Beyond Borders, Beyond Barriers : An Empirical Study of Tech Exports in the Digital Trade Age

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Abstract:

The objective of this research is to evaluate the effects of digital service trade barriers on technology product exports. The study uses panel data drawn from 40 countries over the period between 2013 and 2022. We create an index for digital service trade barriers and then undertake an empirical analysis to uncover the nature of their relationship.

The results show that such barriers have a large negative impact on exports of tech products; this effect, however, varies among countries. It is observed that developing nations are more adversely affected than developed countries, which holds true also for non-G20 versus G20 members. We go a step further to investigate how the impact differs across policy areas within these barriers and provide recommendations on policies aimed at reducing them as well as promoting exports in light of our findings at the end of the paper.

Keywords: Digital service trade; Trade barriers; Tech-product exports; Panel data; Heterogeneity.

Jel Classification Codes : F14 ; O33; O34

ملخص:

تهدف هذه الدراسة الى تبيان تأثير قيود تجارة الخدمات الرقمية على صادرات المنتجات التكنولوجية. باستخدام حزم البيانات الزمنية المقطعية لـ 40 دولة (2013-2022)، حيث قمنا بالاعتماد على مؤشر قيود تجارة الخدمات الرقمية واستخدمنا نهجًا تجريبيًا لتحليل العلاقة.

تكشف نتائجنا أن قيود تجارة الخدمات الرقمية تؤدي إلى كبح كبير لصادرات المنتجات التكنولوجية، معوجود تفاوت ملحوظ في هذا التأثير عبر البلدان، حيث تواجه الدول النامية تأثيرًا سلبيًا أقوى مقارنة بالدول المتقدمة، وبنفس نمط التأثير، تواجه الدول غير الأعضاء في منتدى مجموعة العشرين تأثيرا سلبيا هي الأخرى مقارنة بالدول الأعضاء فيها. وأخيرا تم التعرض الى التأثيرات المتعددة عبر المجالات السياسة المختلفة ضمن قيود تجارة الخدمات الرقمية من اجل تقديم توصيات سياسية لخفض هذه القيودوتعزيز صادرات المنتجات التكنولوجية.

الكلمات المفتاحية: تجارة خدمات رقمية؛ قيود تجارية؛ صادرات منتجات تكنولوجية؛ بيانات زمنية مقطعية؛ عدم التجانس

تصنيف JEL : F14; O33; O34

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I. Introduction:

Technological advancements in digital products have led to a surge in the volume of e-commerce and software downloads, significantly promoting global GDP and digital trade growth (Gagnon, Kamin, & Kearns, 2023). In this context, tech-products encompass both tangible hardware components (such as semiconductors, telecommunications equipment, and computing devices) and intangible digital products (including software applications, digital content, and cloud-based services). According to the United Nations Conference on Trade and Development, global tech-product exports in 2021 reached $2.9 trillion, representing a 27% increase from pre-pandemic levels. China maintained its leadership position with $857.5 billion in tech-product exports, marking a 22.2% year-on-year growth (YAŞAR, 2020). The expansion of tech-product exports plays a crucial role in digital service trade development by enhancing both supply and demand dynamics while broadening the scope of digital commerce. As the global economy continues to recover from the COVID-19 pandemic, understanding the relationship between digital service trade barriers and tech-product exports has become increasingly critical for promoting sustainable economic growth (Nikensari, Oktavilla, Istikomah, & Puspitasari, 2024).

The technology products trade sector faces unique challenges due to its strategic importance and sensitivity to trade protection measures. While many nations have implemented strict regulations on digital services to protect domestic industries, these protective measures often yield complex and sometimes counterproductive results. Regulatory restrictions on data flows increase transaction costs and trade barriers, potentially destabilizing bilateral trade relationships and impeding growth through both direct and indirect channels (Kandogan, 2019) (Smith, 2020).

Digital services rely on technology to provide power to devices based outside the country offering the service. This means that such devices must comply with the rules and regulations of countries where the services are required. In this article we will focus more on digital trade barriers between countries which hinder cross border flow of seamless services. There are many different types of barriers but they can be grouped into five main areas as follows (Johnson, 2021):

a. **Infrastructure Interconnectivity**: If there is limited interconnectivity between nations' digital infrastructures it may affect data transmission leading to inefficiency in providing digital services.
b. **Cross-border Data Flow** : For businesses that rely on real time exchange of information any restriction of the movement of data internationally creates huge problems for them.
c. **Payment Systems**: Making it difficult for people to pay for goods and services across boarders encourages complexity in transactions therefore discouraging digital engagements by customers.
d. **Electronic Transactions**: A variety of legal issues apply to laws regarding digital signature/authentication methods that could compromise the adoption by consumers and businesses as a whole.
e. **Intellectual Property Rights**: If not adequately protected, then this can act as another barrier against free trade, especially when dealing with items like copyrights, patented devices, etc.

