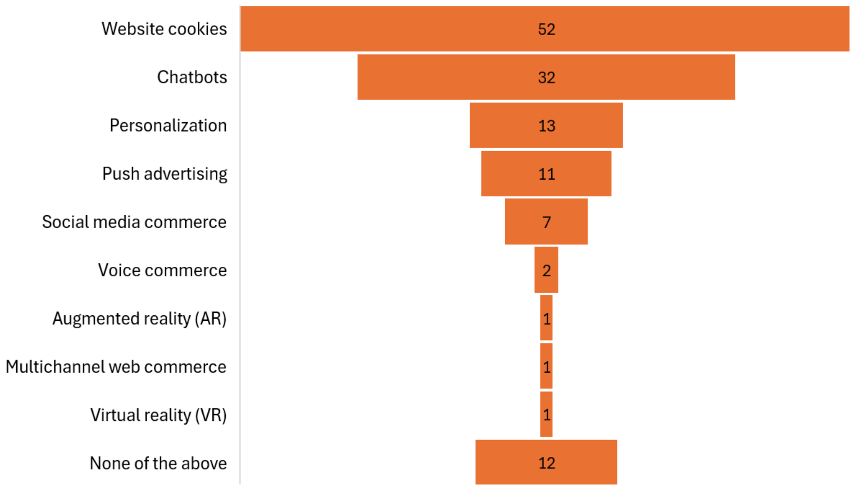


Figure 5: Overview of Web Commerce Trends Encountered by Respondents

Figure 6 shows the responses to the question regarding the importance of chatbots and their impact on user experience.

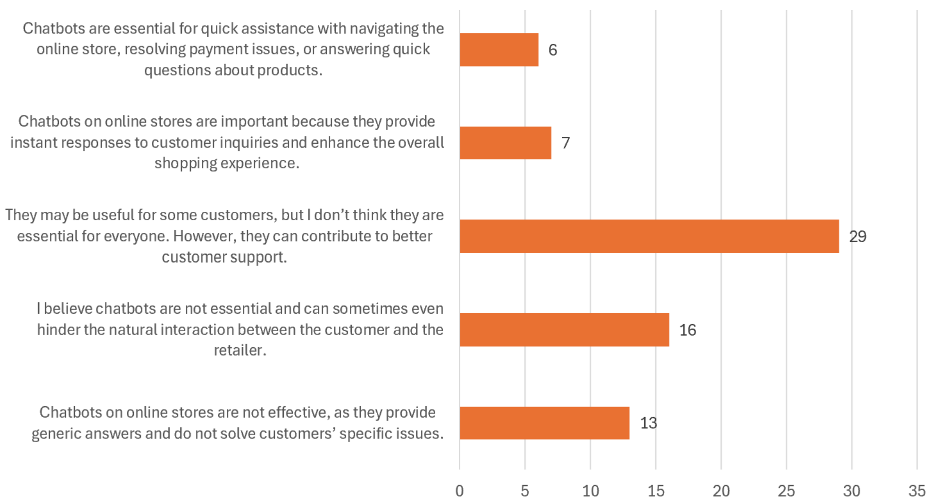


Figure 6: The Importance of Chatbots and Their Impact on User Experience

Most of the respondents, 41% (29), believe that chatbots are not essential for all customers but can contribute to improved customer support. Only 9% (6) consider chatbots to be crucial for providing quick assistance with website navigation, payment issues, and general product inquiries. Additionally, 10% (7) view chatbots as important for delivering instant answers to customer questions, thus enhancing the overall shopping experience.

Conversely, 18% (13) of respondents believe that chatbots are ineffective because they provide only generic responses and fail to address customers' specific problems. Furthermore, 23% (16) agree with the statement that chatbots are not essential and may sometimes hinder the natural interaction between the customer and the online store.

These findings highlight a divided perspective on the effectiveness of chatbots in e-commerce. While many respondents recognize their value as tools to improve customer support, a significant portion remains sceptical about their effectiveness due to the impersonal and limited nature of their responses. Some also feel that chatbots may disrupt the natural communication flow between customers and retailers. For online businesses, these insights suggest the importance of implementing a balanced strategy, one that supplements rather than replaces human customer service. A hybrid model, combining automated efficiency with personalized human interaction, may be the most effective approach to improving customer satisfaction and enhancing the overall user experience.

A simple question was posed in the survey: whether respondents can distinguish between virtual reality (VR) and augmented reality (AR) (Figure 7).

Survey results indicate that 62% (44 respondents) are unable to differentiate between theaugmented reality (AR) and virtual reality (VR), which is significantly higher proportion compared to the 38% (27 respondents) who recognize the difference. This indicates a relatively low level of awareness and understanding of these technologies, which could pose a challenge for businesses aiming to implement AR and VR features in their online shopping experiences.

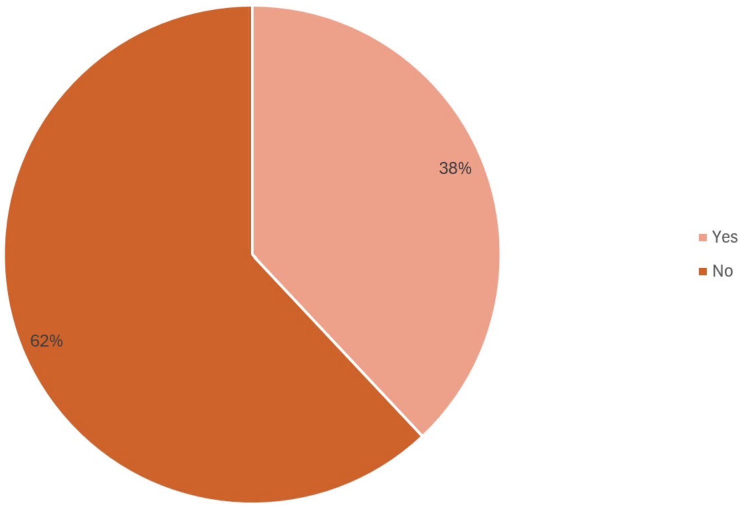


Figure 7: Differentiation between Virtual Reality (VR) and Augmented Reality (AR)

The survey then aimed to assess how well respondents could distinguish between augmented and virtual reality by using two images (Figure 8). The upper image depicts IKEA's mobile application, which allows customers to shop using augmented reality (AR). The application overlays virtual furniture into real-life spaces, enabling customers to see how items would fit and complement their existing home décor. 49% (35 respondents) correctly identified this example as AR.

In the lower part of Figure 8, a scenario of a vehicle prototype configuration in a simulated showroom environment, which represents virtual reality (VR), is presented. However, 20% (15 respondents) incorrectly identified this image as augmented reality. In addition, 31% (22 respondents) were unable to determine which of the two images illustrated augmented reality.

These findings confirm a significant lack of understanding among respondents regarding the difference between AR and VR, reinforcing previous results. This suggests that online retailers should invest more in educating and informing their customers about these emerging technologies—especially those that are already being integrated into the shopping experience.

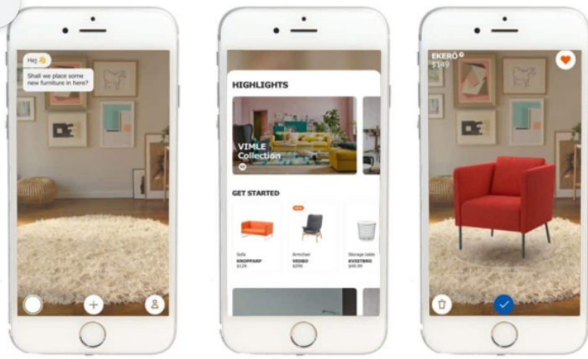
Which of the images represents augmented reality?	N=71 Frequency	%
 Top image	35	49 %
I don't know	22	31 %
Bottom image 	15	20 %

Figure 8: Differentiation between augmented and virtual reality based on visual examples

Figure 9 presents the results of a survey question exploring whether the ability to try products in augmented reality (AR) would influence participants' willingness to overlook delivery costs during online purchases.

According to the results, 14% (10 respondents) stated that they would be more likely to disregard delivery fees if an online store offered the option to preview products using AR. Additionally, 45% (32 respondents) indicated that they would only be willing to overlook delivery costs if the AR experience was highly convincing and significantly reduced the risk of making an incorrect purchase. This finding suggests that AR has the potential to positively influence purchase decisions by providing consumers with a more accurate and immersive product experience. By minimizing the uncertainty and dissatisfaction associated with online shopping, AR may help retailers enhance customer, ultimately leading to higher conversion rates and reduced return rates.

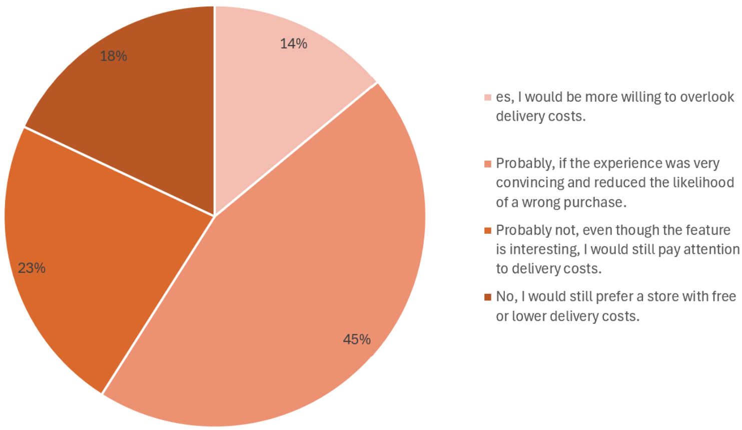


Figure 9: The impact of AR product trials on overlooking delivery costs in online shopping

On the other hand, 23% (16 respondents) indicated that even though AR product trials are a compelling feature, it would not be enough to ignore delivery fees. Meanwhile, 18% (13 respondents) believed that the option to try products in AR is not important at all and would still prefer stores that offer free or lower-cost shipping.

Overall, these findings indicate that AR can significantly impact consumer behaviour regarding delivery charges. A high-quality AR experience may encourage customers to overlook delivery costs; however, actual shipping prices and perceived product value remain decisive factors. Online retailers should, therefore, consider these insights when designing strategies to improve the overall shopping experience.

To examine customer expectations regarding next-generation online stores, we aimed to gain insight into which aspects of online shopping respondents consider most important for the future. These include factors such as security, technological trends, integration with social media, and personalization.

Figure 10 presents the expectations of respondents concerning next-generation online stores. The data reveals that the majority—45% (32 respondents)—expect future online stores to prioritize improving security and protecting customers' personal data. Interestingly, only 13% (9 respondents) expect that advanced technologies such as augmented reality, artificial intelligence, and personalization will be heavily utilized. This suggests a gap between technological capabilities and consumer awareness or demand, indicating a potential need for educational initiatives to showcase the value of these innovations. A notable 24% (17 respondents)—anticipate that online stores will strengthen their integration with social media. Meanwhile, 17% (12 respondents) expect personalized experiences tailored to their specific needs and preferences.

What are your expectations for next-generation online stores?	Frequency	%
I expect next-generation online stores to focus more on offering personalised experiences tailored to the specific needs and preferences of each individual user.	12	17 %
I expect online stores to become increasingly integrated with social media, enabling a more interactive and social shopping experience.	17	24 %
I expect next-generation online stores to make extensive use of advanced technologies, such as augmented reality, artificial intelligence, and automation.	9	13 %
I expect online stores to prioritise improving security and the protection of customers' personal data.	32	45 %
Other: – Greater ecological awareness and less commercialisation.	1	1 %

Figure 10: Expectations for Next-Generation Online Stores

An interesting perspective was shared under the "Other" option: "As much ecological awareness as possible and less commercialization." This comment highlights the importance of environmental issues, which may have been somewhat overlooked in the study. However, an increasing number of online stores are moving toward sustainable practices—be it through eco-friendly materials, sustainable packaging, or greener delivery methods—reflecting the growing demand for environmental awareness among consumers.

The findings clearly indicate that respondents emphasize the importance of data security and protection, which will need to be at the forefront of online store development in the future.

Figure 11 shows that only 4% (3 respondents) believe that new trends in web commerce could contribute to greater security and trust—provided that appropriate security measures, such as data encryption and secure authentication, are properly implemented. In contrast, as many as 34% (24 respondents) believe that emerging trends like personalized experiences and the integration of social media could decrease trust in online security, as they involve increased collection and use of personal data. Meanwhile, 45% (32 respondents) feel that trustworthiness depends on whether online retailers are able to clearly communicate their security and privacy policies and ensure adequate protection of personal information. Lastly, 17% (12 respondents) found it difficult to assess the situation due to a lack of relevant knowledge or experience.

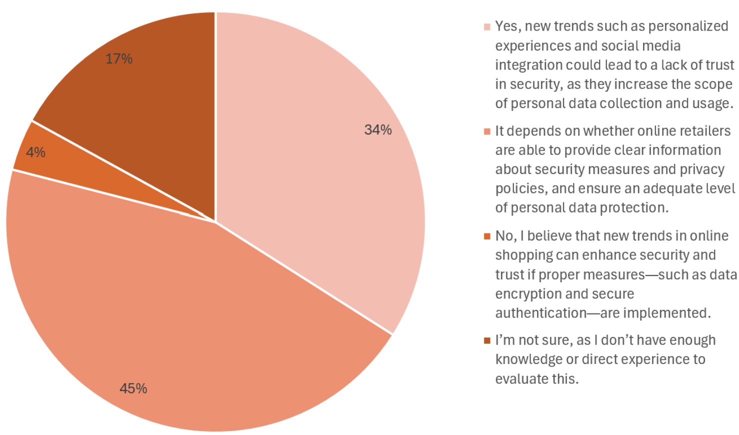


Figure 11: Lack of trust in the security of online shopping due to emerging trends

These responses reveal a divided perception among participants. Based on the findings, we conclude that online retailers will need to dedicate increasing attention to ensuring secure online shopping—particularly by clearly communicating their data protection measures—to strengthen customer trust.

The findings of the study clearly indicate that online retailers will need to place data security and the protection of personal information at the core of their future development efforts. They will need to invest in advanced security technologies and communicate transparently about their data protection practices in order to maintain and strengthen customer trust. Surprisingly low interest in advanced technologies such as augmented reality (AR) and artificial intelligence (AI) suggests that retailers still have work to do to raise awareness and educate consumers about the benefits these technologies can offer. Furthermore, the growing concern for ecological awareness indicates that future online stores will need to invest more significantly in sustainable practices, which include careful consideration of materials, products, packaging, and delivery methods. Aligning their strategies with user expectations in these areas will be crucial. Ultimately, the success of online commerce will depend on how effectively it can address these evolving consumer priorities.

5 Discussion

The findings of the pilot study provide valuable insight into consumer perceptions, behaviours, and expectations concerning modern developments in web-based commerce. The data suggests that while consumers are increasingly dependent on digital shopping environments their attitudes are shaped by a dynamic interplay between usability, convenience,cost, trust, and technological awareness.

A key result of the study is the high importance placed on product and service variety, which was identified as the most valued feature of online stores among respondents. This indicates that today's consumers expect online platforms to offer broad, diverse, and accessible inventories, allowing them to find exactly what they need in one place. Additional features such as 24/7 availability and easy access to relevant product information also ranked highly, confirming that convenience and well-informed decision-making are critical components of the user experience.

Despite the growing popularity of e-commerce, the study reveals that certain barriers to purchase completion remain prevalent. The leading cause of cart abandonment is still high delivery costs, followed by concerns regarding the security of online transactions. These findings highlight the continued importance of cost transparency and robust security in influencing consumer behaviour. It is notable that only a small fraction cited poor user experience as a key deterrent, suggesting that technical usability has generally improved, while economic and trust-related factors remain more decisive.

Another important insight relates to the way consumers search for products. Although social media plays an increasingly visible role in product discovery (with 45% of respondents frequently purchasing items encountered on platforms like Facebook and Instagram), search engines and direct browsing remain the primary method for finding products online (54%). This suggests that while social commerce is rising, traditional search behaviour still dominates.

When it comes to new technological trends, there is a clear gap between usage and awareness. While cookies and chatbots were recognized by most respondents, more advanced technologies such as augmented reality (AR), virtual reality (VR), and voice commerce are still under-recognized or misunderstood. The inability of most respondents to distinguish between AR and VR, even when presented with visual examples, illustrates a lack of familiarity with these technologies—despite their growing integration into modern e-commerce platforms.

Moreover, the impact of AR on purchase behaviour was shown to be promising, with a significant proportion of respondents indicating they would be more likely to overlook delivery costs if AR provided a convincing and realistic preview of products. This highlights AR's potential as a tool not only for improving the user experience but also for influencing economic decision-making. However, cost sensitivity remains high, as some consumers would still prioritize lower shipping fees over technological enhancements.

The perception of chatbots also varied significantly. While many respondents acknowledged their usefulness in providing instant customer service, others criticized them for offering only generic responses and disrupting natural customer-retailer interactions. This indicates that, although automation can improve efficiency, a human-centered approach is still vital—particularly for complex queries or personalized support.

One of the most prominent concerns expressed by respondents was data privacy and online security. With 45% expecting future online stores to focus on protecting personal information, and 34% believing that trends such as personalization and social media integration may lead to trust issues, it is evident that digital trust remains a central factor in e-commerce adoption. Only 4% of respondents saw new trends as a direct contributor to better security—suggesting that most consumers are skeptical about the safe use of emerging technologies. Importantly, 45% indicated that their trust depends on how transparently retailers communicate about data protection, emphasizing the importance of clear privacy policies, encryption standards, and ethical data use.

Finally, while personalization and technology adoption are among the core strategies of modern web commerce, only 13% of respondents expected heavy implementation of advanced technologies in the future. This underlines a gap between industry innovation and consumer perception, possibly due to a lack of exposure, understanding, or education. On the other hand, the call for ecological awareness expressed by some participants highlights a growing expectation for sustainable business practices, signalling a broader shift toward ethical consumerism.

In conclusion, while consumers are generally open to new developments in web commerce, their expectations are rooted in practical benefits—such as convenience, price transparency, and security—rather than in purely technological novelty. For businesses, this presents an opportunity to bridge the gap between innovation and user engagement through better education, transparent communication, and continued investment in secure, accessible, and sustainable e-commerce environments.

6 Conclusion

In recent decades, we have witnessed the rapid development of the Internet, which has profoundly transformed the global business environment. As internet access expanded, companies began to leverage its potential for improving customer communication and streamlining business processes. The rise of e-commerce opened new avenues for simple, efficient shopping and end-to-end management of transport and logistics. Today, e-commerce stands as one of the most dynamic and rapidly evolving sectors, closely interwoven with advancing digital technologies.

This thesis explored emerging technological trends—including artificial intelligence (AI), the Internet of Things (IoT), augmented reality (AR), virtual reality (VR), voice commerce, chatbots, and social commerce—which are progressively reshaping the online shopping experience. These innovations have the potential to personalize customer journeys, automate service delivery, and enhance operational efficiency. In particular, AI is proving essential for data-driven decision-making, dynamic pricing, fraud detection, and targeted marketing.

The pilot study provided empirical insight into consumer behaviour in relation of these trends. While respondents largely appreciated the convenience and product diversity offered by online shopping, they remained sensitive to delivery costs, concerned about data security, and divided on the utility of emerging tools. Although trends like cookies and chatbots are widely recognized, more advanced tools–such as AR and VR–are less understood, indicating a clear need for greater user education and technological familiarization.

The study also emphasized the crucial importance of trust and transparency in digital commerce. Consumers expect online stores to prioritize the ethical use of their personal data, communicate privacy policies clearly, and adhere to robust cybersecurity standards. Furthermore, the growing emphasis on sustainability signals that modern shoppers value not only efficiency and innovating but also environmental and social responsibility.

Interestingly, although only a minority of respondents currently recognize the practical value of technologies like AR, the data suggests that realistic and user-friendly implementations of this technology can positively influence purchasing behaviour- potentially offsetting concerns related to costs and risk.

While chatbots and automation are gaining ground, their adoption must be carefully balanced with human support to ensure a positive and personalized customer experience. Retailers must also navigate the challenges of over-automation, which may alienate customers seeking authentic interaction.

In conclusion, the success of future e-commerce ventures will not depend only on the implementation of cutting-edge technologies, but on businesses' ability to build trust, deliver value, educate users, and adhere to sustainable practices. These factors will be essential in shaping a competitive, ethical, and user-centered digital marketplace.

One limitation of this study is the small sample size, which may not provide a fully representative view of the broader population. Additionally, the underrepresentation of respondents under the age of 18 - a demographic likely to possess distinct, tech-forward shopping behaviours – may have skewed the results toward more conventional perspectives.

Future research could benefit from larger, more diverse samples, enabling more robust comparisons across age groups, regions, and socioeconomic backgrounds. It would also be valuable to conduct longitudinal studies to track how consumer attitudes evolve as emerging technologies become more prevalent. Another promising direction would be to examine the organisational adoption of these technologies and how employees adapt to digital transformation in retail environments.

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XV. The Impact of the Digital Economy on Logistics and Supply Chain Management Under the "Belt and Road" Initiative

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This paper explores the impact of the digital economy on logistics and supply chain management in countries participating in the Belt and Road Initiative (BRI). It highlights how digital technologies–such as big data, AI, IoT, and blockchain–enhance efficiency, improve risk management, and support sustainable development across international logistics networks. The study also identifies significant challenges, including infrastructure gaps, customs inefficiencies, and digital disparities. Through a comprehensive analysis, it proposes digital strategies to optimise logistics performance and strengthen cooperation among BRI countries. The findings emphasise the transformative role of the digital economy in facilitating cross-border trade, reducing costs, and fostering integration in global supply chains.

