The Influence of the Development Level of Digital Economy on Import and Export Trade

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Abstract: Under the background of rapid iteration of global digital technology, it is a key issue to explore its mechanism and differential influence on import and export trade. This paper constructs a "technology-market-system" analysis framework, and uses panel regression and case comparison methods to reveal that the development of digital economy affects the scale and quality of trade by reducing trade costs, expanding market boundaries and optimizing industrial structure. According to the differences of countries, industries and institutional environment in different stages of development, a multi-dimensional analysis framework is further constructed. Further analysis shows that the national development stage, industry technical attributes and policy openness constitute the core variables that affect the differentiation of effects-developing countries need to break through the double constraints of "digital divide" and "low-end lock-in", while developed countries face the risk of attenuation of innovation kinetic energy and loss of rule dominance. Based on this, this paper puts forward some policy suggestions, such as promoting digital infrastructure construction by classification, reforming anti-monopoly framework to promote technology diffusion, and constructing multilateral digital trade rules. These findings provide a theoretical basis for countries to formulate differentiated digital trade strategies, emphasizing the need to choose the path of technology catching up or rules leading in combination with their own development stages in order to enhance trade competitiveness in the wave of digital globalization.

1. Introduction

The explosive development of digital technology is reshaping the global economic map. Digital economy has become the core driving force of economic recovery in the post-epidemic era [1]. At the same time, the global trade structure has undergone profound changes [2]. The resonance between this technological revolution and the trade model forces the traditional international trade theory to face a fundamental question-when digital technology breaks through physical boundaries, reconstructs production factors and changes the logic of interest distribution, is the classic trade model based on comparative advantage and factor endowment still applicable? What mechanism does the development of digital economy affect the scale, structure and efficiency of import and export trade? This series of questions urgently need systematic answers at the theoretical level.

The existing research shows obvious differentiation. On one hand, some scholars continue the new trade theoretical framework and emphasize that digital technology can promote trade growth by reducing transaction costs and expanding market scale [3]. On the other hand, the critical view points out that the monopoly of digital platforms, data privacy barriers and the separation of technical standards may lead to new trade protectionism. Behind this academic debate, three theoretical gaps are exposed [4]. First, the understanding of the essential characteristics of the digital economy is still at the tool level, ignoring its subversive transformation of the factor endowment structure as a new production factor [5]. Secondly, the analysis of trade cost focuses on explicit cost, ignoring the reconstruction of implicit cost caused by digital technology. Third, the research on the distribution of trade benefits is mostly based on the national macro perspective, lacking the investigation of the behavior logic of micro-subjects [6].

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This study attempts to achieve breakthroughs in the following dimensions: 1) Study and construct a three-dimensional analysis framework of "technology-system-industry" to reveal the complete path of digital economy's influence on trade by reducing information asymmetry, expanding market boundaries and reshaping value chains. 2) Introduce the concept of digital factor endowment, modify the traditional H-O model's factor type hypothesis, and explain the "paradox of late-comer advantage" of developing countries in digital trade. 3) By comparing the institutional differences between developed and developing countries, explain how digital technology can enlarge or narrow the trade imbalance between North and South. This study is helpful to deepen the theoretical understanding of trade laws in the era of digital economy, and provide a theoretical basis for countries to formulate digital trade strategies and participate in the formulation of international rules. Under the background of accelerating the iteration of digital technology and reconstructing the global trade governance system, this exploration has urgent practical significance.

2. Digital economy development and import and export trade theory

The essence of digital economy is the transformation of economic form driven by data elements. Unlike the traditional economy, which relies on land, labor and capital, the digital economy takes data as the core production factor, and realizes the rapid allocation and value multiplication of factors through digital technology [7]. Its core features are manifested in three aspects: first, virtuality, digital products break through the limitations of physical carriers and realize "production is delivery"; Second, the network effect, the expansion of user scale feeds back the value of the platform, forming a "winner takes all" market structure; Third, the return on scale is increasing, the fixed cost of digital infrastructure is diluted with the increase of users, and the marginal cost is close to zero. These characteristics fundamentally changed the cost-benefit analysis paradigm of traditional economics [8].