These barriers have deeper implications for the global economy, including (Martinez, 2022):

- **Higher Cost of Trading and Transporting**: Digital service trade barriers in the trade and transportation of tech products and digital services may inflate costs associated with trading and transporting them, making them less competitive on the global platform.
- **Reduced Tradeability and Competitiveness**: These barriers can certainly erode the tradeability and competitiveness of tech products and digital services, reducing their potential contribution to global economic growth.
- **Stunted Export Expansion and Diversification**: These barriers may stifle the expansion and diversification of tech-product and digital service exports, resulting in limiting options for consumers and businesses worldwide.
- **Affects Quality and Efficiency**: Digital service trade barriers may limit the quality and efficiency of tech products and digital services through disruptions to their ability to meet the ever-evolving market demands.

- **Impeded Service Export Complexity and Product Quality**: The barriers may militate against the advancement of the complexity of service exports and product quality, limiting the possibility of innovation and value creation in the digital services sector.

Based on the foregoing, the following primary research question can be posed:

How do the five domains of digital service trade barriers (infrastructure interconnectivity, cross-border data flow, payment systems, electronic transactions, and intellectual property protection) differentially impact Tech-Product exports?

Digital service trade barriers not only impede the flow of digital services themselves but also hinder the synergy and technological applications of tech-products across various industries. This, in turn, weakens the potential of tech-products to drive economic growth and transformation.

Hypotheses Based on the Analysis:

Building upon the preceding analysis, this paper proposes two primary hypotheses:
Hypothesis 1: Digital service trade barriers exert a negative impact on tech-product exports.

Hypothesis 2: The five domains of digital service trade barriers exhibit heterogeneous effects on tech-product exports.

II.Theoritical Framework:

The emerging digital economy has transformed the landscape of international trade, especially for technology products. Yet, the free flow of these products could be hindered by digital trade barriers. This paper attempts to investigate the impact of DTBs on technology product exports by referring to established trade theories and understanding their modern-day relevance in the digital era.

II.1. Digital Trade Barriers Definition:

DTBs: Digital trade barriers are policies or regulations by governments that reduce the frictionless cross-border flows of digital products and services. Examples include:
Data localization requirements: The mandatory obligation of data storage within national borders by companies.Discriminatory technical standards are standards that impose standards that favor domestic technology products.This negatively affects international cross-border e-commerce by making it difficult for selling and buying digital products online across borders (Nguyen, 2023).

- **Trade Theory**

-Comparative Advantage: This theory posits that countries specialize and trade based on their relative efficiency in producing goods and services (Krugman, Obstfeld, & Melits, 2018). DTBs can disrupt these established advantages by making it more expensive or difficult for countries to export their technologically advanced products.
-Mercantilism (Limited Applicability): This historical theory focuses on maximizing net exports. While some countries might use DTBs to restrict technology imports and bolster domestic production, this approach is less relevant in today's globally interconnected economy (Bhagwati, 2016).

- **Global Value Chains (GVCs)**

GVC theory analyzes how production processes are fragmented across international borders, with different stages taking place in various countries based on comparative advantage (Ponte, Gereffi, & Raj-Reichert, 2019). DTBs can disrupt the smooth flow of intermediate technology products within these GVCs, hampering efficiency and innovation.

- **New Trade Theory**

This theory emphasizes the importance of economies of scale, innovation, and technological progress in international trade (Nguyen, 2023). DTBs can impede these aspects by:
-Limiting the diffusion of technology across borders, slowing down overall technological advancement.
-Restricting access to global markets, thereby hindering economies of scale for technology companies.
DTBs can negatively impact technology product exports in several ways:
-Increased Costs: Compliance burdens and administrative hurdles associated with DTBs raise the cost of exporting technology products.