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1 Introduction

The Belt and Road Initiative (BRI) is a global cooperation initiative proposed by China to promote connectivity and economic collaboration among countries along the Belt and Road. This initiative aims to foster common development and prosperity by strengthening infrastructure construction and facilitating trade and investment (Li, 2019). In recent years, the rise and development of the digital economy have profoundly changed how global logistics and supply chain management are conducted. As a critical component of the Belt and Road Initiative, logistics and supply chain management are key in enhancing trade cooperation, improving efficiency, and reducing costs. With digital technology's continuous application and innovation, the digital economy has introduced unprecedented opportunities and challenges for logistics and supply chain management (Xing, 2022).

Studying the impact of the digital economy on logistics and supply chain management within the Belt and Road Initiative framework is of great significance. First, this research provides scientific guidance and decision-making support for logistics and supply chain management under the BRI. With the rapid advancement of the digital economy, traditional logistics and supply chain management models are increasingly unable to adapt to emerging challenges and demands. By conducting an in-depth analysis of the digital economy's impact on this field, it is possible to identify and summarise effective innovation models and management strategies, offering practical insights and recommendations for enterprises and organisations involved in the Belt and Road Initiative (Ba & Lv, 2024).

Secondly, this study contributes to fostering international cooperation and exchange. As a global initiative, the Belt and Road requires nations to collaborate, share resources, and exchange experiences. By exploring the influence of the digital economy on logistics and supply chain management, this research can deepen cross-national understanding in this field and facilitate international dialogue and cooperation. Additionally, the study serves as a valuable reference for policymakers in shaping logistics and supply chain management strategies in different countries, promoting coordinated development within this sector (Wang, 2022).

Finally, this study is crucial in advancing economic development and social progress. Logistics and supply chain management are fundamental components of modern economies, and their efficiency is instrumental in improving production output, reducing costs, and optimising resource allocation. By examining the impact of the digital economy, the study aims to promote the modernisation and digital transformation of logistics and supply chain management further, enhancing overall economic performance and global competitiveness (Mi & Lu, 2023). This contributes to sustainable development goals, establishing an open world economy, and fostering mutually beneficial regional partnerships.

The first section of this paper introduces the research, while the second section discusses the theoretical foundations of the digital economy, logistics, and supply chain management. It starts by defining the digital economy and its characteristics before moving on to the fundamental concepts and classical theoretical frameworks of logistics and supply chain management. The third section provides an overview of the current logistics and supply chain management landscape in Belt and Road countries. It explores the challenges and opportunities that arise in this context due to digital economic advancements (Liu, 2023). The fourth section analyses how the digital economy influences supply chain efficiency, risk management, and sustainable development. The fifth section discusses logistics and supply chain management optimisation strategies within the Belt and Road Initiative in the digital economy era. Finally, the sixth section presents prospects for future research on the impact of the digital economy on Belt and Road countries.

2 The concept of digital economy and classic theories of logistics and supply chain management

2.1 Concept and characteristics of digital economy

As a broad concept, the digital economy can be included in any economic form that directly or indirectly uses data to guide resources and promote productivity development. At the technical level, it includes emerging technologies such as big data, cloud computing, the Internet of Things, blockchain, artificial intelligence, and 5G communication. At the application level, "new retail" and "new manufacturing" are typical representatives.

The characteristics of the digital economy are relatively distinct compared to non-digital economies. The summary includes the following characteristics:

Fastness – First, the Internet has broken traditional national and regional boundaries. It is connected by the network, making the whole world closely linked and turning the earth into a "village." Secondly, it breaks through time constraints, allowing people's information transmission and economic exchanges to take place over a smaller period. Once again, the digital economy is speed-driven. Modern information networks can transmit information at the speed of light, and the digital economy collects, processes, and applies information at speeds close to real-time, greatly accelerating the pace (Xiao & Liang, 2023).

High permeability – The rapidly developing information technology and network technology have incredibly high penetration functions, which have led to the rapid expansion of the information service industry towards the primary and secondary sectors, blurring the boundaries between the three major industries and leading to a trend of mutual integration between the primary, secondary, and tertiary sectors (Song, 2024).

Self-inflation – The value of the digital economy is equal to the square of the network nodes, and the benefits generated and brought by the network will grow exponentially with the increase of network users. In the digital economy, due to people's psychological reactions and behavioural inertia, under certain conditions, once advantages or disadvantages appear and reach a certain degree, it will lead to continuous intensification and self-strengthening, resulting in a "winner-takes-all" monopoly situation where the strong become more substantial. The weak become weaker (Mi & Lu, 2023).

Marginal Benefit Incremental Performance – The main manifestations are: firstly, the marginal cost of the digital economy is decreasing; secondly, the digital economy has cumulative value-added effects (Liu, 2023).

External Economics – The externality of the network refers to the utility that each user receives from using a particular product, which is related to the total number of users. The more users there are, the higher the utility each user receives (Wang, 2022).

Sustainability – The digital economy can effectively eliminate the excessive consumption of tangible resources and energy by traditional industrial production, causing environmental pollution, ecological degradation, and other hazards, achieving sustainable development of the social economy (Xing, 2022).

Due to the development of the Internet, the economic organisation structure tends to flatten, allowing the producers and consumers of network endpoints to connect directly, thus reducing the necessity of traditional intermediaries, significantly reducing transaction costs, and improving economic efficiency (Liu & Zhang, 2016).

2.2 Basic concepts and classic theories of logistics and supply chain management

Logistics is the physical flow of goods from the supply location to the receiving area, involving comprehensive management of functions such as transportation, storage, loading and unloading, packaging, circulation processing, distribution, and information processing. The basic concept of logistics revolves around the efficient and low-cost flow of goods, including core activities such as warehousing, transportation, and distribution, aimed at meeting the needs of consumers. In the logistics process, various logistics activities such as storage, loading and unloading, handling, packaging, circulation processing, and information processing need to be organically combined according to the actual situation to ensure that goods can flow smoothly and efficiently from the place of origin to the place of consumption.

Supply chain management refers to the integrated management of product flow, information flow, and capital flow, aiming to maximise customer value and minimise supply chain costs. The supply chain covers the entire process from raw material procurement to final product delivery to consumers. The core of supply chain management lies in integrating and optimising all aspects of this process, including suppliers, manufacturers, distributors, retailers, and end users, to form an efficient functional network. The essence of supply chain management is to comprehensively coordinate and manage the product, information, and fund flow that runs from customers to suppliers. It emphasises the key role of information technology systems in identifying problems, analysing problems, and making decisions, and it states that fund flow is often closely related to information flow.

The classic theories of logistics management mainly include Just In Time (JIT) theory and Lean Logistics theory.

JIT theory is a production method aimed at improving production efficiency by reducing inventory and waste. The JIT theory encourages enterprises to produce and distribute when needed rather than making and storing in advance. The key to this theory lies in establishing close connections with suppliers and customers to ensure the smooth progress of the production process (Qu, 2020).

Lean Logistics is a method of optimising logistics processes to reduce waste and improve efficiency. This theory encourages companies to analyse their logistics processes and eliminate all unnecessary waste, such as excessive transportation and inventory. The key to this theory lies in establishing a flexible, reliable, and sustainable supply chain (Song, 2024).

The classic supply chain management theories include value chain, consumer response, and integration theories.

The core idea of Michael E. Porter's value chain theory is to focus on the big and let go of the small, distinguish priorities, focus on significant output activities on the value chain, and elevate them to a strategic level. Value chain management is a series of strategic management methods formed from the starting point of essential activities that can create and obtain value. Among them, the supply chain is a manifestation of the value chain, and the value chain is the content reflected by the supply chain.

Consumer response, derived from the study of consumer behaviour in marketing, refers to the initial perception that consumers, as the main body, obtain from a company's products, services, behaviour, or culture, the formation of purchase intention, and the psychological and behavioural response state throughout the entire process of generating purchase behaviour. Enterprises need to design, manage, and analyse their supply chain strategies from the perspective of consumer response attitude, willingness, and behaviour. Different supply chain management strategies achieve different results, often requiring a balance between speed, efficiency, and satisfaction.

Since Joseph Harrington first proposed the concept of "integrated manufacturing" in 1973, integrated thinking has attracted widespread attention from scholars both domestically and internationally. Scholars such as Qian and Ma have injected integrated management ideas into the supply chain management system, inheriting the previous views of consumer response and operational schools. Integrated management is not simply about adding up but about forming an excess complementarity result of "1+1>2". The focus of supply chain integration management is that enterprises at each node of the supply chain participate in the integration activities on the "chain" with resources that can generate competitive advantages, achieving the integration effect of "strong alliance + complementary combination."

3 Current situation of logistics and supply chain management under the "the Belt and Road" initiative

Some common problems exist in the logistics and supply chain management of countries along the Belt and Road. The lagging infrastructure construction is a significant challenge. Many countries along the route have inadequate infrastructure, such as roads, railways, and ports, resulting in low logistics transportation efficiency. The problem of traffic congestion and poor road conditions in the land routes between China and Central Asian countries can easily affect the timely delivery of goods.

Secondly, the cumbersome customs clearance procedures are also a common problem. Xiao et al. (2023) pointed out that due to trade barriers and complex customs clearance procedures between countries along the way, the clearance time for goods is longer, which increases logistics costs (Xiao & Liang, 2023). Taking China and ASEAN countries as examples, although they have signed free trade agreements, they still face cumbersome customs clearance procedures and complex document requirements, which limit trade development.

In addition, the low level of supply chain informatisation is also a common problem faced by countries along the Belt and Road. Many countries along the route have low levels of supply chain informationisation and lack efficient logistics information systems, resulting in poor information transmission between various links in the supply chain and making it difficult to achieve transparency and visualisation of the supply chain. This not only affects logistics efficiency but also increases the risk of the supply chain.

Taking the ten ASEAN countries (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) that play an essential role in the Belt and Road initiative as an example, the three indicators of digital infrastructure, digital economic development, and logistics infrastructure are comprehensively considered, as shown in Table 1.

Table 1: Composition of Cooperation Foundation Index

Primary indicators	Secondary indicators	Third level indicators
	Digital infrastructure	Mobile phone registration rate
		Internet coverage
		Broadband network speed
Fundamentals of Cooperation	The development level of the digital economy	The scale of the digital industry
		The completeness of e-government
		E-commerce activity
	Logistics infrastructure	Logistics Performance Index (LPI)

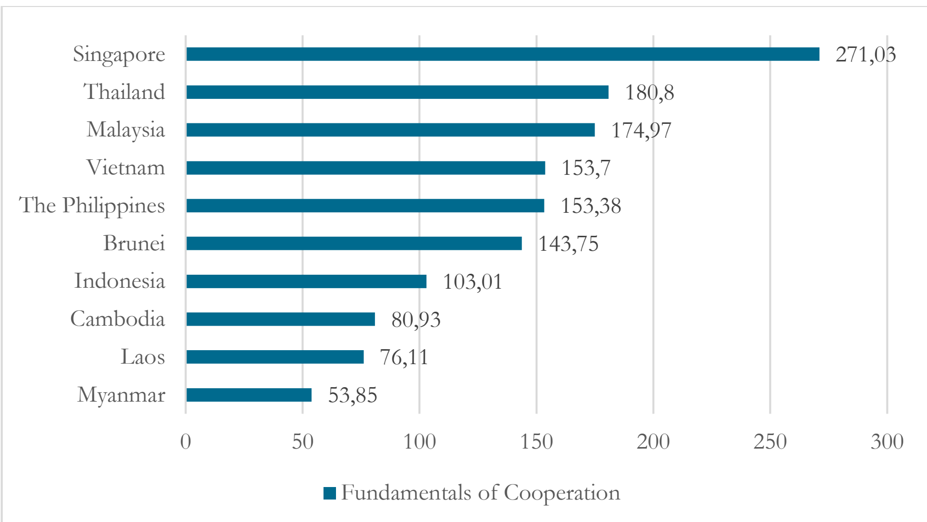

Figure 1: Basic Index of ASEAN Ten Countries Cooperation in 2022

Data source: Hua Xin Research Institute from China

Among the ten ASEAN countries, Singapore has the best cooperation foundation. As one of the few developed countries along the "Belt and Road," Singapore is leading in digital infrastructure, digital economy development, and logistics infrastructure. Compared to Thailand, which ranked second in Figure 1, the cooperation foundation index increased by 89.23. However, the cooperation foundation of the five countries ranked second to sixth is not significantly different. However, it is worth noting that Indonesia, Cambodia, Laos, and Myanmar are considerably lower than the average of 139.15, reflecting that these four countries still have significant disadvantages in digital infrastructure, digital economic development, and logistics infrastructure.

Of course, information asymmetry is also a problem that affects logistics and supply chain management. Due to the lack of effective information-sharing platforms and communication technologies, enterprises find it difficult to promptly obtain market information and supply chain dynamics, affecting decision-making accuracy and flexibility. For example, in the Middle East, due to political instability and information lockdowns, it is difficult for companies to obtain accurate market intelligence and supply chain data, making it challenging to make timely adjustments.

Security issues also need attention. The security situation of countries along the route is unstable, and terrorism, piracy, and other activities threaten the security of logistics transportation. The Strait of Malacca is one of the busiest shipping routes in the world, but due to pirate activities in the region, ships often face the risk of being hijacked.

To solve these problems, Mi et al. (2023) believe that countries along the Belt and Road (including ASEAN countries) can strengthen infrastructure construction and improve logistics transportation efficiency (Mi & Lu, 2023). At the same time, simplifying customs clearance procedures, promoting trade facilitation, and reducing logistics costs are essential measures. In addition, establishing an information-sharing platform and strengthening the application of communication technology can help improve the transparency and accuracy of information. Finally, security cooperation should be strengthened to address security risks in logistics transportation jointly. Through these joint efforts, the logistics and supply chain management of countries along the Belt and Road will improve, thereby promoting the development and prosperity of the regional economy.

The logistics performance level of countries and regions along the Belt and Road is directly related to the success of the initiative's implementation. These countries' logistics performance index (LPI) has generally remained low for an extended period, even below the world average. Central Asia, Mongolia, Russia, and South Asia are the core hinterland regions of the Silk Road Economic Belt and the Maritime Silk Road. Still, they also represent the weakest links in the Belt and Road logistics corridor. Low customs efficiency and poor logistics infrastructure quality are these regions' primary constraints. As a result, the weak logistics performance in these countries hinders the successful implementation of the Belt and Road strategy.

The logistics performance disparities among countries and regions along the Belt and Road directly impact the efficiency of cross-border logistics integration. Significant differences exist in logistics performance among these countries, with a widening gap over time. Consequently, cooperation in logistics remains challenging due to high barriers. Sub-factors contributing to logistics performance disparities include trade and transportation-related infrastructure, quality of information systems, and customs efficiency. Customs clearance efficiency and the effectiveness of other border agencies show the most significant variation, significantly affecting the smooth integration of logistics and supply chains in the Belt and Road region.

The logistics performance base of countries and regions along the Belt and Road remains generally low, with an unpromising growth rate. In the short term, significant improvements in logistics performance appear unlikely. In recent years, the growth rate of logistics performance in top-ranked countries such as China, India, Israel, and Qatar has remained around 2%. Some countries, such as Egypt, Myanmar, Lithuania, and Kazakhstan, have shown significant LPI growth, but their overall LPI base remains relatively low. Meanwhile, other countries have experienced negative LPI growth, including Singapore, which had a higher base, and lower-base countries, such as Syria and Laos.

4 The impact of the digital economy on logistics and supply chain management under the "the Belt and Road" initiative

4.1 Analysis of the impact of the digital economy on logistics and supply chain efficiency of countries along the "Belt and Road."

The digital economy significantly impacts the logistics and supply chain efficiency of countries along the Belt and Road. Liu et al. (2016) argue that with the continuous development and widespread application of digital technology, logistics and supply chain management have entered a new digital and intelligent transformation phase. In the era of the digital economy, logistics and supply chain management place greater emphasis on information sharing and circulation. Improving logistics efficiency and reducing costs through digital means has become a significant trend (Liu & Zhang, 2016).

The digital economy has promoted the informatisation of logistics and supply chain management. In the digital economy, information flow is one of the core elements, and digital technology enhances the real-time sharing and circulation of logistics and supply chain information. For example, by utilising digital technologies such as big data and artificial intelligence, intelligent tracking, distribution, and warehousing of goods can be achieved, thereby improving logistics efficiency and accuracy.

The digital economy has also driven the intelligent upgrading of logistics and supply chain management. In the digital economy, smart devices and technologies—such as automated sorting systems and drone delivery—are widely used in logistics and supply chain operations. The introduction of these devices not only improves work efficiency but also reduces labour costs. At the same time, digital technology enables real-time monitoring and management of goods, allowing for timely detection and resolution of potential issues, thereby ensuring the security and stability of the supply chain.

Moreover, the digital economy fosters cooperation and mutually beneficial outcomes in international logistics and supply chains. In the era of the digital economy, trade between countries is becoming more frequent, and logistics and supply chain management require closer cooperation and coordination. Digital technology makes cross-border logistics and supply chain management more convenient and efficient while providing countries with new cooperation opportunities and development prospects.

To sum up, the digital economy has profoundly impacted the logistics and supply chain efficiency of the Belt and Road initiative. It promotes the informatisation and intelligent development of logistics and supply chain management, improves logistics efficiency and accuracy, reduces costs, and creates favourable conditions for trade exchanges between countries. In the future, it will be essential to strengthen the application of digital technology in logistics and supply chain management further, contributing to the prosperity and development of the global economy.

4.2 Analysis of the impact of digital economy on logistics and supply chain risk management

The impact of the digital economy on logistics and supply chain risk management is profound and widespread. In the era of the digital economy, with the massive growth of data and the continuous progress of technology, logistics and supply chain risk management are transforming traditional empirical judgment into data-driven decision-making.

Song (2024) pointed out that the digital economy has enhanced risk identification and early warning capabilities. With the help of big data and artificial intelligence technologies, enterprises can collect and analyse real-time data on various aspects of the supply chain, including transportation, warehousing, and sales, to accurately identify potential risks (Song, 2024). For example, by analysing historical weather and traffic flow data, companies can predict the potential impact of natural disasters or traffic congestion on logistics and take proactive response measures.

The digital economy promotes risk diversification and transfer. On digital platforms, enterprises can more conveniently share information with other supply chain participants and jointly respond to risks. Meanwhile, through insurance technology, enterprises can purchase insurance for various links in the supply chain to reduce potential losses. This risk diversification and transfer mechanism helps reduce the risk pressure a single enterprise bears.

The digital economy helps optimise risk management decisions. Through data analysis and simulation techniques, enterprises can quantitatively evaluate various risks before making decisions, thereby selecting the optimal risk management strategy. For example, when choosing a transportation method, enterprises can comprehensively consider cost, time, and safety to choose the most suitable transportation method for the current situation.

The digital economy has driven continuous innovation in risk management. With the constant development of digital technology, new risk management methods and tools are constantly emerging. These innovations improve the efficiency and quality of risk management and bring new development opportunities to enterprises. For example, blockchain technology can be used to establish immutable supply chain records, thereby improving the transparency and traceability of the supply chain and reducing risks of fraud and counterfeiting.

4.3 Analysis of the impact of digital economy on sustainable development of logistics and supply chain

Through its unique advantages, the digital economy provides strong support for the sustainable development of logistics and supply chains. For example, digital technology can help enterprises predict and manage resource usage more accurately, reducing waste and unnecessary consumption. In addition, digital tools can optimise transportation routes and reduce idle rates and carbon emissions, lowering environmental pressure. Big data analysis can precisely track the location and status of goods in real time, ensuring their safety and stability during transportation. This transparency improves customer satisfaction and reduces resource waste caused by damaged or lost goods. At the same time, IoT technology enables devices to report their operational status and maintenance needs in real-time, thereby achieving preventive maintenance of devices, extending their lifespan, and reducing the frequency and cost of device replacement (Wang, 2022).

The digital economy provides unprecedented opportunities for cooperation in globalised logistics and supply chains. The Belt and Road Initiative aims to promote the economic cooperation and development of countries along the Belt and Road, and the digital economy provides strong support for realising this goal. Through digital platforms, countries can share logistics information, coordinate transportation resources, optimise supply chain structures, and achieve more efficient and green logistics operations (Liu, 2023). This cooperation not only reduces logistics costs but also improves the reliability and resilience of the supply chain.

The openness and inclusiveness of the digital economy also provide more development opportunities for countries along the Belt and Road. Through digital technology, countries can better integrate into the global supply chain system and share the benefits of globalisation. By promoting sustainable development and strengthening international cooperation, the digital economy has injected new vitality into the sustainable development of logistics and the supply chain of the Belt and Road (Ba & Lv, 2024). This vitality contributes to the economic growth and social development of countries along the Belt and Road and positively contributes to the prosperity and stability of the global economy.

5 Problems in logistics and supply chain management under the Belt and Road initiative

5.1 Infrastructure construction

Infrastructure construction and improvement are essential prerequisites for the Belt and Road Initiative's promotion of regional economic integration. However, in practical operation, infrastructure construction faces many challenges. Taking transportation infrastructure as an example, according to a report by the World Bank, land transportation costs in some regions of South Asia and Southeast Asia are four times higher than those in East Asia and the Pacific. The Gwadar Port and its supporting road and railway construction projects, which China invested in in Pakistan, can improve the regional logistics situation in the long run. However, due to insufficient supporting facilities, safety issues, and local political factors in the early stages, project progress was slow, making it difficult to achieve the expected results. In addition, differences in railway gauges between different countries also increase the difficulty and cost of cross-border transportation (Liu, 2023).