The development of international trade theory always resonates with technological change. Ricardo's theory of comparative advantage is based on the relative differences of production technologies in different countries, and the Heckschel-Olin model further attributes the advantage to the differences of factor endowments [9]. The new trade theory introduces economies of scale and imperfect competition to explain intra-industry trade. However, the rise of digital economy makes these theories face double challenges. On the one hand, the reproducibility of digital technology dispels the scarcity of traditional factor endowments, and the "digital comparative advantage" created by cross-border data flow is difficult to be measured by factor abundance. On the other hand, the zero marginal cost makes economies of scale lose their explanatory power, and the monopoly position of platform enterprises is more due to network effect than production scale.

3. The mechanism of the development of digital economy affecting import and export trade

3.1 Reduce trade costs: from explicit costs to implicit barriers

The reduction of trade costs by digital technology is characterized by "from the outside to the inside". Early research paid more attention to the reduction of explicit costs such as logistics and customs clearance by digital technology. For example, the electronic document system reduced the cross-border settlement time from three days to real-time arrival, and the intelligent port dispatching system improved the efficiency of cargo turnover. But the deeper impact lies in the elimination of hidden trade barriers: blockchain technology can trace the whole process of supply chain through distributed account books, so that agricultural products in developing countries can break through non-tariff barriers such as EU "carbon tariffs"; Natural Language Processing (NLP) technology automatically translates multilingual contract terms, reducing the institutional transaction costs of small and medium-sized enterprises participating in international trade. See Figure 1 for the impact path and effect evaluation of digital technology on trade costs:

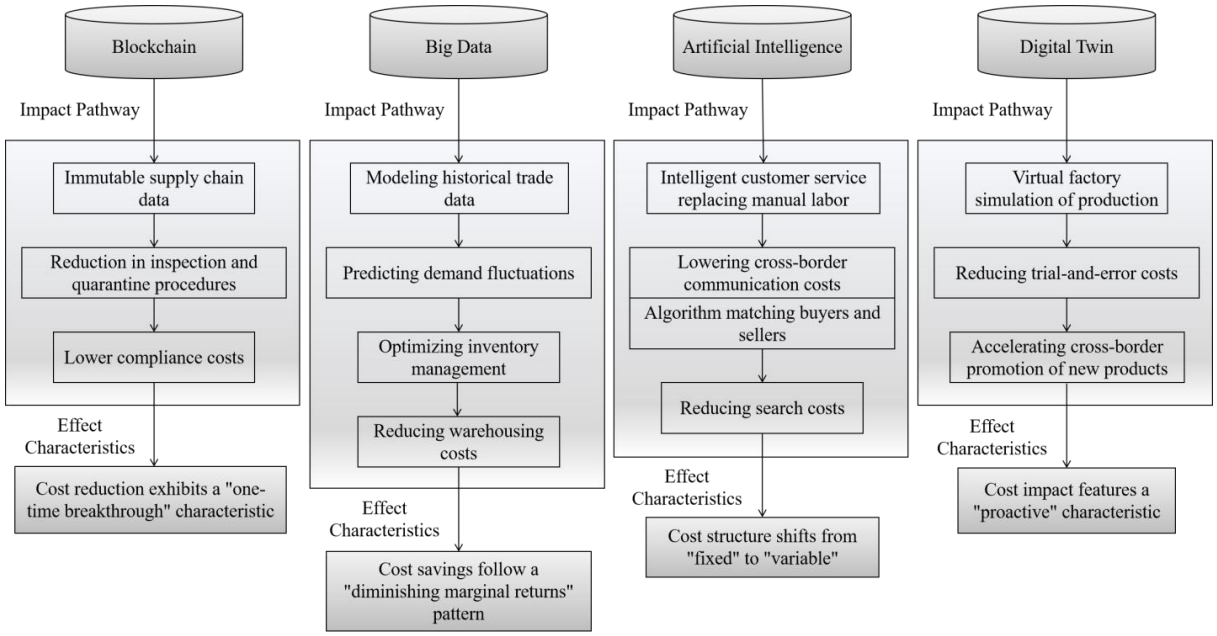

Figure 1 Impact Pathways and Effect Evaluation of Digital Technology on Trade Costs

3.2 Expanding trade boundaries: paradigm shift from physical space to virtual market

Digital platform breaks the geographical constraints of traditional trade and creates a complex ecology where "borderless markets" and "bounded services" coexist. Cross-border e-commerce platforms enable individual operators to directly participate in global trade by lowering the entry threshold, forming a phenomenon of "micro-globalization". The rise of digital service trade has made service products break through the restrictions of "non-storability" and "simultaneity of production and consumption", and promoted the continuous increase of the proportion of service trade. This boundary expansion is not only manifested in the increase of trade objects, but also in the fundamental change of trade mode: the traditional linear process of "export-import" is replaced by the network structure of "global collaborative research and development-localization customization" because of the characteristics of "production is delivery" of digital products.