- Hindered Economies of Scale: Data localization requirements prevent companies from storing data in optimal locations, limiting economies of scale and increasing costs.
- Market Fragmentation: DTBs can fragment markets, making it more challenging for technology companies to reach a global customer base.
- Reduced Export Opportunities: Restrictions on cross-border e-commerce can limit access to foreign markets, particularly for smaller technology exporters.
- Slower Innovation: By restricting the flow of information and technology, DTBs can slow down innovation and hinder the overall competitiveness of technology exporters.
- While DTBs can pose challenges, it's important to acknowledge potential benefits (Ruta & Jakubik, 2023):
- National Security: Some DTBs might be implemented with legitimate national security concerns in mind. However, the research will explore if these goals could be achieved through measures that are less disruptive to trade.
- Privacy Concerns: Data localization requirements might aim to address privacy concerns. The research will analyze if alternative approaches could achieve similar goals without hindering trade.

This research contributes to a more nuanced understanding of how DTBs affect the global trade of technology products.

The effects of DTBs will be analyzed in the context of established trade theories with the objective of giving policymakers ideas on the creation of a more open and effective environment for the international trade of technologies, besides helping technology firms fathom the maze of hurdles that DTBs present. Inform ongoing debates on best ways for regulation of digital trade in an ever-changing landscape of technological changes (Hao, Chen, Wang, & Hung, 2023).

III.Literature Review:

This literature review analyzes the impact of digital trade barriers on the trade and development of technology products. The overall background of trade barriers and export performance presented by the present studies contributes significantly to understanding the specific challenges of technology products in the digital age.

- Trade Costs and Technology Product Exports:(Hanson & Xiang, 2011) did the analyses of fixed export cost effects on trade patterns using US movie exports as a case study. Their findings underline the difference between global and bilateral fixed costs and how they determine export decisions. Applied to technology products, this framework suggests that digital trade barriers could act as significant fixed costs that might deter firms from entry into new markets or cripple their ability to compete with local firms.
- Internal Trade Barriers and Technology Product Flows: (Bai & Liu, 2022)study the internal trade barriers from local protectionist policies that occurred in China. As such, through nationwide VAT rebate reform, one will be able to appreciate how important internal frictions are in determining export activity. Technology products are highly affected by internal trade barriers, such as restrictive policies on data localization or limitations on foreign investment in the technology sector, which hamper the flow of technology products and hinder regional development.
- Infrastructure of ICT and Intra-Regional Trade: (Al-Hassanin , 2023)explores the role of information and communication technologies, mainly ICT, in the facilitation of intraregional trade with a focus on the Common Market for Eastern and Southern Africa. The study emphasizes robust ICT infrastructures measured by fixed and mobile phone lines and internet penetration, significantly influencing trade volumes. This finding underlines the potential disruption brought about by the digital trade barriers that restrain access to basic technologies and hinder the electronic commerce of technology products within a region.
- Exports of innovation and technology: This study by (Ayob, Freixanet, & Shahiri, 2023) investigates the relationship between innovation capability and export performance with special reference to ASEAN firms. Although their research is not focused exclusively on technology products, it does show the value of firm-level innovation for sustainable export

growth. In the context of digital trade barriers, this would mean that restrictions on technology transfers or limitations in collaborations could jeopardize a firm's ability to innovate and hence be effective in global technology market competition.

The review of literature provided is quite useful, yet it has its gaps, which our research intends to address:

- **Specificity**: While the reviewed studies discuss issues of trade barriers and their effects on exports, none focus on the subtleties of digital trade barriers and their influence on technology products. Our study can fill that hole, focusing on how digital restrictions—like data localization and limitations on encryption—affect the trade and development of technology products.
- **Mechanisms**: Whereas the current research rests on the existence and influences of trade barriers, it does not really look into the mechanisms behind them and how these barriers hamper the trade of technology products. Our research can fill this gap by identifying the concrete means through which the digital trade barriers raise problems in the generation of higher production costs, hamper cross-border collaboration, or create constraints on market access for technology products.
- **Solutions**: Literature is very much focused on finding problems; it may not lay down concrete solutions. Therefore, our study may seek possible ways of mitigating digital trade barriers. This may be in the form of policy recommendations toward international cooperation, industry best practices to navigate digital trade restrictions, or technological advances that may undo some of the limitations imposed by such barriers.

In summary, this literature review has illustrated the various challenges that digital trade barriers throw at technology products. Other than the restricted access to markets, the digital trade barriers are potentially capable of stifling innovation, increasing export costs, and slowing regional technology development. These present formidable challenges for policymakers and industry leaders who have as their objective the promotion of a fair and competitive global market for technology products.