5.2 Customs clearance efficiency

Regarding customs clearance efficiency, taking the China-Europe freight train as an example, although it dramatically reduces the transportation time of goods from China to Europe, each country's customs policies and inspection standards differ due to the involvement of multiple border crossings. These differences result in the need for re-inspection and customs clearance of goods at each border station, increasing time and logistics costs. Additionally, some countries enforce strong tariff policies to protect specific commodities, such as imposing high import tariffs or implementing quantity restrictions on sensitive goods like agricultural products and textiles. This threatens supply chain stability (Xiao & Liang, 2023).

5.3 Political risks

The Belt and Road Initiative covers many countries and regions, and political risk is one of its inevitable challenges. For example, political turmoil in the Middle East may lead to fluctuations in oil and gas prices, affecting energy costs and logistics budgets. The Ukrainian crisis has directly impacted the transportation of goods between China and Europe, and some Chinese companies have suffered financial losses due to their investments in the region. In Africa, policy changes resulting from regime shifts or political conflicts in certain countries may disrupt the stability of local logistics projects and supply chain security (Ba & Lv, 2024).

5.4 Financing difficulties

Funding is crucial for driving infrastructure and logistics projects. However, many developing countries participating in the Belt and Road Initiative are experiencing serious financing problems. For example, some infrastructure projects require substantial funding, and local governments and enterprises often struggle to raise sufficient capital. Even with the support of China's Silk Road Fund, the Asian Infrastructure Investment Bank (AIIB), and other financial institutions, negotiating loan terms, interest rate levels, repayment periods, and other economic factors may create obstacles to cooperation. Moreover, the issue of debt sustainability is critical, as ensuring that loans do not lead to debt traps is essential for maintaining long-term partnerships.

5.5 Differences in laws and regulations

The legal systems of countries along the Belt and Road are complex and diverse, requiring enterprises to invest significant time and resources to adapt to different legal environments. For example, regarding trade regulations, countries have different requirements for standards, quality control, and intellectual property protection related to import and export goods. In labour law, regulations on labour contracts, working hours, benefits, and dismissal rules vary across countries. Such differences present significant challenges for enterprise compliance management. For instance, when Chinese companies invest in building factories in Southeast Asian countries, they must thoroughly understand and comply with local labour regulations; failure to do so may result in labour disputes, damaging their reputation and operational efficiency.

6 Optimization strategy of logistics and supply chain management under the "the Belt and Road" initiative

6.1 Give full play to the leading advantages of the Silk Road Fund and the Asian Infrastructure Investment Bank platform

After introducing the Belt and Road strategy, the Chinese government took immediate steps to address the significant infrastructure gaps in countries and regions along the Belt and Road and to accelerate the strategy's implementation. To support and promote infrastructure development, the Chinese government established the Silk Road Fund and the Asian Infrastructure Investment Bank. Li (2019) believes that logistics infrastructure is key in executing this strategy. The Chinese government should continue to build interconnected logistics infrastructure projects with Belt and Road countries, such as Gwadar Port in Pakistan, utilising platforms like the Silk Road Fund and the Asian Infrastructure Investment Bank. This approach will facilitate the transition of high savings in Belt and Road countries into effective logistics infrastructure investment, improving regional logistics and laying a solid foundation for genuine connectivity.

6.2 Establishment of the Belt and Road free trade zone

Ba and Lv (2024) argue that establishing a free trade zone is advantageous for reducing cross-border tariffs, eliminating trade barriers, and ensuring the free movement of goods and services. China has signed 14 free trade agreements with 22 countries and regions worldwide, promoting bilateral and multilateral international trade liberalisation. Customs efficiency remains a weak link in trade among Belt and Road countries. The Chinese government should accelerate negotiations to establish regional free trade agreements, such as the Asia-Pacific Free Trade Area and the Regional Comprehensive Economic Partnership Agreement, and explore new opportunities arising from the Belt and Road strategy. Further studies should be conducted on establishing a Belt and Road free trade zone, which could significantly enhance customs clearance efficiency and improve trade flow among participating nations.

6.3 Jointly build "the Belt and Road" logistics big data information centre

The data generated in the process of economic and trade exchanges between China and countries and regions along the "Belt and Road," commodity production, storage and transportation, and personnel exchanges have new features that traditional databases do not have, such as large-scale, multiple data types, the uncertain relationship between models and data, diversified processing objects, and more advanced and complex processing tools. Therefore, China and the "Belt and Road" Countries and regions along the Belt and Road should be aware of the necessity and urgency of establishing the "Belt and Road" logistics big data information centre. Wang (2022) believes that the information centre can capture, clean, integrate, select, and update the data in all stages and links of the logistics cooperation of countries and regions along the "Belt and Road" and then use data mining technology to mine the potential value of data information, realise data value-added, and present the final results in a visual way, which helps to accurately guide the "the Belt and Road" to improve the quality and capacity of logistics services of countries and regions along the "Belt and Road".

6.4 Building the "the Belt and Road" global supply chain

In 2012, the United States released the National Strategy for Global Supply Chain Security, which aimed to promote efficient and secure transportation of goods, cultivate resilient supply chains, and maintain its continued leading position globally. China is the world's second-largest economy, with the most significant import and export trade volume. It has the ability and conditions to build a Chinese version of the global supply chain. Forming a worldwide supply chain is a systematic project that requires cooperation, multi-link coordination, and a stable development environment. To this end, China can use the "Belt and Road" strategy as a breakthrough to build a global supply chain and achieve the optimal integration and rational allocation of resources in countries and regions along the line, including market, production capacity, enterprises, and logistics, through market-oriented operation, to promote further the free flow of economic factors The advantages of international transportation convenience and logistics performance complement each other.

6.5 Establish "the Belt and Road" logistics planning head office or similar institutions

The "Belt and Road" involves the "Asia, Europe, and Africa" continent and the surrounding sea areas. There are developed countries, developing countries, and underdeveloped countries. For such a vast and complex strategic system, countries or regions along the line will inevitably feel rejection or even resistance. By establishing logistics planning headquarters or similar institutions jointly operated by countries and regions along the "Belt and Road," the interests of all countries will be tied together to eliminate unwarranted suspicion and suspicion. Xing (2022) pointed out that the primary function of the"Belt and Road" logistics planning head office or similar institutions is to coordinate the deployment and operation of railway, maritime, highway, and aviation logistics infrastructure resources in countries and regions along the line, plan and organise cross-border multimodal transport business, guide the standardisation of logistics systems, develop transport routes, carry out rapid and effective cross-border logistics emergency response, properly manage differences and contradictions, and ensure that the "the Belt and Road" cross-border logistics transport is timely and reliable.

6.6 Build the "the Belt and Road" intelligent logistics system

The big data information centre provides a prerequisite for realising intelligent logistics. The "Belt and Road" intelligent logistics system based on the Internet of Things technology enables online information and offline logistics to be integrated to achieve coordinated development. Liu (2023) believes that the accuracy of logistics information recognition can be improved through digital and visualisation technologies. Then, based on the target customers' expected logistics demand conditions, logistics resources should be allocated reasonably, and efficient one-stop logistics solutions should be planned. Qu (2020) thinks that using Global Positioning System (GPS) and Geographic Information System (GIS) to obtain real-time information on the location of goods accurately and using Radio Frequency Identification (RFID) technology to provide real-time feedback on the status of goods in various time points, relevant information is synchronised and shared with customers, and based on this, the optimised logistics implementation plan is adjusted; Finally, deliver the accurate quantity and expected quality of goods to the agreed destination or target customer within the specified time.

7 Research outlook

As a critical international cooperation framework proposed by China, the Belt and Road Initiative aims to promote the common development and prosperity of countries along the Belt and Road by strengthening infrastructure construction and promoting trade and investment. As core components of this initiative, logistics and supply chain management play a crucial role in achieving regional economic integration. However, the current countries along the "Belt and Road" face common problems in logistics and supply chain management, such as lagging infrastructure construction, low customs clearance efficiency, and low supply chain informatisation. These problems have seriously affected the logistics efficiency and stability of the supply chain.

The rapid development of the digital economy has provided new ideas and tools to solve these problems. By utilising technologies such as big data, cloud computing, the Internet of Things, and artificial intelligence, logistics and supply chain management efficiency and transparency can be improved, operating costs can be reduced, and the resilience and sustainability of the supply chain can be enhanced.

At the same time, the digital economy has also promoted international logistics and supply chain cooperation, providing more development opportunities for countries along the route.

A series of measures must be taken to further optimise the logistics and supply chain management under the "Belt and Road" initiative. First, we should fully play the role of platforms such as the Silk Road Fund and the Asian Infrastructure Investment Bank, increase investment in infrastructure construction, and improve logistics efficiency. Secondly, establishing free trade zones and logistics big data centres can promote information sharing and trade facilitation. In addition, building a global supply chain and intelligent logistics system can further enhance the quality and capacity of logistics services.

In a word, by deepening the application of digital technology in logistics and supply chain management, strengthening international cooperation, and jointly building infrastructure, we can effectively solve the problems of logistics and supply chain management in countries along the "Belt and Road" and promote regional economic integration, and achieve common development and prosperity.

In the future, research on the impact of the digital economy on the "Belt and Road" initiative will focus on several key areas. Firstly, the study will focus on the construction and cooperation of digital infrastructure, exploring how to strengthen the connectivity of countries along the route through cross-border fibre optic networks, data centres, and intelligent logistics systems, as well as the role of PPP in financing and operation. Secondly, focus on developing cross-border e-commerce and digital trade and how digitalisation promotes trade facilitation and reduces transaction costs.

In addition, research on digital currencies and payment systems will become a hot topic, especially regarding potential impacts on international trade settlement, financial market stability, and monetary policy. The innovation of intelligent logistics and supply chain management will also be valued, involving the application of technologies such as the Internet of Things, artificial intelligence, and big data. At the same time, the role of digital financial services and financial technology in improving financial inclusivity will be analysed in depth. Data governance and network security, digital skills training and talent mobility, and the construction of digital innovation and entrepreneurship ecosystems are essential research directions. In addition, the study will explore the impact of the digital economy on social and cultural aspects, including its applications in areas such as educational resource sharing and tourism. Finally, the research will focus on environmental sustainability and green digital practices, such as intelligent energy management and carbon footprint monitoring. These research directions not only help to understand how the digital economy shapes the future of the "Belt and Road" but also provide valuable insights for policymakers, business leaders, and academic researchers in countries along the Belt and Road and jointly promote the successful implementation of this global initiative.

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XVI. The Impact of the Development Level of Digital Economy on the Export Trade Between China and Countries Along the "Belt and Road

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As an emerging economic form supported by new technologies, the development of the digital economy is changing the global economic pattern. It profoundly impacts the market pattern of international trade and the production organisation structure. Institutions and scholars also have different opinions on measuring digital economy development indicators. Much research is on the development of global trade in the digital economy. At present, the main research directions of the academic circle are the impact mechanism of the digital economy on international trade, the heterogeneous impact of the digital economy on the trade of different countries, and the impact on trade with other countries. This paper mainly studies the current situation and existing problems of the development of the digital economy, analyses the impact of the digital economy on China's export trade with countries along the "Belt and Road" through theoretical knowledge, and puts forward future policy suggestions based on the impact.

Keywords:
"The Belt and Road",
emerging economy,
digital economy,
export trade,
China

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1 The background and significance of the topic

After the Belt and Road Initiative was formally proposed in 2013, China, as the initiator, has vigorously coordinated the development of economic and trade cooperation with neighbouring regions, continuously improved the scale and quality of trade exchanges, and promoted the high-quality development of foreign trade. In 2018, the fifth World Internet Conference was successfully held. With the theme of "Creating a Digital World of Mutual Trust and Governance," the conference had in-depth discussions on the Internet, big data, and other topics.

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2 Literature review

2.1 Research on the development and measurement of the digital economy

At home and abroad, research on the evaluation system of the digital economy is mainly undertaken by government agencies or scientific research institutions, each approaching the topic from different perspectives. However, a comprehensive and unified index system for measuring the development of the digital economy has yet to be established.

Jiao et al. (2021) constructed a comprehensive evaluation index system of China's inter-provincial digital economy from the perspectives of digital foundation, innovation, application, and transformation thinking. Yang and Jiang (2021) included digital output in defining digital development indicators. They developed an index system based on digital industrialisation and industrial digitalisation, applying principal component analysis to assess digital development levels across Chinese provinces objectively. Wan, Luo, and Yuan (2019) built a model grounded in previous digital economy indicator systems from the input-output perspective, incorporating the governance environment as a regulating factor throughout the digital economy's processes. Duan and Feng (2023) used the entropy method to construct an evaluation system for digital development, enhancing prior models by adding first-level indicators such as digital talent and digital trade status. Meanwhile, various official documents at home and abroad have proposed different frameworks for constructing a digital economy index system.

2.2 Research on the "Belt and Road" countries under the background of the digital economy

The digital economy influences countries along the Belt and Road in numerous ways, including promoting green economic performance, high-quality development, investment growth, and industrial upgrading.

Duan and Feng (2023) pointed out that the level of digital development among Belt and Road countries affects low-carbon green performance primarily through industrial structure optimisation and technological innovation. Their analysis also considered variations across income levels and institutional quality. Qi and Ren (2020) examined the impact of digital economy development on economic growth, trade, investment, and high-quality development in Belt and Road countries. Liu, Zhang, and Zeng (2022) also explored how the digital economy drives high-quality development along the Belt and Road by enhancing innovation and industrial upgrading.

2.3 Research on the impact of digital economy on international trade

With the widespread application of technologies such as artificial intelligence, the Internet, and cloud computing, the digital economy has become a significant engine of global economic growth. This section analyses the mechanisms through which the digital economy impacts international trade and how these impacts vary by country and trade type.

Impact mechanism of digital economy on trade status

First, the digital economy can significantly reduce trade costs by promoting trade. Enhanced information sharing reduces information barriers, improves efficiency, and mitigates issues related to information asymmetry. Chaney (2014) found that effective information communication in service trade can reduce trade costs by minimising information gaps between trading partners. Similarly, Sun (2017) proposed that using the Internet and ICT can overcome these barriers and reduce trade-related search and matching costs.

Second, developing a digital economy can reduce export inefficiencies, improve trade mechanisms, and expand international trade. Meijers (2014) and Abeliansky and Hilbert (2017) demonstrated that the application of the Internet and ICT significantly enhances the scale of global trade.

Study on the impact of digital economy on trade of different countries

Wen, Chen, and Zhang (2023) examined the role of digital infrastructure in the Guangdong-Hong Kong-Macao Greater Bay Area and found it significantly boosted the region's foreign trade, with innovation and economic growth acting as transmission mechanisms. Wang (2022) analysed trade data between Jiangsu Province and RCEP countries and found that a 10% increase in digital economy development among trade partners leads to a 1.8% rise in bilateral import and export volume, confirming that digital economy development positively impacts trade.

2.4 Summary

Scholars across the globe have recognised the crucial role of the Internet and digital communication technologies in driving socio-economic development and have approached this topic from various disciplinary angles. Despite the proliferation of measurement models for the digital economy, no globally unified standard remains. Moreover, much research has focused on how the digital economy influences national economies and trade structures. However, most existing studies focus on China's digital economy and its bilateral trade effects, while literature explicitly addressing the digital economy development of Belt and Road countries and its impact on China's bilateral trade remains relatively limited.

3 Current situation of the digital economy

3.1 Connotation and current situation of the development of the digital economy

In recent years, China's digital economy has developed rapidly, ranking second globally in scale. The share of the digital economy in national GDP has continued to grow. Since the official proposal of the "Digital Silk Road" in 2017, China has intensified cooperation with Belt and Road countries in cutting-edge areas such as artificial intelligence, cloud computing, and quantum information, promoting innovation in the broader Belt and Road framework. Notable progress has also been made in constructing the China-ASEAN Information Port, and cross-border trade between China and Arab countries has flourished through the "Online Silk Road", reinforcing the role of the digital economy in driving regional development.

The digital economy fosters enterprise-level innovation in production models, facilitates industrial restructuring, and accelerates the emergence of new economic paradigms. From a value-transition perspective, data functions as a core production factor within the digital economy, with digital technologies enabling data transformation into valuable information. The evolution of network technologies has dramatically improved the efficiency of converting complex data into actionable insights, which has, in turn, transformed operational models across society and industry. Systematic and creative innovation underpins these developments, bringing unprecedented opportunities and significant challenges.

On the demand side, the digital economy actively uncovers both current and latent consumer needs through advanced communication technologies. The digital economy transforms traditional market mechanisms and business models by delivering personalised and customised services to diverse markets. As innovation in technologies such as the Internet and artificial intelligence continues, the digital economy is expected to serve as a transformative force in social and economic structures and a powerful engine for national and global economic growth.

3.2 Current problems in the development of digital economy

Network information security issues

With the widespread availability of network resources and the explosive growth of information and data, the digital economy has significantly enhanced industrial productivity and efficiency. However, this expansion also exposes enterprises, governments, and users to serious security risks, including breaches, unauthorised data use, and privacy violations. Ensuring information security has become a pressing challenge for all stakeholders.

Data gap problem

Significant disparities in resource endowment exist across different regions. The eastern coastal areas of China have made far more substantial progress in digital economic development than the western regions, intensifying regional imbalances. Additionally, from a demographic perspective, groups such as older people and individuals without internet access are often excluded from the benefits of digitalisation. These disparities create a "data gap" that must be addressed through inclusive digital strategies.

Regulatory policies lag behind

As digital technologies evolve, new industrial formats emerge, often overlapping and outpacing existing regulatory frameworks. The rapid emergence of new digital trading models and business practices requires timely regulatory responses. However, delays in formulating and implementing appropriate policies often result in regulatory gaps or overreach, leading to inefficiencies and inconsistencies in governance.

3.3 Measurement indicators of the digital economy

Digital infrastructure

The level of a country's digital infrastructure serves as a fundamental indicator of its digital economy development. Key metrics include the number of domain names, broadband access ports, mobile phone penetration rates, and the length of long-distance cable lines. These elements reflect the basic conditions needed for digital economic activity.

Digital industry transformation

Another critical measurement dimension involves the degree of digital transformation within industries. This can be assessed through indicators such as the number of patents filed by Belt and Road countries, the number of enterprises engaged in e-commerce, and the proportion of total sales derived from digital channels. These indicators help capture the extent of digital integration in business operations.

4 China's analysis of the export trade status of countries along the "Belt and Road"

4.1 Total export trade of China to countries along the Belt and Road

Since implementing the Belt and Road Initiative in 2013, trade cooperation between China and countries along the Belt and Road has intensified significantly. China has promoted high-quality economic development by leveraging its national resources, talent, and technology advantages, thereby creating a mutually beneficial cooperation framework within the initiative.

By September 2023, China had signed over 230 cooperation documents related to the Belt and Road with more than 150 countries and over 30 international organisations. As of 2022, the total GDP of these participating countries exceeded 22 trillion USD, accounting for approximately 23% of global GDP and representing a population of nearly 3.7 billion—about 47% of the worldwide total.

In 2023, China's total import and export volume reached USD 5.94 trillion, a year-on-year decrease of 5%. Exports amounted to USD 3.38 trillion (down 4.6%), imports to USD 2.56 trillion (down 5.5%), and the trade surplus was USD 823.2 billion (down 1.7%).

Between 2013 and 2021, China's export trade with central Belt and Road countries grew from USD 558.07 billion to USD 1,049.53 billion. In 2022, trade with Belt and Road countries reached USD 2.07 trillion, marking a 15.4% year-on-year increase–11 percentage points above the national foreign trade growth rate. Exports reached USD 1.18 trillion (up 15.7%), and imports reached USD 891.3 billion (up 15%).

In 2022, trade with Belt and Road countries accounted for 32.8% of China's total foreign trade, surpassing the 30% threshold for the first time. This share has risen steadily, from approximately 25% in 2014 to 29.3% in 2019, and has remained around 29% in subsequent years. The 2022 data underscores the growing significance of Belt and Road trade within China's foreign trade structure.

E-commerce cooperation has emerged as a new driver of trade under the Belt and Road framework. In 2020, China's cross-border e-commerce trade volume rose by 28.6% to 198 billion yuan, with export growth reaching 44.1%. By the end of 2022, China had signed memorandums of understanding on Digital Silk Road cooperation with 17 countries and established bilateral e-commerce cooperation mechanisms with 23 countries.

4.2 China's analysis of the export trade structure of countries along the Belt and Road

From 2013 to 2023, China's exports to Belt and Road countries have been dominated by electronic equipment and mechanical instruments. These sectors accounted for USD 278.73 billion in 2013 and USD 543.28 billion in 2021, comprising 51.8% of total exports to Belt and Road countries—showing substantial growth.

Exports of textiles, footwear, and hardware products (HS Code Chapters 50–83) also expanded from USD 194.45 billion to USD 276.02 billion over the same period, accounting for 26.3% of total exports in 2021. However, this category showed volatility, notably declining in 2020 due to the COVID-19 pandemic.

Exports of mineral chemicals, plastics, rubber, and wood products (HS Code Chapters 25–49) exhibited the fastest growth—from USD 6.19 billion in 2013 to USD 190.13 billion in 2021—at an average annual growth rate of 53.4%. The gradual deepening of trade and economic ties under the Belt and Road Initiative has optimised China's export structure and driven robust export trade development.