3.3 Reshaping trade rules: power transfer from multilateral negotiations to technical standards

The development of digital economy has triggered profound changes in the trade rules system. At the macro level, issues such as data flow, digital taxation and source code protection have become the core contents of WTO reform and RTA negotiations. At the micro level, platform enterprises actually master the "private rules" of digital trade by formulating technical standards and algorithm rules. This phenomenon of "code is law" makes the traditional trade governance system face a legitimacy crisis. Developing countries are faced with a double dilemma: they have to deal with the hegemony of digital rules dominated by developed countries, and they need to prevent the domestic digital industry from being "technology locked" by transnational platforms.

3.4 Interactive effect between mechanisms: dynamic cycle of technology-market-rules

The above mechanisms do not operate in isolation, but form a mutually reinforcing circulatory system. For example, blockchain technology reduces compliance costs (cost mechanism), attracts more SMEs to enter the cross-border e-commerce market (border mechanism), and then promotes countries to include "SME protection" clauses in digital trade rules (rule mechanism). Strict digital privacy regulations (rule mechanism) may force enterprises to adopt localized data storage schemes (cost mechanism), and ultimately limit the cross-border provision of digital services (border mechanism). This complexity requires policy makers to deal with the trade impact of the digital economy in a systematic way, and to avoid the fragmented governance of "treating the headache".

4. Analysis of the heterogeneous influence of the development level of digital economy

4.1 Differences in national development stages: the dual pattern of technology monopoly and catch-up

Developed countries occupy the commanding heights of digital technology by virtue of their first-Mover advantage, and their influence path presents the characteristics of "technology-rule" two-wheel drive. On the one hand, it has mastered the underlying technologies such as artificial intelligence and quantum computing, and consolidated its monopoly position through patent barriers and standard setting. On the other hand, it dominates the negotiation of international digital trade rules, and incorporates clauses such as "free flow of data" and "prohibition of compulsory technology transfer" into the FTA, forming a closed loop of "technology for rules". This advantage makes its digital trade surplus continue to expand. Developing countries are faced with "catch-up trap": although some countries have achieved local breakthroughs in the digital application layer, the "stuck neck" problem of core technologies limits the release of their trade potential. See Figure 2 for the comparison of the impact paths of national digital economy development on trade at different development stages:

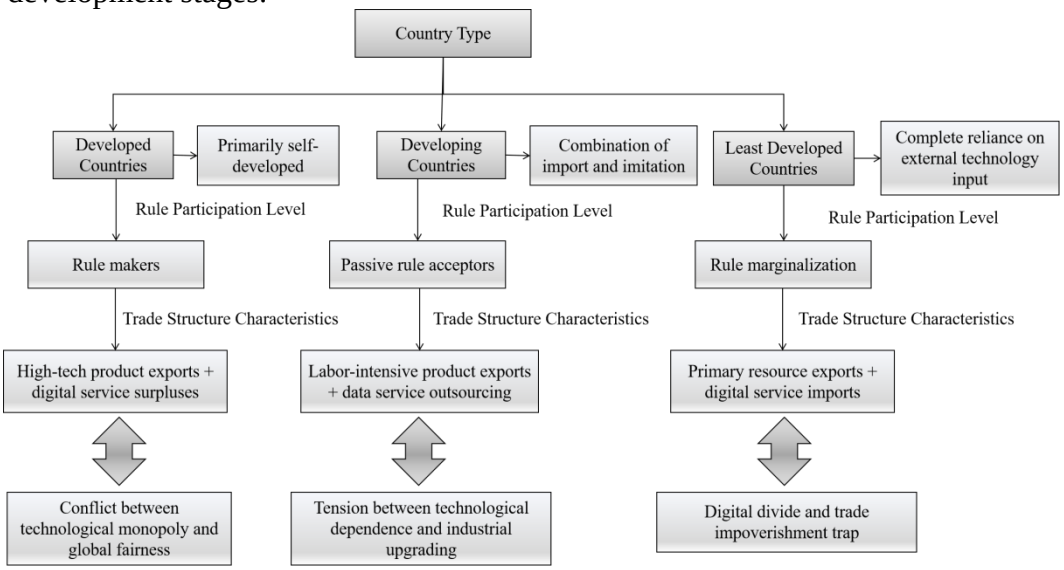

Figure 2 Comparison of Impact Pathways of Digital Economy Development on Trade in Countries at Different Development Stages