4.3 Problems in China's export trade with countries along the Belt and Road

The trend of anti-globalisation hinders China's trade with Belt and Road countries

The global trade environment has become increasingly volatile, with rising protectionist measures—particularly from the United States—encouraging some countries to erect trade barriers. These developments have negatively affected regional trade cooperation within the Belt and Road framework. For example, in April 2021, the Australian federal government cancelled a Belt and Road agreement between China and the state of Victoria, disrupting established trade dynamics.

Diverse trade entities among Belt and Road countries

Trade relations between China and Belt and Road countries must overcome differences in political systems, religious and ethical norms, languages, and cultural values. These variations often lead to trade barriers. However, the digital economy offers new opportunities to bridge these divides by enabling digital cultural exchange and increasing localisation of Chinese products. It also supports mutual cultural understanding, fostering economic collaboration through digital integration.

Inadequate financial service systems in Belt and Road countries

Some Belt and Road countries face challenges related to underdeveloped financial service infrastructures and incomplete social credit information systems. For instance, certain African regions still lack robust legal systems and a sufficient network of banking services. These shortcomings hinder practical trade cooperation with China.

The promotion of digital finance offers a potential solution. Countries can build and refine their social credit systems by leveraging big data. Additionally, digital payment systems can compensate for inadequate banking infrastructure and facilitate smoother export trade processes.

5 The impact of the digital economy on export trade between China and countries along the "Belt and Road"

The advancement of the digital economy significantly contributes to the growth of export trade between China and countries along the Belt and Road. Indicators such as per capita GDP and trade openness, alongside the development of digital technologies, jointly foster the stable expansion of trade relations. The digital economy reduces operational costs for Chinese export-oriented enterprises, broadens the range and diversity of trade participants, and accelerates technological innovation. It becomes a vital engine for promoting international trade by lowering trade barriers and expanding transaction opportunities.

The digital economy can reduce trade costs

The digital economy penetrates all stages of international trade via Internet platforms and big data technologies, thereby reducing trade costs and increasing the profitability of export-oriented enterprises. It optimises cost structures by minimising information asymmetries and streamlining processes such as data collection and customs clearance. Lower trade costs enhance product competitiveness and support the expansion of export trade.

The digital economy can expand the scope of transactions

Digital platforms help overcome communication barriers in international trade, facilitating smoother and more efficient exchanges between trading parties. These platforms also create opportunities for small and medium-sized enterprises (SMEs) to enter global markets, thus challenging the traditional dominance of large multinational corporations. Moreover, the digital economy improves the accessibility and accuracy of commodity information, helping consumers make more informed decisions and expanding market reach.

The digital economy promotes trade development through technological progress

Digital technologies stimulate innovation and enhance professional knowledge and information circulation, creating a collaborative and dynamic technology ecosystem. Export entities benefit from digital platforms that optimise financing, contract execution, and settlement methods, thereby reducing transaction risks and fostering a more secure and efficient trade environment.

6 Policy suggestions

Under the Belt and Road Initiative framework, the integration of digital and traditional industries has given rise to new economic opportunities, presenting great potential for developing China's export trade with participating countries. To further promote trade transformation and the international competitiveness of China's foreign trade, the following policy recommendations are proposed:

Seize the opportunity of digital economic development to address anti-globalisation

The rapid rise of digital trade, including cross-border e-commerce and digital services, has injected new vitality into China's export sector. China should leverage this momentum to counter anti-globalisation trends by deepening international cooperation in digital trade and expanding its influence in global trade networks.

Strengthen digital infrastructure development in Belt and Road countries

The foundation of a thriving digital economy lies in robust digital infrastructure. Given the uneven levels of digital development across Belt and Road countries, China should collaborate with its partners to accelerate the construction of Internet infrastructure and improve the overall layout of the digital economy. Multidimensional cooperation can enhance digital capacity and, in turn, support trade development across the region.

Improve digital economy legislation in Belt and Road countries

As data becomes the core asset of the digital economy, safeguarding data security is paramount. However, many countries along the Belt and Road lack comprehensive legal frameworks to govern digital trade, leaving regulatory gaps and increasing the risk of data breaches. China should promote the formulation and harmonisation of digital trade rules, advocate for secure and transparent digital trade environments, and support the modernisation of regulatory systems in partner countries.

7 Conclusion

This paper examined the current state of China's export trade with countries along the Belt and Road. It explored how the digital economy can promote this trade through cost reduction, expansion of transaction scope, and technological innovation. It also identified key challenges facing China's trade relations with these countries and proposed policy solutions based on the development of the digital economy. Overall, leveraging digital transformation provides a strategic pathway for enhancing the quality and sustainability of China's international trade under the Belt and Road Initiative.

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XVII. Study on the Impact of China's Business Environment on Service Trade

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With the upgrading of national economies, outward foreign direct investment (OFDI) and service trade have become increasingly vital to global trade. China's economic restructuring has promoted high-quality growth in the service sector, making it a key driver of economic development. Studies show that a favourable business environment–transparent legal systems, efficient procedures, low business costs, and firm public services–can attract investment and talent, enhancing service trade performance. Such an environment reduces operational costs, improves efficiency, and fosters fair competition, enabling service trade enterprises to gain market share and improve profitability. This paper analyses the mechanisms through which the business environment affects service trade and proposes policy recommendations further to optimise conditions for sustainable growth in the sector.

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1 Introduction

In 2021, the contribution of China's net exports of goods and services to economic growth reached 20.9 per cent. Of particular concern is that while trade in goods grew by 30 per cent year-on-year, China's total trade in services reached 5,298.27 billion yuan, with the trade in services deficit narrowing to 211.27 billion yuan, the lowest since 2011.2022. From January to February 2022, China's service trade grew by 33.5 per cent again year-on-year, reaching 953.48 billion yuan. Among them, the increase in service exports was 11.1 percentage points greater than that of imports, driving the service trade deficit down by 57.6 per cent to 18.31 billion yuan, continuing the momentum of the strong development of China's trade in services over the past year, and fully reflecting the positive results achieved by China in the field of service trade in terms of structural adjustment and export competitiveness enhancement. However, there is still a big gap compared with the developed economies with higher levels of competitiveness in the world trade in services, mainly because China does not have a competitive advantage in the emerging service industry. The development of trade in services is primarily concentrated in labour- and resource-intensive traditional service areas, while the developed economies have absolute international competitive advantages in the capital-, knowledge- and technology-intensive emerging modern service areas due to the mastery of advanced technology, abundant capital, and rich management experience. International competitive advantage. China's enterprises "going out" and in-depth participation in the globalisation of the division of labour need to accelerate the development of service trade exports.

Service exports involve a wide range of factors: the quality of a country's government services, infrastructure construction, legal system regulation, ease of financing, market supply and demand, etc., will affect the service exports, and these factors essentially belong to the scope of the business environment. Doing Business includes social, economic, political, and legal factors affecting business activities. The World Bank defines Doing Business as "the time and costs required for an enterprise to comply with policies and regulations in the areas of business start-up, operations, trading activities, tax payments, bankruptcy, and enforcement of contracts, etc. Based on this definition, it has devised indicators for assessing Doing Business to facilitate the quantification and comparison of Doing Business. Quantification and comparison of business environment". A favourable business environment promotes the development of the domestic service industry, enhances the international competitiveness of service trade, and promotes service exports. Therefore, strengthening research on the impact of the business environment on trade in services is conducive to understanding and grasping the law of developing trade in services under China's reform and opening-up economic conditions and deepening the knowledge of the significance of improving the business environment to provide a scientific and reasonable policy basis for further promoting the development of trade in services. This paper studies the impact of the business environment on trade in services to improve the reference for government departments to plan the structure of the service industry, the adjustment of the structure of trade in services, and the formulation of several economic policies, such as the allocation of resources.

2 The significance of study

Regarding trade in services, most studies focus on two aspects: the international competitiveness of a country's trade in services and the influencing factors of trade in services. Few studies have analysed the impact of trade in services from the business environment perspective. The business environment faced by enterprises in different regions may show significant differences within a country due to differences in government policies, regulations, and law enforcement. The importance of the business environment in the development of the world economy is becoming more and more prominent, and the scope of the impact of the business environment on the economy is expanding, involving areas ranging from investment to trade development. The study of the effects of the business environment on trade in services further enriches the research on optimising the business environment and trade in services.

The 14th Five-Year Plan points out the need to "deepen the reform and opening up of trade in services," "accelerate the process of digitisation of trade in services," and "optimise the industry structure of trade in services." The report of the 20th CPC National Congress report emphasised the need to innovate mechanisms for developing trade in services, develop digital trade, and accelerate the construction of a strong trading nation.

Since 2010, the scale of China's service exports has been gradually expanding. However, there are still many problems: the trade deficit in services has continued to widen, the structure of exports is unreasonable, and the international competitiveness of service exports is weak. To solve the various problems of service exports and promote the development of China's service exports, China should pay attention to the impact of the business environment on service trade. The business environment is composed of a series of social, economic, and legal elements that affect the activities of enterprises and involve various aspects such as the opening, operation, trade, taxation, contract enforcement, and bankruptcy of enterprises. Improving the business environment can help improve the productivity of the service industry and promote service exports.

This paper studies the impact of the business environment on service trade, which can provide specific references for the government to improve the direction of the business environment and provide policy suggestions for optimising the structure of service exports (Cui, 2020).

3 Relevant studies on the business environment

The World Bank defines the business environment as the conditions such as the time and cost required for a business to comply with policies and regulations regarding opening, operating, trading activities, paying taxes, closing, and enforcing contracts. This definition facilitates the production of business environment indicators for countries worldwide and makes quantifying and comparing the business environment easier (Cui, 2020).

In addition, some marketing books equate the marketing environment with the business environment, which is divided into the micro and macro business environments. The so-called micro business environment refers to a variety of participants closely associated with the enterprise itself that directly affect the regular operation of the enterprise. These participants include the enterprise, customers, competitors, the public, etc. The so-called macro business environment refers to the demographic environment, economic environment, natural resources environment, scientific and technological environment, political and legal environment, and social and cultural environment. All of these environments will directly or indirectly affect the regular operation of an enterprise in some way (Li et al., 2019).

In addition, the Baidu Encyclopedia defines the business environment as the social, economic, technological, political, and other general conditions of the country or region where the enterprise is located.

3.1 Definition of business environment by foreign scholars

The definition of business environment initially originated from the World Bank, but different scholars have different emphases on the interpretation of business environment. Foreign scholars have expressed their views, especially regarding the evaluation index system of the business environment. American scientists Isiah Ritfak and Bantin (1968) proposed the cold and hot map analysis method in the Conceptual Framework for International Business Arrangements, published in 1968, the earliest research on evaluating the business environment. This framework highlights factors such as economic development conditions, geographical resources, market environment, cultural differences, national political stability, and obstacles to enterprise development as key elements in evaluating the investment environment of a region.

The Fraser Institute of Canada, in constructing the evaluation index system of the business environment, focuses on seven aspects: financial and social stability, foreign trade transactions, economic conditions, market environment, freedom of monetary exchange, government services, and the legal system. Eifert et al. (2005), based on data on Africa's investment environment, argue that the business environment consists of infrastructure that affects the operational efficiency of different enterprises, human resources, geography, policies, institutions, and other related factors. Scholars focus on various dimensions when studying the influencing factors of the business environment.

Alby et al. (2013) found that many enterprises in developing countries struggle with normal operations due to an insufficient electricity supply, identifying electricity as a crucial factor affecting enterprise development. Similarly, Bah and Fang (2015) used a quantitative approach to examine business environment conditions in African countries, focusing on business regulations, infrastructure, access to finance, crime, and corruption to explore the factors influencing productivity in African economies. According to Witkowska (2011), in the process of economic development in Western societies, the government and the market influence each other and are inseparable. Government departments should allow market autonomy while maintaining macroeconomic control and providing essential services.

3.2 Definition of business environment by Chinese scholars

Chinese scholars have also conducted different studies on the assessment methods and impacts of the business environment. Based on the ecosystem theory, Li (2022) constructs the evaluation index system of China's urban business environment from seven dimensions: market environment, innovation environment, financial services, public services, human resources, rule of law environment, and governmental environment, and analyses China's urban business environment in the northern and southern regions.

Zhang and Cao (2021) used quadratic weighted factor analysis and cluster analysis to select indicators from the four dimensions of governmental environment, market environment, innovation environment, and public service, aiming to construct a systematic evaluation index system of the business environment in the context of the "release of administrative services" reform. Several scholars have studied the evaluation index system of the business environment, and some have analysed its importance.

Li et al. (2019) used China's inter-provincial panel data from 2017-2018 to construct China's business environment evaluation index system. They measured the index of the development level of the business environment in each province using the equal weight method. They proposed that while China's business environment is improving, the overall business environment in the eastern region is better than in the central and western areas. However, the speed of improvement in the central and west regions is higher than in the east region, making regional disparities the primary reason for the uneven distribution of the national business environment index.

He et al. (2020) utilised data from 2000 to 2017 covering 217 countries and regions provided by the World Bank, Fraser Institute, and Polity IV to examine the impact of the business environment on technology, finance, investment, industrial structure, energy environment, gender equality, and economic growth. They applied fixed-effects modelling and systematic generalised moment estimation (Ritfak & Bantin, n.d.).

Zhang et al. (2020) constructed an evaluation index system for the business environment in Chinese provinces by considering the four primary dimensions of market, government, law and policy, and humanities. Their framework was based on domestic and international evaluation index systems for the business environment and incorporated the Regulations on Optimizing the Business Environment. They further determined secondary-level indexes and corresponding weights and conducted a quantitative analysis using relevant data.

Cui (2020) confirmed the business environment's positive impact on border countries' economic development using the fixed-effects panel model, instrumental variable method, and generalised moment estimation method.

4 The influencing factors of service trade

4.1 Definition of service trade

The General Agreement on Trade in Services (GATS), signed during the Uruguay Round negotiations under the auspices of the General Agreement on Tariffs and Trade (GATT), defines international trade in services as a commercial activity that transcends national borders for the transaction of services. This involves a service provider from the territory of one country delivering services to consumers in another country through the business side of an enterprise or a natural person, thereby earning foreign exchange. Trade in services covers multiple sectors and is characterised by its complexity. It can be categorised from different perspectives, but according to GATS, it is classified into twelve main categories (Mattoo, Rathindran, & Subramanian, 2001):

1. Trade in construction services – Involves engineering and architectural design, siting, and construction-related services.
2. Trade in tourism and related services – Includes accommodation, catering, and travel agency services required for tourism.

3. Trade in education services – Divided into five subsections: higher education services, secondary education services, primary education services, adult education services, and other education services.
4. Trade in environmental services – Covers services such as sewage and waste treatment.
5. Trade in financial services – Encompasses banking, insurance, and other economic activities.
6. Trade in health and social services – Includes medical and other human health-related services and social services.
7. Trade in business services – Involves services provided in business activities, including personal consumption services and those required by enterprises and governments.
8. Trade in cultural, recreational, and sports services – Excludes television, cinema, and radio services.
9. Trade in communication services – Mainly includes postal, courier, audio-visual, telecommunication, and other related services.
10. Trade-in transport services – Covers freight, passenger, aerospace, and other related services.
11. Trade in financial services – Includes banking, insurance, and asset management activities.
12. Trade in social services – Encompasses goods transport, passenger transport, space launch services, and other transport-related services, along with additional services attached to transport.

4.2 Research results on influencing factors of service trade by foreign scholars

First, foreign scholars have different views on the factors affecting trade in services. Among them, some scholars point out that human capital affects service trade. Riddle (1986) shows through empirical research that human capital significantly impacts the enhancement of service trade's competitiveness. Wyszkowska-Kuna (2014) studies the competitiveness of knowledge- and technology-intensive service trade in Poland and believes that technological innovation and human capital are the main factors affecting service trade.

Other scholars have proposed different factors affecting trade in services. Falvey and Gemmell (1991) argued that the difference in the competitive advantage of trade in services between developed and developing countries is determined by factor inputs of production. Developing countries have an advantage in labour-intensive service trade, whereas developed countries are more competitive in the capital- and technology-based service trade.

Mattoo et al. (2001) studied the impact of market openness in service trade on economic growth, taking financial and telecommunication service sectors as examples, and found that in the long run, the transparency of the financial service sector significantly contributes to economic growth, while service sector liberalisation is generally conducive to economic development.

Eric (2016) found that FDI significantly affects service trade competitiveness and plays a crucial role in promoting service trade. For studies on the factors influencing service trade competitiveness, China is often compared with other countries to analyse the factors affecting international service trade competitiveness.

Waren et al. (2009) studied the sources of competitiveness of information technology-based service trade. They concluded that scale economies and product differentiation enhance the competitiveness of the information services trade sector. For example, Laurent (2020) examined the impact of inter-country factors on various segments of service trade and conducted a comparative analysis (Didier, 2020). The results indicate that inter-country influences strongly negatively impact service trade, with financial and travel service trade particularly susceptible to these effects.

4.3 Chinese scholars' research results on the influencing factors of services trade

In the research on trade in services, Chinese scholars have lagged slightly behind their foreign counterparts. Before the 1990s, scholars primarily focused on theoretical aspects of trade in services. After the 1990s, China's earliest research on trade in services with an open perspective was International Trade in Services. Since then, domestic scholars have begun to explore the factors influencing trade in the service industry. With China's gradual accession to the WTO, the gap between domestic and international research on trade in services gradually narrowed. Chinese scholars started to analyse the competitiveness of trade in services and potential sectors for development.

He (2005) expressed the international competitiveness of service trade by measuring the export volume of service trade. The study results indicated that at the present stage, improvements in China's human capital, urbanisation progress, and the quality of foreign direct investment have enhanced the quality of resource endowment, thereby strengthening the competitiveness of service trade (Ritfak & Bantin, n.d.).

Li and Cai (2008) applied the least squares method to analyse the factors affecting the development of China's service trade. They found that both the growth of the domestic service industry and the expansion of international trade in goods positively influenced the development of service trade.

Li (2022) conducted an empirical analysis using a panel data model and found that the competitiveness of developing countries' trade in services is positively related to economic growth, the level of the service industry, service infrastructure, human capital, and government fiscal expenditure. Conversely, it negatively correlates with trade in goods and foreign direct investment.

Hu et al. (2022) pointed out that human capital in the service industry, economic development levels, foreign direct investment, Internet development, and the openness of service trade contribute to the competitiveness of digital service exports. However, foreign direct investment exerts a dampening effect. In terms of economic development, the expansion of the Internet has a non-significant and weak dampening impact on the competitiveness of digital service exports in developing countries.

Pan and Liu (2022) argued that regardless of whether regional trade agreements (RTAs) are signed, variations in Internet development, trade in goods, and geographical distance significantly impact service trade networks.

Chen and Yang (2020) asserted that economic factors, geographical factors, and trade agreement conditions primarily influence the formation of regional trade agreements in services.

Lu (2023) emphasised that GDP per capita, service trade openness, foreign direct investment, and the development of trade in goods positively affect China's service trade exports.

He and Wang (2020) examined the openness level and influencing factors of productive service trade from the perspective of productive service trade, using panel data from BRICS countries to conduct an empirical study.

5 The influence of business environment changes on service trade

Optimising the business environment is essential in enhancing trade competitiveness in services. The business environment reflects the competitiveness level of a region, especially in its far-reaching impact on tertiary industries such as finance, tourism, computer and information services, education, health, and the environment, which are directly linked to import and export trade. A favourable business environment promotes trade development in these services, strengthens the competitiveness of China's trade in services, and expands the scale and quality of exports.

The policy environment, market environment, social environment, infrastructure environment, and public service environment constitute key elements of the business environment. These elements significantly promote the service industry's high-quality development by reducing transaction costs for enterprises, enhancing market vitality, improving service industry productivity, and facilitating structural upgrades within the sector. Since different regions have varying development conditions, institutional frameworks, and resource endowments, the degree of impact of optimising the business environment on service industry development also varies. In economically developed regions with well-established conditions, business environment optimisation significantly fosters high-quality growth in the service sector. Additionally, business environment optimisation promotes high-quality service industry development through innovative incentives and enhanced communication mechanisms.

By opening up the service industry, enterprises can access higher-quality intermediate service inputs, encourage competition, and adopt advanced technologies and practices, thereby improving the production quality of final products. However, different types of enterprises experience varying degrees of impact from the liberalisation of the service sector. The quality of export products from general trading enterprises is more susceptible to the effects of service sector liberalisation. At the same time, the quality of export products from non-state-owned enterprises is also more significantly influenced.

Moreover, the business environment directly affects how service liberalisation enhances export product quality in manufacturing enterprises. Improving the business environment facilitates the growth of the non-state economy and enhances product quality. It also significantly impacts foreign enterprises in the service sector, improving their operating conditions. On the other hand, enhancements in the business environment encourage competition among domestic enterprises, boost their learning capacity, and maximise the spillover effects of service liberalisation. Additionally, improvements in the business environment contribute to the development of the product and factor markets, forming a more complete industrial chain and promoting the expansion of China's cross-border service enterprises.

6 Policy recommendation

6.1 Promoting regional coordination to realise the healthy development of trade in services

There is an uneven regional development of the domestic service industry. There are significant gaps between the eastern and western regions, coastal and inland areas, economically developed regions, and economically less developed regions, and local governments need to adapt to local conditions and adopt service industries and policies suitable for their regions. Financial expenditure and policies should be biased in favour of economically underdeveloped regions so that these regions can have the basis for developing their industries with comparative advantages. The state should formulate and introduce relevant policies, establish an orderly market system, and build financial services and other public service platforms so that more enterprises can participate in the development of the service industry to create good conditions for resources, explore new development modes, to narrow the gap in trade in services across the country.

6.2 Improve the financial market system to make financing more convenient

For science and technology service-oriented enterprises, capital is a key element in the entrepreneurial process, and a continuous supply of capital is a necessary prerequisite for SMEs to research and develop new technologies and products in the early stage of entrepreneurship. However, as it is difficult for SMEs to obtain financial support from financial institutions at the early stage of their Business, the government will support the expansion of credit and financial service channels and improve the financing system to ensure that SMEs have sufficient funds to invest in innovation. Therefore, a sound financing system is an effective guarantee to promote financing for technology-based service enterprises. By strengthening financial innovation, the government can encourage the comprehensive development of the service industry, the benign development of the service industry, and the development of the much-needed intellectual property trade. Through financial innovation, the government can reduce the management cost of enterprises, make finance work more effectively, and realise the integration effect of "1+1>2". At the same time, the government can improve the financial environment by reducing information asymmetry and increasing financing channels. Through tax incentives, tax breaks, and other disguised tax reduction measures, it can increase the liquidity of enterprises for R&D and innovation activities, stimulate export growth of enterprises, boost regional economic growth, and improve the innovation ability and international competitiveness of Chinese service enterprises.

7 Conclusion

Comprehensive domestic and foreign research on the impact of service exports and business environment found that scholars at home and abroad on the one hand, research on the business environment are mainly focused on the connotation of the business environment, the economic effect, the evaluation of the index system, and the impact of investment; on the other hand, the research on the trade in services is mainly focused on the study of export competitiveness and the impact of the factors, as China's trade in services expanding the scale of trade in services, the effect of the institutional environment on the trade in services has not been ignored. Still, there is a lack of research on their relationship.

With the expansion of China's service trade, the impact of the institutional environment on service trade can not be ignored, but there is a lack of research on the relationship between the two; this paper further collates relevant studies on the impact of business environment optimisation on the high-quality development of the service industry, and after sorting out, it is found that the business environment of the market environment, the institutional environment, and the infrastructural environment faced by a country or a region is an essential factor that affects the transformation and the high-quality development of the service industry. The optimisation of the business environment has played a prominent role in promoting the high-quality development of the service industry. However, business environment optimisation's role in promoting the service industry's high-quality development varies in different regions. In the eastern and central areas, optimising the business environment is very beneficial to the development of the service industry. In contrast, in the western region, the optimisation of the business environment does not play a prominent role in promoting the high-quality development of the service industry.

From the viewpoint of internal mechanisms, the optimised business environment can positively promote the service industry's high-quality development through information communication and innovation incentives. The business environment for high-quality service industry development is a comprehensive and complex system, which contains many aspects and enriches the research perspective.

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XVIII. Research on the Export Trade Potential of Chinese Agricultural Products With Belt and Road Countries

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This paper focuses on the trade potential of agricultural products, exploring the development and application of the gravity model for measuring trade potential from both domestic and international perspectives. Scholars commonly use GDP, population, and spatial distance as primary indicators. From the perspective of the agricultural product trade potential, the paper analyses agricultural trade research between Belt and Road countries and other regions. It focuses primarily on measuring trade potential from China's perspective, with limited studies on other countries' trade potential with China. The analysis often involves comparative advantage and complementarity indicators, with limited use of the Trade Potential Index (TPI).

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1 Introduction

2013, during visits to Central and Southeast Asian countries, Chinese President Xi proposed a significant initiative to develop and continue the Maritime Silk Road Economic Belt. Under China's leadership as the economic locomotive, 65 countries, including those in East Asia, ASEAN, West Asia, South Asia, Central Asia, and the Commonwealth of Independent States, actively participated in constructing the Belt and Road economic initiative. Since then, stable financial and trade relations have been established between China and these 65 countries. This cooperation spans various fields, including infrastructure construction, opening of maritime port routes, and comprehensive agricultural development. The countries along the route possess abundant resources and diverse product categories, facilitated by convenient international transport, promoting frequent exchange of goods among these nations.

Notably, the Central Committee's No. 1 Document in 2024 explicitly emphasises the need to deepen agricultural cooperation with Belt and Road countries. This policy indicates China's increased focus on agricultural cooperation with Belt and Road countries, highlighting the importance of collaboration and communication in the agricultural sector. It further underscores the broader prospects for future farm cooperation and trade, providing robust policy support for more in-depth and comprehensive agricultural product collaboration between Belt and Road countries.

Research on the export trade potential of Chinese agricultural products in Belt and Road countries holds theoretical and practical significance. Firstly, as globalisation deepens and international economic interdependence increases, agricultural product trade plays a crucial role in international trade. Therefore, in-depth research on the trade potential of Belt and Road countries of Chinese farm products helps better understand and grasp the current global trends in agricultural product trade.

Furthermore, this study contributes to advancing the implementation of the Belt and Road initiative. Understanding the demand and potential for Chinese agricultural products in Belt and Road countries can optimise trade policies and promote sustainable agrarian trade development. It provides concrete and practical guidance for economic cooperation among Belt and Road countries, facilitating regional economic integration and achieving the strategic goals of the Belt and Road initiative. Understanding the demand and preferences of countries for Chinese agricultural products can offer scientific policy recommendations, aiding in the formulation of flexible trade policies that adapt to market demands and enhance the efficiency of agricultural trade. Additionally, this research strengthens international cooperation and supports joint efforts to address global challenges. As agricultural trade is a crucial aspect of international economic cooperation, it involves food security and sustainable agricultural development. By thoroughly researching the trade potential of agricultural products between countries, new insights and directions can be provided for global agricultural cooperation, contributing to establishing cooperative mechanisms to address global challenges.

Therefore, in-depth research on the export trade potential of Chinese agricultural products in Belt and Road countries not only promotes the development of international trade but also provides more opportunities for cooperation among nations, contributing new knowledge and practical experience to global agricultural trade and sustainable development.

2 Trade potential research overview

Since the inception of the Belt and Road Initiative in 2013, there has been a continuous proliferation of literature on Belt and Road trade. Regarding trade potential, Kong and Dong (2015) posit that the trade potential among Belt and Road countries is substantial, with the size of trade potential positively correlated to a nation's economic prowess. Given that agriculture serves as the bedrock of a nation's economy and considering China's status as an agricultural powerhouse, special attention should be directed towards issues about the trade of farm products.

He (2008), employing the Revealed Symmetric Comparative Advantage (RSCA) index and regression analysis, notes a declining overall comparative advantage in China's agriculture, with more agricultural products lacking comparative advantage. Yet, stability persists in the agricultural trade pattern (He, 2008). Extending He's (2008) theoretical framework, Xian (2011) concludes that China's comparative advantage in agricultural products exhibits no discernible fluidity. Hence, research on Belt and Road countries' trade in Chinese agricultural products is imperative. Although there is currently limited literature on Belt and Road countries' exports of agricultural products to China, substantial research exists on trade potential and agricultural potential.

2.1 Trade potential

Trade potential, measuring the benefits a country can accrue when transitioning from a market with trade barriers to one without, is primarily analysed through the gravity model. Foreign research on trade potential dates back to the last century. Drawing inspiration from Newton's law of universal gravitation, Tinbergen (1962) and Pöyhönen (1963) utilised the gravity model to analyse bilateral trade between countries, reaching a consensus that the scale of trade between two countries is directly proportional to their economic size and inversely proportional to the distance between them. Economic size reflects potential supply and demand capacities, while distance constitutes a trade barrier.

Building on these studies, Aigner and Schmidt (1977) proposed the stochastic frontier estimation method. Anderson and Van Wincoop (2001) derived an operationally robust gravity model based on the constant elasticity of the substitution expenditure system. This provided theoretical support for the gravity model and helped explain various issues and differences in empirical applications, gradually dispelling longstanding doubts about its "lack of theoretical foundation."

Subsequent scholar Batra (2006) utilised an enhanced gravity model with 146 countries as samples, concluding that India and China exhibit tremendous trade potential. Ravishankar and Stack (2014), analysing panel data of 17 Western European countries' bilateral exports to 10 new member countries between 1994 and 2007, identified Hungary, Estonia, and Poland as possessing the most significant trade potential in Eastern Europe. Viorica (2015), using the stochastic frontier gravity model, compared Romania with other EU member states to estimate the trade potential of Romania and EU countries. Tamini and Abbassi (2016) used the stochastic frontier gravity model to analyse the trade potential and realised trade between North African trading partners.

Domestically, research on trade potential is equally profound. Gu (2001) economically analysed the gravity model's theoretical foundation and construction methods, verified it through mainstream international trade models, and proposed a preliminary plan for constructing China's trade gravity model. Lin and Wang (2004), based on Gu (2001), conducted empirical tests, concluding that given limited trade development potential, China should fully utilise domestic resource endowments to deepen domestic trade. Liu and Jiang (2002) classified trade potential into potential reshaping, potential exploration, and substantial potential types based on the ratio of bilateral trade to predicted bilateral trade. Lu and Zhao (2010) estimated China's export potential using the stochastic frontier gravity model.

Bi and Shi (2010), as well as Wang and Wu (2016), established stochastic frontier gravity models to estimate the trade potential, trade inefficiency level, and influencing factors of the Silk Road Economic Belt. They concluded that China's trade inefficiency with Iran, Kyrgyzstan, Ukraine, and Russia is relatively high, and there is significant room for improvement in trade efficiency with these countries.

The diverse range of research methodologies and findings from both international and domestic perspectives contribute to a comprehensive understanding of trade potential within the Belt and Road framework. These studies provide valuable insights for policymakers and contribute to the overall knowledge base of Belt and Road trade dynamics.

2.2 Agricultural product potential

Numerous scholars have put forth their perspectives on the trade potential of agricultural products within the Belt and Road Initiative. Li (2016), employing the stochastic frontier gravity model, examined the agricultural trade potential and influencing factors between China and 30 Belt and Road countries from 2005 to 2014. They concluded that total population and per capita GDP exhibit a significant positive correlation with agricultural trade potential, while geographical distance demonstrates a significant negative correlation.

Using the stochastic frontier gravity model, Li and Zhoz (2016) reexamined China's agricultural trade with Central and Eastern European countries. The results indicated a low average efficiency in agricultural trade between China and Central and Eastern European countries, highlighting substantial trade potential. Furthermore, China's import and export markets predominantly focus on a few countries, such as Poland, Romania, the Czech Republic, and Lithuania, showcasing strong complementarity in agricultural trade with these Central and Eastern European nations.

Using the trade intensity index, Yang and Tian (2018) analysed the trade potential characteristics of agricultural products between China and countries along the 21st Century Maritime Silk Road. The conclusion was that China possesses significant trade potential with Maritime Silk Road countries, particularly with ASEAN nations such as Malaysia, Indonesia, and Thailand.

Using the stochastic frontier gravity model, Yang and Qi (2023) analysed the agricultural trade potential of countries along the Silk Road Economic Belt from an income perspective for 1995-2016. The findings indicated that the Central Asian Economic Belt countries possess the highest overall agricultural trade potential, followed by countries surrounding the Central Asian Economic Belt, with the countries along the Asia-Europe Economic Belt exhibiting minor potential.

Beyond the Belt and Road Initiative, research on the trade potential of agricultural products in other regions is also substantial. Zhao and Lin (2008), through quantitative analysis using the gravity model, assessed the agricultural trade between China and the 10 ASEAN countries. They identified factors such as total GDP, population size, and spatial distance as primary influencers of bilateral agrarian trade flow between China and the ASEAN 10, predicting significant untapped trade potential and emphasising substantial room for developing bilateral agricultural trade.

Tan and Chen (2016), based on agricultural trade data from 1995 to 2013, employed the gravity model to analyse the current status and structure of China's agricultural trade with the five Central Asian countries. Their study estimated the trade potential values for four major agricultural product categories and classified agricultural products, revealing considerable untapped potential in overall agrarian trade between China, Kazakhstan, and Tajikistan across these four categories (Tan & Chen, 2016).

Li and Zhou. (2021), examining agricultural trade data between 2000 and 2020 among BRICS countries, focused on agricultural trade characteristics. The results indicated that economic size and market share positively impact trade, while economic distance has a negative effect. They concluded that China's agricultural trade with BRICS countries falls under the "trade exploration" category, suggesting untapped potential and room for improvement (Li & Zhou, 2021).

3 Review of relevant studies

An analysis of the literature reveals a rich and multidimensional exploration of trade and agricultural trade potential, yielding significant outcomes. Most scholars conducting trade potential research utilise the gravity model, which evolved from the field of physics, for analysis. The gravity model has been continually refined throughout numerous studies, gaining scientific and empirical validity and gradually dispelling doubts about its theoretical foundation. Nevertheless, the gravity model itself has limitations. Most scholars analyse factors influencing trade potential from an economic perspective, such as GDP, per capita GDP, and integration levels, or consider geographical factors like distance and shared language. In comparison, fewer scholars explore factors influencing trade potential from non-economic perspectives, such as history, religion, geopolitical relations, and culture. This is attributed to the difficulty of quantifying these non-economic factors with specific indicators or data, making their integration into the gravity model for regression analysis challenging.

In China, research on trade potential predominantly focuses on studying outward agricultural trade potential with China as the main subject. Due to the complementary nature of China's agricultural trade with many countries worldwide, other nations should also exhibit potential for agricultural trade with China. However, there is limited in-depth analysis of trade potential and trade efficiency from Belt and Road countries regarding their export of agricultural products to China. Furthermore, Chinese research on agricultural trade potential often stays at the competition and complementarity levels, with limited utilisation of other measurement indicators.

In light of the above, this paper proposes using the Trade Potential Index (TPI) to assess the trade potential of Belt and Road countries in exporting agricultural products to China. The gravity model will be incorporated to address the limitation of TPI, which can only measure overall trade potential and cannot distinguish between import and export trade potential. This approach aims to estimate the trade efficiency of Belt and Road countries in exporting agricultural products to China and identify factors influencing this efficiency, ultimately calculating the trade potential and expansion space for agricultural export trade.

4 Conclusion

Our research delved into the export trade potential of Chinese agricultural products in Belt and Road countries. The agricultural sector has immense trade potential between China and Belt and Road countries. Comparative analysis shows that these countries possess rich resources and diverse product demands, which China's agricultural exports can fulfil, further deepening trade cooperation. Implementing the Belt and Road Initiative has been pivotal in driving agricultural trade between China and these countries. Progress in infrastructure development, trade facilitation, and policy communication has created a more favourable environment and opportunities for agricultural trade.

Government policy support is crucial for fostering agricultural trade cooperation among Belt and Road countries. Governments should increase policy support, formulate more flexible trade policies, and promote healthy agricultural trade development. Additionally, the establishment of cooperation mechanisms is paramount. Strengthening international cooperation mechanisms to facilitate information exchange, technological cooperation, and market expansion will collectively drive agricultural trade development. Sustainable development is crucial in agricultural trade. In the future, emphasis should be placed on environmental protection, sustainable resource utilisation, and agricultural technology innovation to achieve sustainable development goals in agricultural trade.

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XIX. Analysis of Enterprise Digital Transformation Under the Background of "One Belt and One Road" – a Case Study of Dashang Tiangou

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With the rapid development of digital trade, many real enterprises have gradually joined the wave of transformation and upgrading. Taking Dashang Group as an example, this study deeply discusses the impact of trade digitalisation on enterprise transformation and upgrading. The study finds that digital transformation helps improve enterprises' market competitiveness but also needs to cope with challenges such as technology updates and data security. Finally, this paper puts forward policy recommendations and points out research limitations and future research directions. This study not only helps to understand the impact of trade digitalisation on enterprise transformation and upgrading but also provides a valuable reference for real enterprises to achieve sustainable development in the fierce market competition.

Keywords:
digitalisation of trade, transformation and upgrading of enterprises, digital transformation, Dashang Group, case study

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1 Introduction And Literature Review

1.1 Background of Research

In today's increasingly deepening globalisation, trade is no longer a simple exchange of goods but involves cultural, political, economic, and other levels of exchange and cooperation. Since the concept of "digital trade" was proposed by the United States International Trade Commission in 2013, it has become the trade direction supported and developed by major economies worldwide. It has also emerged as the core driving force for enterprises in various countries to enhance their competitiveness, bringing vast market opportunities and development potential for traditional trade in goods and services (Hua & Liang, 2024).

The theoretical framework of trade digitalisation primarily involves the application of information technology, developing e-commerce, optimising supply chain management, and innovations in cross-border payment systems. With the rapid development of digital technology, studies on enterprise transformation and upgrading have gradually increased, offering suggestions for promoting the optimisation and upgrading of industrial structures (Liu et al., 2024).

As more scholars invest in research, it has been found that the digital transformation of enterprises significantly contributes to improving the value chain (Karrie, 2022). Digital transformation optimises trade processes through technological advancements and enables rapid responses to customer demand, enhancing enterprise competitiveness. Additionally, digitalisation promotes the facilitation and transparency of international trade, gradually becoming a crucial force driving the development of global trade. At the same time, enterprise digital transformation effectively promotes industrial upgrading, and this influence extends across industries through spillover effects (Du & Lou, 2022).

Therefore, the expansion of digital markets and digital technology not only presents broader international market prospects for large enterprises such as Dashang Group but also fosters economic and technological exchanges and cooperation among countries and regions along the Belt and Road Initiative, leading to mutually beneficial outcomes for national industries and export enterprises. However, while enjoying these opportunities, transforming enterprises face numerous challenges, such as intensified market competition and increasingly diversified customer demands. Although the digital development of Chinese enterprises is progressing well, there remains the issue of imbalanced digital development among enterprises (Wang, 2020).

Thus, studying the impact of trade digitalisation on enterprise transformation and upgrading is of great practical significance and theoretical value.

1.2 Definition of concept

Due to the different regulatory rules of international organisations, the difficulty of quantifying the value of data, and the challenges in differentiating new business models generated by integrated development, there is no unified definition of trade digitalisation. However, the conceptual approach remains broadly consistent. Most scholars refer to the framework established by the International Trade Commission of the United States when conducting empirical research, selecting indicators related to digital trade development to construct a digital trade development index to measure trade digitalisation levels. As a result, there is a lack of uniformity in selecting indicators for measuring trade digitalisation.

Recognising the growing importance of digital trade, the United States International Trade Commission categorised digital trade into four segments in 2013: digital content, social media, search engines, and other digital products and services, facilitating the statistical measurement of digital trade. It also introduced the concept of digitally enabled services; however, broadening the definition of digital trade in this manner may complicate its measurement. Research institutions and scholars worldwide have increasingly focused on digital trade as digital technology advances.

The White Paper on Global Digital Trade (2021) defines digital trade as "the deep integration of digital technology into trade development processes, linking the information interaction and response channels of the production end, trading end, and supply chain end within the industrial chain to build new supply-demand relationships and synergistic relationships, ultimately enhancing industrial chain efficiency." This definition emphasises the digitalisation of trade models.

Professor Ma Shuzhong has provided one of the most comprehensive and authoritative definitions of digital trade among domestic scholars. He describes digital trade as "the efficient exchange of traditional physical goods, digital products and services, digital knowledge, and information through the effective use of information and communication technology, with modern information networks as the carrier. This process facilitates the transition from consumer Internet to industrial Internet and ultimately realises intelligent trade activities in the manufacturing industry" (Ma, Fang, & Liang, 2018).

With the rapid development of the Internet and digital technologies, Ma Shuzhong revised this definition in 2020, refining the "Digital Trade 2.0" concept: "With digital platforms as the carrier, through the effective use of digital technologies such as artificial intelligence, big data, and cloud computing, the precise exchange of physical goods, digital products and services, digital knowledge, and information can be realised. This transformation promotes the shift from consumer Internet to industrial Internet and ultimately leads to intelligent trade activities in the manufacturing industry" (Ma & Pan, 2020). Compared to version 1.0, version 2.0 emphasises the role of digital platforms in trade, better reflecting the digital transformation of trade in the digital era.

In 2023, Dr. Li Cuini put forward a similar perspective, referencing the Digital Trade Measurement Manual released by the OECD. She defined digital trade as "all domestic and international transactions that are digitally ordered and delivered, including international transactions of goods or services realised by digital ordering and digital delivery, as well as domestic trade" (Li, Cui, & Dong, 2023). This definition also incorporates trade in digital services and digital goods.

Other scholars, such as Xiao and Xia, categorised digital trade into broad and narrow concepts, including "goods" as the key distinguishing factor between the wide and narrow definitions of digital trade (Xiao & Xia, 2019).

Some scholars regard value appreciation as the primary indicator of enterprise (or industry) upgrading when measuring enterprise transformation and upgrading. They argue that the higher the value-added rate of an enterprise, the higher its position within the value chain, leading to a more successful transformation and upgrading process (Ma, Zhang, & Wang, 2017).

Other researchers have attempted to quantify enterprise transformation and upgrading through empirical research (Yu, Meng, & Zhang, 2017). However, in the World Bank's survey data on Chinese enterprises, the questionnaire for service enterprises does not include fixed assets, making it impossible to use TFP (Total Factor Productivity) for calculation (Wang, 2020).