4.2 Differences in industry attributes: "gradual penetration" of manufacturing industry and "subversive reconstruction" of service industry

The differences in the absorptive capacity of digital technology in different industries lead to the differentiation of trade impact. In the manufacturing field, digital technology is more manifested as an "empowerment tool". Its influence path follows the gradual logic of "automation-intelligence-networking": the automobile industry realizes global supply chain coordination through industrial internet, shortening the listing cycle of new products by 40%; Textile industry uses 3D modeling technology to achieve "zero inventory" production and reduce cross-border trade risks. Although this penetration has improved the competitiveness of traditional industries, it has not fundamentally changed the value distribution pattern of "smile curve"-developed countries still occupy high-end links such as R&D and brand, while developing countries are trapped in processing and assembly.

The service industry has undergone a subversive change of "digital nativity". Digital services such as cloud computing and telemedicine have broken through the "non-tradeability" restriction, which has aggravated the inequality among industries: knowledge-intensive services such as finance and education have achieved global expansion through digital platforms, while traditional services such as tourism and transportation have been hit hard by physical contact. Developing countries are facing a "double squeeze"-both to deal with the competition of digital service exports

in developed countries and to prevent traditional domestic service jobs from being replaced by algorithms.

4.3 Differences in institutional environment: the path division between open supervision and protective policy

Institutional environment is the "amplifier" or "reducer" of the trade effect of digital technology. The open regulatory system allows digital innovation trial and error through the "regulatory sandbox", reduces the compliance cost of enterprises, and attracts global digital enterprises to gather. For example, Estonia's e-resident program enables multinational entrepreneurs to enjoy digital services without physical presence, which promotes the substantial annual growth of their digital service exports. This policy environment also promotes the integration of regional digital trade by facilitating the cross-border flow of data.

The protective policy strictly controls digital technology on the grounds of "data sovereignty" and "industrial security". India requires all payment system data to be stored locally, which leads to the withdrawal of multinational financial technology enterprises from the market; The Digital Market Law of the European Union forces the platform to open the algorithm interface, which protects the interests of small and medium-sized enterprises, but weakens the global competitiveness of local digital giants. Such policies may safeguard domestic industrial security in the short term, but in the long run, they may hinder technology diffusion and fall into a "protectionist trap".

5. Conclusions

The impact of digital economy development on import and export trade presents multidimensional dynamic characteristics. Technology penetration has become the core driving force of trade expansion by reducing the cost of information, logistics and compliance, but this effect is weakened by 30%-40% in developing countries due to the weak digital infrastructure. At the industry level, the manufacturing industry benefits from global collaborative R&D and supply chain optimization, while the service industry creates new growth points through "tradeability" reconstruction, but both of them face the dual challenges of technology monopoly and employment structure adjustment. In terms of institutional environment, there is an "inverted U" relationship between data flow policy and the intensity of intellectual property protection on trade-moderate opening promotes technology diffusion, while excessive protection or laissez-faire will inhibit innovation spillover. The analysis of national heterogeneity reveals that developed countries maintain their trade advantages by virtue of technology monopoly, but the risk of attenuation of innovation kinetic energy appears; Developing countries catch up through "technology for market", but they need to be alert to the trap of "low-end locking".

Based on the above research, policy enlightenment needs to focus on three major directions. First, developing countries should give priority to investing in digital infrastructure, increase the rural broadband penetration rate to over 70% through public-private partnership mode, and establish local digital technology incubators to lower the technology adoption threshold for SMEs. Second, developed countries need to reform the anti-monopoly framework, incorporate data portability rights into competition policies, and prevent technology giants from hindering innovation through algorithmic monopoly. Third, the global level should promote the establishment of multilateral digital trade rules, form consensus in key areas such as data classification management and cross-border tax distribution, and reduce the fragmentation of the global value chain by the "Digital Berlin Wall". Future research needs to further quantify the impact of digital technology on trade environmental benefits and provide policy basis for sustainable development goals.

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