As a result, labour productivity has been widely used to represent the transformation and upgrading of service and manufacturing enterprises (Li & Yan, 2018). Sun Zhongjuan and Lu Lan further defined digital transformation as "a process in which multiple attributes of an enterprise (such as business processes, organisational structure, business model, and connection with other actors) undergo significant transformation through the application of digital technology and data resource analysis, achieving organisational objectives more efficiently" (Sun & Lu, 2023). This concept extends digital transformation into a multifaceted framework encompassing various attributes of enterprise development.

1.3 Theory and hypothesis of enterprise digital transformation

With the rapid development of trade digitalisation, more and more real enterprises have begun to explore the road to digital transformation. However, there are still many unknown questions about the impact of trade digitalisation on the transformation and upgrading of enterprises. Before studying these issues, examining the theoretical basis of enterprise digital transformation is necessary.

Dynamic capability theory in the context of the digital economy

According to this theory, dynamic capabilities are the foundation of digital transformation (Xiao, 2017). The dynamic capabilities theory advocates that organisations should adopt an "alliance" management model, enhance employee capability input, establish efficient teams, and introduce modern information technologies to foster communication and collaboration.

Digital platform theory

Digital platform theory posits that to realise the full potential of digital transformation, companies must adopt digital platforms. As key carriers of resource aggregation, digital platforms facilitate cross-border integration, resource sharing, and diversified innovation with the support of digital technologies (Yu, Meng, & Zhang, 2017). Based on this theory, existing research has focused on digital platform services, business model evolution (Zhou & Cheng, 2021), value creation (Feng, Wang, & Zhou, 2022; Zhou, Wenhui, Li, & Li, 2022), platform governance, and other issues.

Combination of dynamic capability theory and digital platform theory

This paper argues that when digital platform theory is combined with dynamic capability theory, firms can establish an operational system that possesses both strong technical capabilities and high adaptability. Specifically, digital platforms provide an extensible framework for enterprises to implement refined operations. At the same time, dynamic capabilities enable firms to flexibly adjust strategies and quickly respond to market changes, facilitating transformation, upgrading, and enhancing competitiveness in an increasingly dynamic market environment.

Hypotheses development

Based on the above theoretical analysis, this paper proposes the following hypotheses:

Hypothesis 1: The trend towards digitisation of trade will prompt firms to use digital platforms to collect and analyse user data to adapt to market changes.

Hypothesis 2: Digital platforms serve as collaboration and innovation hubs, enabling firms to jointly partner with external stakeholders to create more value.

1.4 Research methods and data sources

To verify the above hypotheses, this study will adopt the research method of case study, take Dashang Group, a listed enterprise, as the research object, through a literature review, expert interviews and case analysis, conduct an in-depth analysis of the practice of trade digitalisation of Dashang Group, and deeply explore the influence mechanism of trade digitalisation on enterprise transformation and upgrading. This paper discusses the general law and influence mechanism of trade digitalisation on enterprise transformation and upgrading. As a representative enterprise of China's large retail industry, the trade digitalisation practice of large business Groups has a specific reference value for studying the impact of enterprise transformation and upgrading. The data come from relevant policy documents issued by the government, industry reports, the official website of Dashang Tiangou and relevant public materials. In addition, this study will collect first-hand information through field interviews to enhance its empirical and reliability. In summary, this study will explore the new opportunities and challenges of business transformation and upgrading from the perspective of trade digitalisation to provide useful reference and enlightenment for policymakers and business decision-makers.

2 Case study

2.1 The digital strategic layout of the Dashang Tiangou network

Founded in 2014, Dashang Tiangou is a pioneer e-commerce platform established by Dashang Group in response to the trend of trade digitalisation. It is based on the booming development of China's e-commerce market and the increasingly urgent need to transform the traditional retail industry, aiming to promote trade circulation through digital means. In terms of competitive strategy, Dashang Tiandog emphasises quality and service and has established close cooperative relations with well-known brands at home and abroad. Its competitive strategies include localised service, diversified market entry, and strengthening of partner network. Its business model and service features mainly include:

Online and offline integration. Since its establishment, Dashang Tiangou has been positioned to build an e-commerce platform that integrates online and offline. It provides consumers various online products for an all-around and one-stop shopping experience. It combines offline resources to ensure commodity quality and service level through physical stores, warehousing, and distribution centres. At the same time, due to the difference between the contracted brands and the purchase channels, the online commodity prices of Tiangou.com are different from those of the offline supermarkets of Dashang Group, which creates price advantages for the commodities of Tiangou.com.

Diversified business forms. In addition to the traditional retail business, Tiangou has also introduced multiple business forms, such as life service. Its business model integrates O2O transactions, online payment, supply chain management and cross-border e-commerce services to form a comprehensive business ecology. Its service features also include providing multi-language customer support and reducing transaction costs caused by language barriers. And streamline cross-border trade processes with one-stop solutions.

Customised services. Dashang Tiangou is mainly positioned in the middle and high-end market, focusing on brand building and consumer experience. As the embodiment of the online operation of Dashang Group, its primary function focuses on the digital business of Dashang Group. Hence, it naturally inherits the member resources of Dashang Group, and the number of registered members has reached more than 30 million. For different consumer groups, Dashang Tiangou launched customised services and products.

With the deepening of digital transformation, Dashang Tiangou has successfully applied digital technology to its business model and operation process, which has had a positive impact. Currently, the Tiandog team has a professional team of 90 people, among which technical research and development personnel occupy an essential position, including research and development personnel, testing personnel, etc. Therefore, its digital technology is mainly independent research and development while jointly developing some technologies with partners, such as cloud services and hardware procurement, to ensure the advancement and practicality of technology.

Business digitalisation. By building a business centre, Dashang Tiangou has realised centralised management and efficient processing of business data, improving business efficiency and decision-making quality and laying a solid foundation for subsequent data commercialisation.

Data commercialisation. Dashang Tiangou has established a data warehouse to mine the value of data deeply through BI tools and data analysis reports. In addition, recommendation systems, precision marketing, and user behaviour analysis make data better served by the business and realise data commercialisation. At the same time, the data management platform ensures data security and compliance, providing a guarantee for the steady development of enterprises.

Technical support for offline business. Dashang Tiangou has developed an MIS system suitable for more than 100 and some comprehensive business forms and realised the comprehensive management of offline business. For electrical business, the ECMS system provides professional solutions to ensure the smooth operation of the electrical industry.

Technical support for online business. In the online field, Tiangou order, ERP and seller centre systems constitute the technical support system of Dashang Tiangou. These systems are suitable for the online management of over 100 and some comprehensive business forms, which not only improve the processing efficiency of online business but also provide convenient management tools for sellers and promote the rapid development of online business.

2.2 Evolution of digital business models

The digital strategy of Dashang Group, relying on the Tiangou team, focuses on two key aspects: technological innovation and data-driven business decision-making. The digital development of Dashang is divided into three evolutionary stages: large-scale, systematic, and intelligent (Jiao, Yang, & Wang, 2021). This framework describes the integration process between the real economy and the digital economy, highlighting the progressive digital transformation undertaken by the company.

The scale of digital platform (2014-2017)

In the early stage of platform formation, amid increasingly intense domestic and international market competition, Dashang Group's management recognised the limitations of traditional trade methods. At the same time, they acknowledged the positive impact of e-commerce on commodity sales, leading them to initiate the development of an international digital platform. During this period, digital technology applications further enhanced the network effects of physical malls, improving enterprise management efficiency. The Tiangou platform was crucial in supporting enterprises through digital transformation and intelligent operations.

With Dashang Group's digital transformation onset, member services gradually shifted online, offering consumers a more seamless and convenient service experience. By leveraging digital technologies, Dashang Tiangou integrated physical products with application scenarios, enabling offline QR code payments, intelligent parking lot payments, and electronic code verification. Additionally, consumers benefited from in-store self-pickup and logistics distributeon options for online purchases, significantly enhancing shopping convenience.

Regarding intelligent operations, Tiangou actively adopted artificial intelligence (AI) to optimise warehousing management, logistics operations, and supply chain management, significantly improving overall operational efficiency. Furthermore, the integrated application of Internet of Things (IoT) technology enabled real-time tracking of goods from production to sale, enhancing supply chain transparency and overall operational efficiency.

To ensure a frictionless payment experience, Tiangou integrated multiple mobile payment methods into the enterprise's service ecosystem, providing a secure and seamless transaction process. Dashang Group adopted the Kingdee system as its core platform in financial management, facilitating centralised financial oversight and regulation at the group level. This ensured financial stability, transparency, and enhanced efficiency in financial monitoring.

By the end of 2017, Dashang Group achieved notable financial improvements, including:

- A net interest rate of 3.18%, reflecting a 0.85 percentage point increase year-on-year.
- Operating costs of 2.069 billion yuan, marking a 5.12% reduction year-on-year.
- Selling expenses of 171 million yuan, demonstrating a 4.79% decrease year-on-year.

– Administrative expenses of 260 million yuan, showing a 9.12% reduction year-on-year.

Systematisation of digital platforms (2018-2021)

Growth Stage of the Platform

During the growth stage of the platform, Tiangou began to develop a platform with trading functions while offering initial and independent supply chain services. At this stage, the platform provided limited online information matching services, requiring each brand to acquire its online marketing capabilities from customer and platform resources.

With technological advancements, enterprises' backend operation systems gradually transitioned to digitalisation, significantly enhancing operational efficiency. Online marketing further expanded business opportunities, mainly through live streaming, crucial during the COVID-19 pandemic, helping businesses continue operations despite store closures. Additionally, unified and centralised distribution services became instrumental during this period, with Dashang Group even serving as a government-designated distribution point, fully demonstrating the adaptability of the enterprise.

Regarding inventory management, the Tiangou team digitally transformed Dashang Group's inbound and outbound warehousing system, ensuring seamless commodity operations. Within the marketing process, Tiangou's "In-flight Shopping Guide System APP" enabled precision marketing by tagging customer preferences and sending timely reminders. This innovation significantly enhanced the efficiency of shopping guides, offering consumers a more personalised shopping experience through continuous improvements in marketing tools, such as the "Dashing Intelligence Chain System" The company further leveraged shopping guide potential.

Social E-Commerce Transformation

Tiangou actively embraced social e-commerce transformation, utilising social media platforms to develop diverse social e-commerce functions. These efforts not only strengthened consumer interaction but also boosted user engagement. The deep integration with WeChat Enterprise facilitated data synchronisation with the "In-flight Shopping Guide System APP", improving customer management mechanisms and service efficiency.

Additionally, the comprehensive integration of the Tiangou Mini Program, official APP, and corporate WeChat account helped physical stores overcome time and space limitations, enabling broader customer engagement. This strategy enhanced brand awareness and introduced new growth drivers for physical retail stores.

Financial Performance by 2021

By 2021, Dashang Group achieved notable financial growth, reflected in the following performance indicators:

- Operating profit: 1.204 billion yuan, an increase of 19.92% year-on-year.
- Net profit margin: 8.85%, marking a 43.9% increase year-on-year.
- Operating costs: 4.786 billion yuan, representing an 11.27% decrease year-on-year.
- Operating profit: 1.123 billion yuan, up 11.85% year-on-year.
- Selling expenses: 969 million yuan, down 4.15% year-on-year.
- Administrative expenses: 802 million yuan, rising 19.52% year-on-year.
- Inventory: 4.204 billion yuan, an increase of 5.73% year-on-year.
- Employee compensation payable: 68 million yuan, down 17.07% year-on-year.

Intelligent digital platform (2022 -- now)

Mature Stage of the Platform

In the mature stage, Tiangou has developed the capability to provide enterprises with end-to-end supply chain services. By leveraging digital tools and services, the platform enables more accurate and comprehensive data acquisition, fostering a deeper understanding of resource allocation and consumer demand. This lays a solid foundation for enhancing core enterprise competitiveness, facilitating operational upgrades and international expansion.

With the continuous evolution of digital technology, managers are focused on integrating digital applications into business operations, effectively enhancing operational efficiency. During this process, implementing Dashang Intelligence Chain mini-programs, data assets, AI-driven analytics, data heat maps, and various patented technologies provides strong technical support for enterprise development.

Data-Driven Decision-Making

The data-driven decision-making model has become a key strategic tool for enterprises. Through big data analytics, companies can monitor consumer demand and market trends in real-time, providing precise data support for business decisions. Dashang Tiangou applies AI-driven marketing, utilising advanced algorithms to analyse user behaviour, enabling accurate product recommendations.

Additionally, cloud computing infrastructure ensures platform stability and secure data backups, while transaction security measures protect consumer data. Integrating intelligent recommendation systems further enhances the user experience by analysing consumer behaviour and shopping habits and delivering personalised product suggestions that meet individual shopping preferences.

AI technology has significantly improved response times and service quality in the customer service sector, ensuring that consumer inquiries and requests are addressed promptly and effectively. This data-oriented decision-making model enables enterprises to maintain a competitive advantage in an increasingly dynamic market environment.

Cross-Border Expansion and Belt and Road Initiative

By combining digital operations with physical retail, Tiangou has actively expanded into cross-border business, initiating international operations in 2018 and planning to enhance its platform system by 2024. In cross-border e-commerce, enterprises have aligned with the Belt and Road Initiative, engaging in strategic collaborations with Russia, New Zealand, and other participating countries and regions.

This expansion strategy has broadened the consumer market and introduced a more diverse range of product offerings to customers. Through cross-border partnerships, Tiangou drives international trade growth, supporting economic cooperation and technological integration across Belt and Road countries.

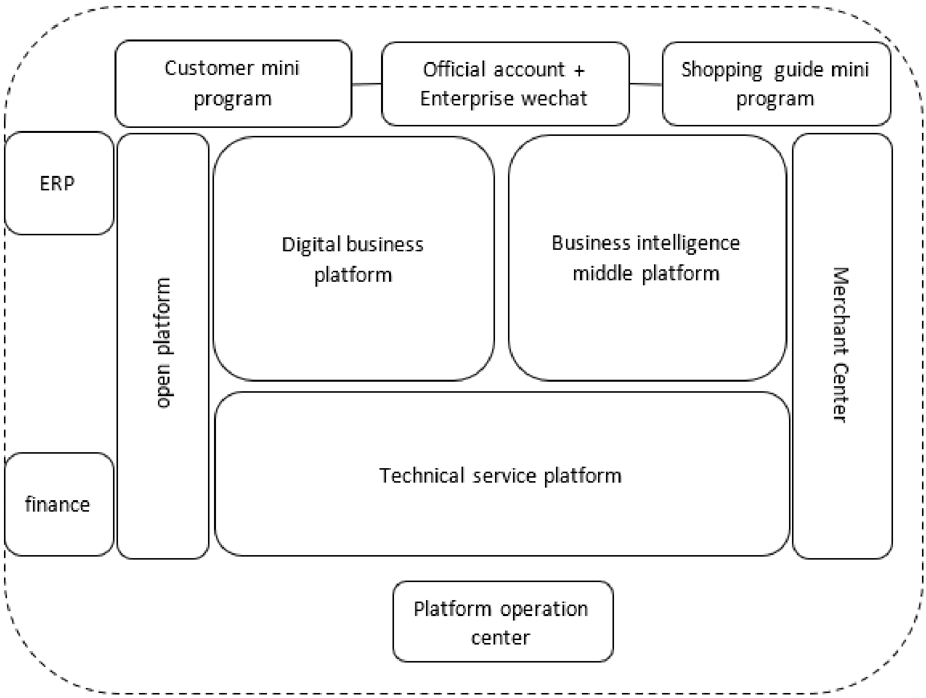

Figure 1 Dashang Group New Retail Operating System

Through digital transformation, Dashang Tiangou has not only optimised its internal management and operation process, formed a set of unique and complete new retail operating systems, enhanced its competitiveness through the "physical + digital" operation system, but also brought users a better service experience, and finally laid a solid foundation for the sustainable development of the enterprise.

3 The study's findings

3.1 Main challenges and coping strategies

Although Dashang Tiangou has achieved significant progress in digital transformation and upgrading, it also faces a series of challenges related to the application of digital technology.

Technological Innovation and Talent Shortage

With the continuous digitalisation of Dashang Group, new technical challenges constantly emerge, requiring enterprises to upgrade their technical architecture and optimise system functions to meet increasingly diverse user needs. Despite the maturity of Tiangou's digital products, the company must continuously iterate and refine its systems to keep pace with business evolution.

Dashang Tiangou has invested heavily in research and development (R&D) to address these challenges, ensuring that its technology remains cutting-edge, thus gaining a competitive market advantage. To this end, the company has recruited and trained technical experts and established strong partnerships with universities and research institutions to explore emerging digital technologies. The innovative approach of Dashang Tiangou's management has helped the company maintain a leading position in digital technology, delivering an enhanced product experience to users.

However, Dashang Tiangou also faces a talent shortage in the current competitive market. A lack of skilled professionals has led to execution gaps, where some strategies and initiatives have not been effectively implemented. At the same time, the oversupply of goods and increasing price competition have further underscored the importance of investing in human capital.

Market Risks and Brand Building

Tiangou recognises the need to maintain a competitive edge in an increasingly competitive market environment by constantly innovating its service and business models to address evolving consumer demands. However, during the integration of online and offline operations, Dashang Tiangou has encountered challenges, including:

- Difficulties in acquiring new offline customers
- Price war pressures
- Limited customer traffic

Dashang Tiangou has adopted innovative business models to counter these challenges, expanded its market share, and explored new profit-generation strategies. The company has strategically focused on its core strengths, adjusting procurement volumes based on market demand and sales performance and optimising cost efficiency and resource allocation to drive profitability.

In the cross-border e-commerce sector, Dashang Tiangou treats international trade as a supplemental sales channel, primarily importing foreign goods for domestic sales. Through initiatives such as IDC certification, establishing a proprietary platform, and streamlined customs reporting, Dashang Tiangou has demonstrated financial strength and a loyal customer base. These measures expand sales opportunities and further solidify the company's market leadership.

Strengthening Brand Influence and Talent Development

Recognising the importance of brand influence, Dashang Tiangou has invested in comprehensive brand promotion strategies to enhance market reputation and visibility. This not only attracts skilled professionals but also opens up new business opportunities.

Additionally, leveraging its expertise in offline retail, Dashang Tiangou acknowledges the growing need to integrate physical retail with digital platforms. This realisation has driven the demand for hybrid professionals with traditional retail and digital operations expertise. To bridge this gap, Dashang Tiangou has implemented:

- Internal training programs to upskill employees

– Collaborations with universities and research institutions to cultivate next-generation talent

In terms of capital operations, although Dashang Group has not yet pursued public listing, its management is actively exploring capital operation models to integrate financial resources and drive rapid business expansion. By focusing on brand strength and talent development, Dashang Tiangou aims to overcome its talent shortage and explore new investment and growth strategies.

Enhancing Compliance and Network Security

As Tiangou expands globally, its cross-border business operations face challenges such as:

– Cultural differences
– Uncertainty in legal regulations
– Network security risks

These factors impact business stability and test the company's adaptability and risk management capabilities.

To address these issues, Dashang Tiangou has implemented proactive measures, including:

1. Strengthened Compliance Management

– Monitoring legal and regulatory changes across different markets
– Ensuring that all business operations comply with local laws and regulations
– Reducing legal risks and supporting long-term stability

2. Enhanced Network Security

– Investing in advanced cybersecurity technologies
– Implementing strict security protocols to protect data privacy and transaction security

- Providing users with a more secure and reliable digital environment

By reinforcing compliance and network security, Dashang Tiangou enhances its risk management capabilities and lays a strong foundation for sustainable international expansion.

3.2 Market performance and successful practice analysis after the transformation

With the development of trade digitalisation, Dashang Group recognised the necessity of digital transformation and initiated its digital strategy in 2014. Key measures in this transformation process included:

- Establishing a global supply chain network
- Implementing cloud computing and big data technologies to optimise business processes
- Developing cross-border e-commerce platforms to enhance international sales
- Introducing innovative platform services to provide more flexible payment solutions

With the advent of the Internet, Dashang Group's customer base expanded, shifting from primarily middle-aged and elderly consumers to younger demographics adept at using digital platforms. Recognising the different consumption habits of younger generations, Dashang Group adopted targeted marketing strategies, a key factor in its digital transformation success.

For instance, during the mature stage of the Tiangou platform, the company enhanced transaction accuracy and user experience by integrating artificial intelligence (AI). Simultaneously, big data analytics allowed Dashang to monitor market dynamics in real-time, providing accurate insights for buyers and sellers, further facilitating trade efficiency.

The trend of trade digitalisation has encouraged Dashang Group to leverage digital platforms for user data collection and analysis through the Tiangou team. This shift has reduced transaction costs, expanded the market, and transformed the company’s business model from traditional to digital trade.

Key achievements in digital transformation

With the support of the Tiangou team, Dashang Group has successfully achieved the following transformational milestones through digital technology:

1. Reduced Operating Costs

The integration of digital technology has enabled Dashang Tiangou to automate order processing, reduce delivery times, and minimise inventory surplus through intelligent warehousing solutions. This has resulted in:

- A 5.73% year-on-year decrease in total operating costs, amounting to RMB 4.512 billion (2022)
- A 4.85% year-on-year decline in selling expenses, totalling RMB 922 million
- A 50.56% year-on-year increase in asset disposal income, reaching RMB 134 million

2. Enhanced Market Competitiveness

By integrating data analytics and personalised services, Dashang Tiangou has improved its market insight and customer service quality, enabling it to meet consumer demands better and maintain a competitive edge. As a result, in 2022:

- Inventory reached RMB 4.436 billion, up 5.52% year-on-year
- Intangible assets grew to RMB 832 million, reflecting an 18.35% year-on-year increase
- Fixed assets increased to RMB 4.2 billion, marking a 3.14% year-on-year growth
- Projects under construction surged to RMB 90 million, an 80% year-on-year rise

3. Restructured Corporate Culture and Organizational Framework

Digital transformation has redefined Dashang Tiangou's corporate culture and fostered an innovation-driven organisational environment. The organisational structure has been optimised to adapt to rapid market changes, ensuring agility and efficiency. As part of this transformation, Employee compensation was reduced to RMB 57 million, reflecting a 16.18% year-on-year decrease.

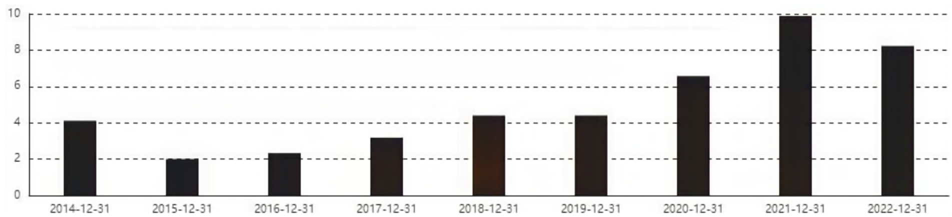

Figure 2: Dashang Group's Net Interest Rate From 2014 To 2022
Data source: Dashang Group's Annual Report.

After its digital transformation, Dashang Group has established a diversified business model, encompassing an online trading platform, multi-channel supply chain, and logistics services. The company's core daily operations are now entirely system-driven, with the development of its business centre system enhancing operational efficiency and data utilisation.

Market Performance and Regional Economic Impact

Following years of experimentation and refinement, Tiangou's data system has successfully integrated heterogeneous data across various online and offline business lines, ensuring stable revenue growth and continuous market expansion. Particularly in Liaoning Province, which plays a significant role in the Belt and Road Initiative, Dashang Group's digital advancements have indirectly contributed to regional economic growth and technological development.

Additionally, the brand influence of Dashang Group has grown significantly, positioning it as a trusted trade partner for domestic and international enterprises.

Future Strategic Initiatives

Looking ahead, Dashang Group plans to develop a "Dashang Digital Circulation Platform", further enhancing digitalisation across the entire supply chain and accelerating digital transformation efforts.

Key strategic actions include:

1. External Supply Chain Enablement. For supply chain optimisation, Tiangou has launched an app-based procurement platform and developed efficient docking systems, such as "One Piece Docking", to streamline supply processes, increase efficiency, and provide a seamless partner experience.

2. Enhancing Internal Management Efficiency. By promoting AI-driven tools across management and operational teams, Dashang Group ensures that employees fully leverage technological advancements, significantly improving work efficiency and overall staff empowerment.

3. Establishing the "Dashing Digital Circulation Platform". Tiangou aims to build a comprehensive digital circulation platform, seamlessly integrating online and offline operations. This initiative will:

- Expand sales opportunities
- Reduce operational costs
- Improve efficiency
- Enhance the consumer digital service experience with greater convenience and transparency

4. Innovation and Expansion in Cross-Border Business. As a leading platform for cross-border commission sales, Tiangou has successfully facilitated numerous brands' entry into the Chinese market. One notable partnership is with Wanzhongyuncang Co., Ltd., a cross-border business partner specialising in Japanese and South Korean brands. With a stable supply chain and extensive agent network, this partnership has ensured a consistent flow of goods for Tiangou.com.

In August 2023, with the support of the Tiangou e-commerce platform, Wanzhongyuncang's sales tripled, demonstrating the platform's effectiveness in driving business growth. Furthermore, Tiangou has strengthened its collaboration with EMS to optimise warehousing and logistics.

Looking ahead, Tiangou.com aims to expand its partnerships with enterprises offering European and American brands, jointly exploring broader international markets, aligning with research hypothesis 2 of this study.

Implementing these strategic measures has not only strengthened partnerships with external stakeholders. Still, it has also enabled Dashang Group to effectively integrate into the global market, improving service quality and enhancing user experiences. These initiatives have successfully facilitated Dashang Group's digital transformation and upgrade, laying a solid foundation for long-term sustainable growth.

4 Conclusions and suggestions

4.1 Research conclusion

This paper discusses the impact of trade digitalisation on enterprise transformation and upgrading through an in-depth analysis of Dashang Group's digital transformation practice. Through the digital tools of Dashang Tiangou, Dashang Group actively promotes the transformation and development of digital construction in the direction of digital intelligence integration. Based on business scenarios and guided by consumer demand, through the profound combination of cloud computing, big data, artificial intelligence and other digital technologies with business, operation, management and other links, it realises the accelerated transmission of data flow, deep mining of value, creation and closed loop of intelligent decision-making. Iterative cycle, scientific reconstruction of a new value chain and digital ecology, with digital intelligence to empower entities to enhance their market competitiveness. The research shows that the trend of trade digitalisation is significant to improve the market competitiveness of enterprises. The case finally confirms the two hypotheses proposed in this study, concluding that trade digitalisation is the key driving force for enterprises to achieve transformation, upgrade, and participate in international competition.

Specifically, enterprises can use digital platforms to collect and analyse user data, understand user needs and behaviours, and quickly adjust product or service strategies to meet market changes through dynamic capabilities. At the same time, the digital platform can also serve as a platform for enterprises to collaborate and innovate with external partners, attracting more developers to join in through shared data and open interfaces and jointly creating more value.

4.2 Policy suggestions

The transformation and upgrading experience of Dashang Group provides valuable insights for other enterprises embarking on their digital transformation journey. These lessons can be summarised as follows:

1. Enterprise-level strategies

Embracing Digital Transformation and Strengthening Innovation

Digital transformation indirectly enhances business performance by driving consumption upgrades (Zhu, 2023). Enterprises should prioritise digital transformation as a strategic focus, fostering a culture of digital innovation among employees. This involves leveraging advanced technologies, such as cloud computing, big data analytics, and artificial intelligence, to enhance operational efficiency and decision-making quality.

Investing in Digital Innovation and Strengthening Cybersecurity

In the digital era, enterprises must stay ahead of technological trends, continuously introducing new technologies while optimising existing business models. Strengthening data management, cybersecurity, and privacy protection improves the efficiency of enterprise-wide information management in the digital environment (Yang, 2023). Establishing strict security protocols and privacy policies helps build consumer trust and ensure regulatory compliance.

Building a Skilled Workforce and Organizational Adaptation

The demand for high-skilled human capital is critical in value chain upgrading during digital transformation (Guo & Zhu, 2024). Enterprises must invest in digital skill training programs, attract and retain top talent, and develop a corporate culture that aligns with digital innovation. Additionally, organisations should adapt their structures to support agile decision-making and new development needs.

Understanding Global Markets and Strengthening Cooperation

To effectively navigate international trade digitalisation, enterprises must develop deep insights into regional market demands and cultural characteristics. Strengthening partnerships with local brands fosters mutual growth and facilitates cross-border trade expansion.

2. Technological innovation and digital transformation

In the era of digitalisation, enterprises must stay at the forefront of technological advancements, quickly adopt new technologies, and enhance operational efficiency to maintain a competitive edge.

Businesses gain valuable insights that support precision marketing and personalised consumer engagement by analysing customer behaviour through online platforms and big data analytics.

The convergence of online and offline commerce is crucial for digital transformation. Tiangou, for example, recognises that maintaining online customer loyalty while increasing offline customer engagement requires continuous updates to digital platforms and marketing content.

3. User-centric product optimization

As consumer demographics shift toward younger audiences, enterprises must adapt to evolving consumption habits and preferences. This requires continuous product and service optimisation to enhance user experience and satisfaction.

Building consumer trust is fundamental for long-term business sustainability. Enterprises must prioritise data security and privacy to safeguard sensitive user information while complying with global regulatory standards.

4. Talent development and incentive mechanisms

In the digital era, market insight and strategic decision-making are essential for seizing opportunities and driving business growth. Ultimately, enterprise competitiveness is rooted in talent.

Enterprises should prioritise talent cultivation and recruitment, strengthen internal training programs and develop competitive incentive mechanisms to stimulate employee creativity and innovation.

5. Expanding international cooperation and digital trade

Enterprises should actively seek international collaborations, share industry knowledge, and jointly promote trade digitalisation. When entering global markets, businesses must adapt strategies to local market conditions and align with regional policy incentives to secure preferential trade benefits. Governments are critical in facilitating digital trade growth, creating favourable policies, and helping enterprises capitalise on new opportunities.

Government-backed brand promotion for regional businesses, particularly in Northeast China, can counteract market stagnation and stimulate business activity. To advance digital trade, governments should introduce:

- Policies supporting e-commerce supply chains
- Incentives for warehousing and logistics development
- Strategic investments in digital platforms

Drawing inspiration from successful case studies in southern China, policymakers can tailor digital trade policies to align with local economic conditions, positioning Northeast China as a digital trade hub. Through policy guidance and market-driven initiatives, local enterprises can emerge as leaders in digital trade, fueling regional economic growth.

The case of Dashang Tiangou highlights the positive impact of trade digitalisation on enterprise transformation and upgrading. By continuously promoting technological innovation, optimising products and services, and expanding international cooperation, enterprises can seize new opportunities, navigate market challenges, and achieve sustainable long-term growth.

4.3 Research limitations and future research directions

Although this study uses Dashang Tiangou as a case, it provides valuable insights into the digital transformation of enterprises, but it also has certain limitations. First of all, in terms of case selection, case studies may not fully represent the situation of all industries and enterprises. They can be expanded to more enterprises for comparative research in the future. Secondly, the data mainly came from public materials and interviews with Dashang Tiangou. Finally, this study uses a case study approach, and in the future, attempts can be made to introduce quantitative analysis methods for more precise quantitative analysis.

With the rapid development of trade digitalisation, in the future, we can further study the profound impact and mechanism of trade digitalisation, as well as how to deal with the possible challenges and risks. We can choose to focus on the following directions:

Cross-industry comparative research. A comparative analysis of the transformation and upgrading of different industries in trade digitalisation is conducted to gain a broader perspective.

Long-term effect evaluation. Track and study the digital transformation process of enterprises to evaluate their long-term effects and continuous impact.

Technology development and application and the role of policy environment. The in-depth study on how emerging digital technologies further promote the innovation of trade mode and the transformation of enterprise business models can also explore how government policies affect the digital transformation of enterprises and international trade activities.

In short, the digitalisation of trade has become an irreversible trend, and enterprises need to grasp the opportunities brought by the rapid development of digital technology and realise the transformation of business models from "old" to "new" through the development and application of digital technology.

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XX. Literature Review of Smart City Construction and Urban Economic Growth in China Under the One Belt and One Road Initiative

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As the core carrier to promote economic development, cities have significantly contributed to the development of national foreign trade, and smart cities, as a high-level form of future urban development, have an essential impact on the development of urban export trade. Since China officially implemented the construction of smart cities in 2012, it has always considered the construction of smart cities a vital development strategy. Therefore, the study of the impact of smart city construction on urban export trade is of great significance for the effective implementation of smart city construction in China and the exploration of new growth drivers of foreign exchange.

Keywords:
Belt and Road Initiative,
smart city,
economic growth,
urban export trade,
China

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1 Introduction

Since the reform and opening up, China's economy has shown a blowout development trend, and the rapid development of China's economy cannot be separated from the export trade. With the vigorous development of the digital economy, the impact of digital infrastructure on trade is increasingly prominent. However, in recent years, exports, as one of the "troika" driving China's economic growth, have gradually slowed its growth rate.

Meanwhile, as an essential link to promote high-quality economic development, the Belt and Road Initiative studies its impact on China's foreign trade and can provide empirical evidence for China to expand the scale of trade import and export. It can also evaluate the policy achievements of the Belt and Road Initiative in the past decade, which is of great practical significance for promoting the construction of a digital Silk Road featuring extensive consultation, joint contribution and shared benefits, mutual assistance and win-win results.

With the increasing uncertainty of the international trade environment and the gradual disappearance of population benefits, the future export growth rate may continue to decline. China urgently needs to find new momentum to develop export trade in this context.

2 Research on the Belt and Road initiative and foreign trade

2.1 Trade pattern between China and countries along the Belt and Road

Zou, Liu, and Yin (2015) pointed out that the slow growth of trade between China and Belt and Road countries began in 2001. Following the outbreak of the financial crisis, trade connectivity intensified, marking the beginning of a rapid development phase.

From a regional perspective, Southeast Asia accounts for a significant share of trade volume, and China maintains a high degree of trade reliance on this region. Among China’s key trading partners, ASEAN countries play an increasingly prominent role in China’s trade strategy, followed by West Asia and Middle Eastern nations.

Zhang and Li (2015) emphasised that among the factors influencing trade flows, trade facilitation has a far more significant impact than tariff reductions. Moreover, the Maritime Silk Road has demonstrated a more substantial effect in promoting trade.

Xu and Liu (2019) highlighted that the trade scale between China and Belt and Road regions is characterised by regionalisation, with China's trade volume with East Asia and Africa leading the way. Additionally, China's export structure to Belt and Road countries exhibits a high similarity, with industrial manufactured goods maintaining a strong competitive advantage.

2.2 The impact of the belt and road initiative on foreign trade between China and countries along the Belt and Road

With the opening up and development of China's foreign trade, the total trade volume of Belt and Road Initiative (BRI) countries has been steadily increasing, accounting for an expanding share of China's total foreign trade. By 2020, China's trade with BRI countries represented approximately one-third of China's total trade, with strong potential for further growth.

Sang and Yang (2015) concluded that China, Southeast Asia, Central and Western Europe, and other BRI countries share similar export structures and strong export competitiveness. At the same time, China's trade complementarity is particularly strong with South Asia, Southern Europe, and other regions, indicating substantial future trade development potential.

Sun, Zhang, and Liu (2017) highlighted that the BRI has facilitated the expansion of China's export trade to partner countries, with its impact on export quantity exceeding its impact on export prices. Additionally, the initiative has significantly influenced the export of heterogeneous products more than homogeneous products. Their in-depth analysis of BRI sub-regions found that the initiative's effect is more pronounced in Maritime Silk Road countries. Furthermore, research on bordering vs non-bordering countries revealed that China's export trade with neighbouring countries benefits more significantly from BRI incentives. These findings confirm strong trade complementarity between China and its BRI partners despite differences in export priorities.

Han and Yuan (2021) employed a differential approach to assess ways to enhance the quality of China's export products. They proposed that optimising the institutional environment, mainly through reducing foreign trade costs and improving the quality of intermediate products, can significantly boost exports. Their study further indicated that non-isolated and non-state-owned enterprises benefit more substantially from these improvements.

Yan and Zhang (2022) pointed out that the prolonged Sino-US trade tensions in recent years have severely impacted China's foreign trade. However, implementing the BRI has significantly mitigated these adverse effects, fostering the positive development of China's export trade despite the challenges posed by the Sino-US trade war.

3 Related research on smart city construction

3.1 Concept of smart city

As urbanisation accelerates and the urban population expands, traditional city construction has entered a bottleneck phase, leading to increasingly severe urban challenges (Guo, 2022). In response, IBM introduced the "smart city" concept, marking the beginning of a new era aimed at addressing urban issues through technology-driven solutions.

Liu (2020) suggested that IBM defines a smart city as a system that utilises modern information technology to detect and analyse key urban operation data, enabling intelligent responses to diverse urban needs, including public services, security, and infrastructure management. However, Albert (2020) pointed out that smart cities often intersect with concepts such as digital cities, intelligent transportation, and e-governance, leading to varying interpretations.

By reviewing relevant domestic and international literature, it is evident that smart cities are typically classified into three main conceptual models:

- Technology-driven smart cities
- Talent-driven smart cities
- Collaboration-driven smart cities

1. Technology-driven smart cities

Smart cities with a technological focus emphasise the application of modern digital tools, such as intelligent computing systems, to enhance infrastructure efficiency and public services, including education, healthcare, and utilities. Wu (2022) described smart cities as functional urban systems developed through the innovative application of information technology to enhance traditional urban management. Zhang (2021) highlighted that information technology is the foundation of smart cities, facilitating cross-sector integration of technology and governance to create brighter urban environments.

2. Talent-driven smart cities

Jin (2013) emphasised that talent-led smart cities focus on attracting and nurturing highly skilled professionals, as human capital is a critical driver of urban development. The concentration of high-level talent serves as a key factor in advancing smart city initiatives. Xu (2013) further elaborated that smart city construction requires a diverse range of professionals, including:

- Technological innovators
- Leadership professionals with strong management and coordination skills
- Comprehensive experts with top-level strategic design capabilities

Developing smart cities through talent cultivation is essential for accelerating national talent development strategies and fostering high-quality economic and social progress. The two primary strategies for talent acquisition in smart cities involve:

- Attracting external talent
- Developing internal talent within urban institutions

3. Collaboration-driven smart cities

Karima (2012) proposed that collaboration-driven smart cities prioritise user experience over technological intelligence, stressing the importance of engagement between various urban stakeholders. This perspective underscores cities' need to mobilize diverse resources to maintain global competitiveness. Yigitcanlar (2008) identified practical cooperation among urban actors as the core principle of smart city governance, ensuring that cities function as integrated and dynamic ecosystems.

Most scholars tend to focus on a single aspect of smart city development or combine elements from the three models without fully integrating them. However, the optimal approach to defining and building smart cities should not be limited to a singular perspective. Instead, the successful realisation of smart cities necessitates a comprehensive and synergistic approach, combining technological innovation, talent development, and collaborative governance.

3.2 Effect evaluation of smart city construction

In 2012, China's first batch of smart city pilots was only more than 10 years ago, but scholars on smart city-related research have been relatively wealthy. Domestic scholars' research on China's smart city construction mainly focuses on evaluating the effect of smart city pilot policies, mainly from the four aspects of economic development, innovative development, industrial development and ecological environment. From the economic development perspective, Zhang (2021) empirically tested by DID and concluded that smart city construction significantly promotes economic growth momentum and results. Zhou (2020) further analysed that smart cities can drive regional economic growth by optimising resource allocation, improving economic agglomeration levels, and promoting upgrading industrial structures. In addition, Tang (2020)] said the construction of smart cities can also enable high-quality economic development by improving the total factor productivity of cities. However, the effect of this promotion effect is different in different cities. Zhao (2020) found that the promotion effect of smart city pilots on high-quality economic development is more significant in the eastern and western regions, and the promotion effect is more evident in the cities with low population density, low administrative level and low innovation degree. Based on the perspective of innovation and development, He (2021) adopted multi-phase DID and PSM-DID methods to test and found that smart city construction significantly promoted urban innovation. There was no lag in the play of innovation effect, and the impact of smart city construction increased dramatically with time. Through Yao's (2022) further analysis, smart cities can promote urban innovation output by increasing urban scientific research investment, optimising information infrastructure, introducing high-tech talents, and promoting industrial structure upgrading. At the same time, for cities with different locations, grades and initial innovation levels, the policy effect is different to some extent, and the innovation effect of smart cities is more significant in the cities with high human resource endowment, low city grade and eastern and central cities.

Based on the perspective of industrial development, scholars have different views on the impact of smart city construction on industrial structure based on the combined relevant literature. Both Zhao (2019) and Wang (2020) proved through empirical tests that smart city construction has a significant positive promoting effect on the rationalisation and upgrading of industrial structures. Zhang (2022) found that although smart city construction can significantly improve the advanced level of urban industrial structure, it can not enhance the rationalisation level of industrial structure. Through further analysis, constructing a smart city can effectively promote upgrading urban industrial structure through three channels: financial development, technological innovation and human capital. In addition, after considering the heterogeneity of regional and city size, it is found that the impact of smart city pilot policies in less developed areas on the upgrading of local industrial structure is greater than that in developed regions (Lin & Wand, 2021; Fan et al., 2021). The smart city pilot policies in medium-sized cities are more conducive to promoting the rationalisation of industrial structure. In contrast, smart city pilot policies in large-scale cities are more conducive to promoting upgrading industrial structures (Fan et al., 2021).

From the perspective of the ecological environment, scholars generally analyse the impact of smart city construction on the ecological environment from two aspects—first, the effect of policies on green economic development. Lin and Wang (2022) and Du et al. (2020) proved through empirical methods that smart city construction can significantly improve the green total factor productivity and green development efficiency of Chinese cities. The PSM-DID method was used to test and find that constructing smart cities can significantly promote green technology innovation. Second, the impact of policies on carbon emissions. Through empirical tests, Zhang and Zhong (2022) concluded that implementing smart city pilot policies would help reduce the scale of carbon emissions at the county level and increase the carbon sequestration level of regional land vegetation. Shi et al. (2018) concluded through research that the construction of smart cities can significantly reduce urban environmental pollution, and the larger the city scale, the more significant the effect of reducing environmental pollution.

4 Research on smart cities and foreign trade along the Belt and Road

In 2012, China launched its first batch of smart city pilot projects, and although just over a decade has passed, research on smart cities has become increasingly extensive. Domestic scholars primarily focus on evaluating the impact of smart city pilot policies, particularly in four key areas:

1. Economic development
2. Innovation
3. Industrial development
4. Ecological environment

1. Economic development and smart cities

Zhang (2021) employed a difference-in-differences (DID) approach and found that smart city construction significantly promotes economic growth by strengthening growth momentum and economic output (Zhang, 2021). Zhou (2020) further analysed the mechanisms driving this economic growth, identifying three key pathways (Zhou, 2020):

- Optimizing resource allocation
- Enhancing economic agglomeration
- Facilitating industrial upgrading

Tang (2020) argued that smart cities contribute to high-quality economic development by improving total factor productivity (TFP). However, the effectiveness of this impact varies across different cities. Zhao (2020) found that the positive effects of competent city pilots on high-quality economic development are more pronounced in eastern and western regions and cities with low population density, lower administrative levels, and weaker innovation capacities.

2. Innovation and smart cities

From an innovation perspective, He (2021) applied multi-phase DID and propensity score matching DID (PSM-DID) models, demonstrating that smart city construction significantly boosts urban innovation levels without any delays in its impact (He, 2021). Additionally, Yao (2022) identified multiple mechanisms through which smart cities enhance innovation output, including (Yao, 2022):

- Increased scientific research investment
- Optimized information infrastructure
- Attraction of high-tech talent
- Industrial structure upgrading

Furthermore, policy effects differ based on city characteristics. The innovation impact of smart cities is most significant in the towns with (Tian, Zhao, & Zhang, 2022):

- High levels of human capital
- Lower administrative grades
- Located in eastern and central regions

3. Industrial development and smart cities

Scholars hold divergent views regarding the impact of smart city construction on industrial structures (Jiang & Wang, 2021). Both Zhao (2019) and Wang (2020) empirically demonstrated that smart city development plays a crucial role in industrial upgrading, particularly in enhancing industrial structure rationalisation (Zhao, 2019; Wang, 2020).

However, Zhang (2022) found that while smart city initiatives significantly advance industrial structure sophistication, they do not necessarily improve industrial structure rationalisation (Zhang, 2022). Further analysis revealed that smart city construction promotes industrial upgrading through three primary channels (Zhang, 2022):

- Financial development
- Technological innovation
- Human capital improvement

Regional and city-size heterogeneity also plays a role. Findings indicate that (Wang, Li, & Ma, 2020):

- Smart city policies in less developed regions have a more significant impact on local industrial upgrading
- Medium-sized cities benefit more in terms of industrial rationalisation
- Larger cities experience more substantial industrial upgrading effects

4. Ecological and environmental impact of smart cities

Scholars analyse the environmental impact of smart cities through two primary lenses:

Green Economic Development. Lin (2022) and Du (2020) applied empirical models and found that smart city construction significantly enhances Green total factor productivity (GTFP) and Green development efficiency in Chinese cities. Further studies confirmed that smart cities substantially promote green technology innovation using the PSM-DID method.

Carbon Emissions and Pollution Control. Zhang (2022) conducted empirical tests and found that smart city pilot policies contribute to reducing county carbon emissions while enhancing regional land vegetation's carbon sequestration capacity. Similarly, Shi (2018) demonstrated that smart city initiatives significantly reduce urban environmental pollution, with larger cities experiencing even more pronounced pollution reduction effects.

5 Literature review

Through combing and analysing the existing research results of domestic and foreign scholars on smart cities and the "Belt and Road" under the background, most literature combine the research of smart cities and the quality of economic development and explains that smart cities promote the birth and reform of new financial models. There is little literature on the impact of smart cities on international economic and trade cooperation, and the existing research results are mainly elaborated from a single perspective, such as Internet construction or e-commerce development.

The research results on trade in the context of the "Belt and Road Initiative" are relatively complete, mainly focusing on the influencing factors and effects of the initiative on economic and trade development, the development of trade patterns of cooperation platforms, etc. No literature studies the impact of smart cities on foreign trade in the context of the initiative. Therefore, based on the background of the "Belt and Road" initiative, this paper builds a multi-dimensional index system for smart cities and studies it in combination with foreign trade, which is conducive to reasonably seizing opportunities based on national conditions and promoting the prosperity and development of China's foreign trade.

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XXI. Digital Economy Infrastructure Development and the "Belt and Road" Initiative

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This paper explores the strategic role of digital economy infrastructure in the "Belt and Road" initiative, highlighting its impact on regional economic development. It discusses the growth of computing power, data centres, and the challenges and opportunities in building digital infrastructure along the route. The paper concludes that international cooperation and policy support are essential for overcoming challenges and leveraging the potential of the digital economy for mutual growth.

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1 Introduction

In today's information age, the concept of the digital economy has become deeply embedded in public consciousness. Centred on data and computing power, it is gradually emerging as a new competitive frontier in the global economy. Computing power, often referred to as arithmetic power, is not only a driving force behind scientific and technological innovation, industrial upgrading, and economic growth but also a key enabler of digital economy development. This power manifests in various forms, including different types of processors such as central processing units (CPUs), graphics processing units (GPUs), and tensor processing units (TPUs), each designed for specific computing tasks and application scenarios.

As general-purpose processors, CPUs excel at managing complex control logic and diverse computational tasks, functioning as the "brains" of computer systems. GPUs, originally designed for graphics and video rendering, have become essential in deep learning and artificial intelligence due to their ability to process large volumes of data in parallel. TPUs are specialised processors tailored for machine learning; they optimise neural network computations, delivering higher performance and efficiency. They are especially suitable for large-scale deep-learning model training and inference.

According to the China Arithmetic Development Index White Paper (2023) published by the China Academy of Information and Communications Technology (CAICT), the global computing power of digital devices reached 906 EFlops (ExaFLOPS) in 2022, reflecting a 47% year-on-year growth. This scale is expected to grow by more than 50% annually over the next five years, surpassing 3 ZFlops by 2025 and reaching 20 ZFlops by 2030. In 2022, global server shipments totalled 15.16 million units, with a market value of $121.58 billion—an increase of 12% and 22.5% year-on-year, respectively. The AI server market alone reached $18.3 billion, growing 17.3% year-on-year. The global AI chip market was valued at $16.86 billion.

In this context, building computing infrastructure—including data centres, supercomputing facilities, and edge computing nodes—has become a strategic objective for countries worldwide. The “Belt and Road” initiative not only creates new opportunities for infrastructure collaboration between China and participating countries but also paves new pathways for the global expansion and evolution of the digital economy. This paper explores the strategic importance of digital economy infrastructure within the Belt and Road initiative and its broader implications for regional economic development.

2 The rise of the digital economy and the global landscape

The rise of the digital economy is due to the rapid development of cloud computing, big data, artificial intelligence and other technologies. The application of these technologies has driven massive growth in data, creating unprecedented demand for computing power. Globally, countries are actively laying out their arithmetic infrastructures to compete for competitive advantages in the era of the digital economy. The construction of computing power infrastructure, such as data centres, super-computing centres, and edge computing nodes, has become the key to promoting technological innovation and industrial upgrading (Guo, Song, & Zhang, 2024).

The construction and layout of global data centres are the foundation of the digital economy. The United States, China, and Europe are the main concentrations of data centres, and the scale and number of data centres in these regions take the lead globally. According to the International Data Corporation (IDC) report, the U.S. leads the global data centre market with about 30% share as of 2022, followed by China with about 10% of the worldwide market. For example, Silicon Valley in the United States, Guizhou and Ningxia in China, and Frankfurt in Europe are essential data centre clusters. The scale of the global arithmetic industry is growing rapidly, especially in artificial intelligence, big data analytics, and cloud computing, where the demand for arithmetic power is rising (Ghimire, Ali, & Sun, 2023). China, the United States and other countries have invested heavily in developing the arithmetic industry, and the scale and growth rate of arithmetic power are among the top in the world.

The internal architecture of a data centre typically consists of server racks, network switching equipment, storage systems and security facilities. As data centres grow in size, effective cooling technologies become critical. Modern data centres use various technologies, such as air and liquid cooling, to maintain equipment at the proper temperature, ensure system stability and extend the life of the hardware. Energy efficiency is a key consideration in data centre operations. Adopting virtualisation technologies, optimising server utilisation, and using energy-efficient hardware and software-defined data centres can significantly reduce energy consumption. According to The Green Grid, through these measures, the global data centre energy efficiency ratio (PUE) has been reduced from 2.0 in 2007 to about 1.6 in 2022.

In addition, open-source technologies have played an essential role in developing cloud computing and big data. Open-source software such as Apache Hadoop and Spark provide potent platforms for big data processing, and their support for distributed computing makes processing large-scale datasets more efficient and cost-effective. Open-source technologies in cloud computing, such as OpenStack, promote the standardisation and interoperability of cloud services, helping enterprises and service providers build scalable and flexible cloud infrastructures (Nguyen, Toan, & Phong, 2024).

With the development of 5G, IoT and other technologies, the construction of global arithmetic networks has become a new trend. Governments and enterprises are promoting the construction of arithmetic networks to realise data's rapid transmission and processing. For example, China's "East Counts, West Counts" project aims to optimise the allocation of computing power resources in the East and West and improve the overall efficiency of the computing power network (Niankara & Traoret, 2023). According to China's National Development and Reform Commission (NDRC), the project is expected to increase the utilisation rate of arithmetic resources in the western region to more than 80% by 2025. In the global layout of the digital economy, international cooperation and competition coexist. While promoting the development of their arithmetic industries, countries are also seeking international cooperation to jointly promote the progress and application of arithmetic technology (Herman & Oliver, 2023). At the same time, the control and distribution of arithmetic resources have become a new focus of competition among countries.

To improve the efficiency of the utilisation of arithmetic resources, countries are exploring the optimal allocation of arithmetic resources, including the establishment of arithmetic trading platforms and the construction of arithmetic network monitoring platforms, to achieve accurate planning and efficient utilisation of arithmetic resources. These measures promote the rational allocation of arithmetic resources and support the sustainable development of the digital economy.

According to the analysis of Frost & Sullivan, a global business consulting firm, the global arithmetic service market is expected to reach a size of about US$250 billion by 2027 through optimising the allocation of arithmetic resources (Mao, Geng, & Shao, 2023).

3 Infrastructure development under the "Belt and Road" initiative

The "Belt and Road" Initiative aims to promote connectivity among countries along the routes and regional economic integration through infrastructure construction. Under this framework, the construction of arithmetic infrastructure helps improve the informatisation level of countries along the route and provides solid support for developing the digital economy (Rong, 2022). Constructing cross-border data channels and cloud computing platforms can promote the sharing of data resources and accelerate scientific and technological innovation and industrial digital transformation.

The construction of cross-border data channels is key to realising data connectivity. These channels rely on efficient data transmission protocols, such as TCP/IP and HTTP/2, significantly enhancing transmission speeds and reliability. According to Akamai's report, websites using HTTP/2 experienced a 16% reduction in average page load time.

Deploying cloud computing platforms is an essential part of arithmetic infrastructure development. Containerisation technologies such as Docker and Kubernetes are crucial in this process. According to a CNCF survey, 78% of organisations had adopted Kubernetes in their production environments by 2021 (Nguyen, Toan, & Phong, 2024).

Cooperation between China and Belt and Road countries in digital infrastructure has been expanding. For instance, China has signed memorandums on the Digital Silk Road with 17 countries and established Silk Road e-commerce mechanisms with 23 others. At the Digital Economy Forum during the third Belt and Road Summit, the Beijing Initiative for International Cooperation on Digital Economy was jointly released by China and several partner nations, reinforcing international cooperation in digital infrastructure, transformation, capacity, and security (Ghimire, Ali, & Sun, 2023).

Chinese enterprises have been active in building data centres in countries such as Pakistan and Egypt, contributing to local digital transformation. According to the China Academy of Information and Communications Technology, the number of overseas data centres constructed by Chinese firms increased by about 150% between 2019 and 2022.

4 Challenges and opportunities in building infrastructure for the digital economy

In the countries along the "Belt and Road," the construction of computing power infrastructure is driving the digital transformation of regional economies, but it also brings a series of challenges. The lack of uniform technical standards has led to cross-border equipment compatibility issues, affecting the efficiency of data flow. Cybersecurity risks are particularly prominent, as the globalised layout of computing power exposes cross-border data transmission and storage to threats of hacking and data leakage (Niankara & Traoret, 2023). Energy supply and environmental impact are also significant concerns, with data centre power demands putting pressure on energy systems while increasing carbon emissions. Furthermore, building such infrastructure requires massive investment, especially in developing countries where capital mobilisation is difficult and return on investment is uncertain. Talent shortages further limit the ability to build and maintain infrastructure, and variations in national policies and regulations can hinder implementation and operations. Geopolitical risks, cultural and linguistic barriers, mismatches between market demand and supply, and maintenance and upgrade challenges must all be addressed.

International cooperation, policy support, technological innovation, and talent development are crucial to overcome these challenges. Jointly formulating international standards, strengthening cybersecurity cooperation, promoting green energy, and offering financial and educational support are all necessary to ensure the healthy development of digital economic infrastructure along the Belt and Road (Herman & Oliver, 2023).

Regarding cybersecurity, technologies such as encryption, intrusion detection systems (IDS), and security information and event management (SIEM) are critical. Encryption protects data transmission, IDS enables real-time monitoring, and SIEM centralises security data to detect and respond to potential threats. According to

IBM, adopting encryption technology can reduce the financial damage of data breaches by approximately $3.82 million (Nguyen, Toan, & Phong, 2024).

Intelligent operations and maintenance (AIOps) significantly improve the reliability and efficiency of data centres through real-time data processing, automated monitoring, and predictive maintenance. Markets and Markets (Mao, Geng, & Shao, 2023) estimated that the AIOps market, valued at $2.3 billion in 2020, will grow to $7.3 billion by 2025.

Meanwhile, the construction of computing infrastructure stimulates the development of related industrial chains, including equipment manufacturing, cloud computing services, and big data analytics. For example, the global data centre equipment market was valued at approximately $150 billion in 2022 and is expected to grow at a compound annual growth rate of 5% by 2025 (Guo, Song, & Zhang, 2024).

International collaboration also offers an opportunity to develop technical standards, enhance cybersecurity, optimise energy use, and support green development. These efforts promote informatisation and contribute Chinese wisdom and solutions to global digital economy advancement (Ghimire, Ali, & Sun, 2023).

Despite the challenges, there are immense growth opportunities. Many Belt and Road countries are in the midst of digital transformation and face significant demand for computing infrastructure. This presents vast market potential, not only for China's technology exports but also for the economic development of the partner countries. The global cloud computing market is expected to reach $650 billion by 2025, with Belt and Road countries becoming key growth areas (Ghimire, Ali, & Sun, 2023).

Governments along the route are introducing supportive policies—such as tax incentives and financial aid—to encourage infrastructure development. At the same time, China's strengths in 5G, big data, and cloud computing offer a competitive edge in exporting technology and collaborating with local enterprises to create customised solutions (Rong, 2022).

The Belt and Road Initiative also offers a platform for multilateral cooperation, allowing countries to share resources and reduce risks. Infrastructure development drives the growth of upstream and downstream sectors—software, hardware, data analytics—and provides demand for skilled professionals, creating opportunities for education, training, and exchange.

Green, low-carbon development has become a global consensus. Computing infrastructure construction can adopt green energy and efficiency technologies to promote sustainable development while meeting international environmental standards. The Digital Silk Road supports data sharing and regional integration through investments in fibre-optic cables and data centres. Interconnected infrastructure improves information flow and reduces transaction costs, enhancing regional competitiveness.

Finally, building computing infrastructure stimulates innovation, supports new business models, and unlocks new growth drivers for partner countries. High-quality regional development can be achieved by seizing these opportunities and managing risks through cooperation, policy, innovation, and talent development.

5 Synergies between the digital economy and the "Belt and Road" initiative

The construction of digital economy infrastructure should be aligned with the overarching goals of the "Belt and Road" Initiative to achieve mutual benefit and win-win outcomes. On one hand, China can leverage its technological expertise and experience in computing infrastructure to support informatisation in Belt and Road countries. On the other hand, these countries' vast data resources and market potential present significant opportunities for Chinese enterprises. Through collaborative construction and resource sharing, the optimal allocation of computing power can be achieved, promoting the advancement of the Digital Silk Road (Ghimire, Ali, & Sun, 2023).

Achieving the synergistic development of the digital economy and the Belt and Road Initiative requires strategic efforts in multiple areas. Firstly, strengthening policy communication and coordination is essential. Countries should harmonise standards and technical specifications for computing infrastructure to ensure compatibility and efficient data exchange. For instance, adopting unified cloud interface standards can reduce cross-border technical barriers and support seamless service delivery (Rong, 2022).

Secondly, fostering technological cooperation and innovation is key. This involves encouraging joint research, knowledge sharing, and co-development of localised technological solutions. Open-source software and hardware play a crucial role in this context. They promote technology diffusion, reduce development and deployment costs, and enhance flexibility. For example, open-source software has been reported to lower IT costs by 10–20%, while tools like the Raspberry Pi offer affordable platforms for education and innovation in emerging markets.

Talent development is another pillar of synergistic progress. Education systems must be adapted to train professionals in key digital economy areas such as data science, cybersecurity, and cloud engineering. Project-based learning and industry collaboration—such as involving students in real-world technical projects—have proven effective in enhancing employability and providing practical skills (Guo, Song, & Zhang, 2024).

In addition, establishing a multi-level cooperation mechanism is vital. Participating countries can share information and complement each other's resources through platforms such as the Digital Silk Road. Policy incentives, investment support, and risk-reduction frameworks can help attract domestic and international capital to support infrastructure development (Herman & Oliver, 2023).

Promoting green development is also crucial. Adopting energy-efficient technologies and renewable energy sources in computing infrastructure projects—such as in the construction of green data centres—contributes to sustainability and global environmental goals (Mao, Geng, & Shao, 2023). Ensuring cybersecurity through strict data security protocols and oversight of cross-border data flows is equally essential for the safe and stable operation of digital infrastructure (Nguyen, Toan, & Phong, 2024).

Furthermore, integrating upstream and downstream industrial chains will foster a complete digital economy ecosystem and strengthen competitiveness. The Belt and Road Initiative also opens international markets for digital services and products, enabling global optimisation of computing resource distribution and service delivery (Ghimire, Ali, & Sun, 2023).

Lastly, robust risk management mechanisms must be in place. These include comprehensive risk assessment and response systems that ensure the long-term sustainability of infrastructure investments. By implementing these measures, countries can realise deep integration between the digital economy and the Belt and Road Initiative, accelerating digital transformation and fostering high-quality regional development.

This coordinated approach advances national economies and contributes to the inclusive and sustainable development of the global digital economy.

6 Conclusion

This paper has examined the strategic significance of developing digital economy infrastructure within the "Belt and Road" Initiative framework and its broader implications for regional economic development. The findings suggest that digital infrastructure construction is a key pillar of the initiative and a powerful driver of economic cooperation and integration among participating countries. Amid the challenges, international cooperation is a central strategy to advance computing power infrastructure's construction and effective deployment. A globally coordinated approach to the digital economy allows countries to enhance their competitiveness while contributing Chinese experience and solutions to the growth of the global digital economy (Ghimire, Ali, & Sun, 2023).

Computing power infrastructure—such as data centres, cloud computing platforms, and 5G networks—is fundamental in enabling digital transformation and boosting economic growth. These facilities support efficient information flow, productivity improvements, and new business models, accelerating regional integration. By enabling interconnectivity and information sharing, such infrastructure contributes to the collective prosperity of economies along the Belt and Road (Guo, Song, & Zhang, 2024).

In the era of globalisation, cross-border collaboration is essential for the successful development of computing infrastructure. The Belt and Road Initiative provides a framework through which China and its partners can share technological know-how, financial resources, and talent, thereby fostering mutual benefits. Open standards and open-source technologies are particularly valuable in this context as they enhance system compatibility, lower technological barriers, and promote collaborative innovation (Rong, 2022).

Policy support and coordination among governments are also essential. This includes creating investment-friendly environments, safeguarding data privacy, and standardising technical norms. Technological innovation and talent cultivation are the foundation of digital economy development, requiring robust education systems, digital literacy enhancement, and the development of high-end technical talent (Herman & Oliver, 2023).

Furthermore, machine learning and data analytics offer novel methods for optimising the allocation of computing resources. These technologies can forecast demand, improve resource efficiency, reduce waste, and enhance service quality. For instance, predictive models based on machine learning can effectively manage data centre workloads and support energy efficiency optimisation (Mao, Geng, & Shao, 2023).

Environmental sustainability must also be prioritised. Energy-efficient technologies and renewable energy sources should be integrated into infrastructure projects to meet sustainable development goals while reducing long-term operational costs. Green computing principles are critical to minimising environmental impact and supporting global climate objectives (Niankara & Traoret, 2023).

Lastly, cultural and linguistic exchange is vital to successful cross-border cooperation. Through intercultural dialogue and language training, collaborative efficiency can be improved, misunderstandings minimised, and partnerships deepened.

In conclusion, the challenges associated with digital economic infrastructure can be overcome through international cooperation, strong policy frameworks, continuous technological innovation, and focused talent development. Seizing the opportunities offered by the Belt and Road Initiative will boost the economic development of participating countries and contribute significantly to the advancement of the global digital economy.

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The Impact of Digital Economy on One Belt One Road Initiative

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This publication offers a comprehensive overview of the impact of digital economy development on the Belt and Road Initiative (BRI). It brings together empirical analyses, comparative studies, and conceptual contributions that highlight the connections between digital transformation, cross-border trade, outward foreign direct investment (OFDI), innovation, and digital infrastructure. The authors explore the role of digital technologies such as artificial intelligence, blockchain, digital payments, and smart cities in enhancing cooperation between China and BRI countries. The publication also covers modern business models, digital transformation strategies, and aspects of legislation, sustainability, and user perception. It is intended for researchers, policymakers, and practitioners interested in digital connectivity, sustainable development, and opportunities within the BRI framework.

Keywords:
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