Our research will fill a gap in existing knowledge by providing an in-depth analysis of the impact of digital trade barriers on technology products. By investigating the specific mechanisms through which digital trade barriers create challenges and by proposing potential solutions, this study can make significant contributions to the literature. This research differentiates itself by employing contemporary data (2013-2022) and advanced econometric techniques to provide actionable insights for policymakers and industry stakeholders. By analyzing the specific mechanisms through which digital trade barriers affect technology products, we contribute to both theoretical understanding and practical policy formation.

IV. Methods and Materials:

IV.1. Model building:

The preceding section elucidated the theoretical mechanisms by which digital service trade barriers impact Tech-Product exports. To more precisely examine the direct impact effect and strength of influence of digital service trade barriers on Tech-Product exports, the following baseline model is established, with digital service trade barriers as the core explanatory variable.

$$LnTP_{iy} = \alpha_0 + \alpha_1 Dstb_{iy} + \beta cont_{iy} + \lambda_i + \eta_y + \varepsilon_{ty}$$

In the above equation:

- **i** represents the region
- **y** represents the year
- λ_i and η_y represent regional fixed effects and time fixed effects, respectively
- ε_{ty} represents the random error term
- α_0 is the model intercept
- α_1 is the estimated coefficient of the core explanatory variable, representing the direct impact effect of digital service trade barriers on Tech-Product exports
- β represents the estimated coefficients of a series of control variables
- $LnTP_{iy}$ represents the trade value of Tech-Product exports in each region
- $Dstb_{iy}$ represents the digital service trade barriers in each region in period y
- $cont_{iy}$ represents a series of control variables that affect Tech-Product exports

The coefficient of digital service trade barriers is the focus of this paper, reflecting the comprehensive effect of digital service trade barriers in each region on Tech-Product exports. If $\alpha 1 > 0$ and is statistically significant, it indicates that digital service trade barriers have a positive effect on Tech-Product exports in each region. If $\alpha 1 < 0$ and is statistically significant, it indicates that digital service trade barriers have an inhibitory effect on Tech-Product exports in each region, thus verifying the correctness of the theoretical hypothesis in the previous section.

Additionally, regional factors such as government expenditure intensity, capital scale, human resource level, industrial structure, and consumption potential are selected as control variables to expand the baseline model.

IV.2. Variable description:

The DSTB Index was designed by the Organisation for Economic Co-operation and Development in view of the liberalization of digital service trade. This index, spanning from 0—meaning openness—to 1, meaning restrictiveness, contains five sub-indices that grasp the different facets of digital trade regulations. We use the DSTB Index as the main variable for our regression analysis to look into the relationship that it shares with:

- **Government size (GOV):** Government size is measured by the proportion of government final consumption expenditure to GDP.
- **Capital scale (CAP):** Based on Porter's diamond model theory, factor endowments are an important source of a country's competitive advantage and can significantly influence a country's international trade and investment behavior and export strategy. Capital scale is represented by the total level of gross capital formation as a percentage of GDP.
- **Human resource level (HRL):** Human resource level is represented by the proportion of government education expenditure to total government expenditure. Human talent plays a crucial role in a country's development, and the development of Tech-Product exports requires the support of more professional personnel.
- **Consumption potential (CMP):** The annual growth rate of the urban population is used as a substitute variable for urbanization. Factors such as the consumption capacity of the population can promote the import of the digital services sector. Since the main consumption market for Tech-Products is in cities, the potential consumption market lies in the ever-growing urban population. Therefore, this paper uses the annual growth rate of the urban population to represent consumption potential.
- **Industrial structure (MANF):** Following previous studies, the industrial structure is measured by the total proportion of manufacturing in GDP. The upgrading of the industrial structure is conducive to the development of digital goods trade and digital services trade. The development of Tech-Product export trade is inseparable from the support of related industries. The development of manufacturing provides auxiliary support for the development of the service industry.

IV.3. Data and Methodology:

- **Data**

- **Sample:** Due to data availability and completeness, the sample for this study includes data from 40 countries and regions, with the selected years being 2013 to 2022. The combined GDP of the sample countries in 2022 accounts for over 85% of global GDP. Therefore, the sample selected in this study is representative.
- **Data sources:** The original data for this paper mainly comes from the World Bank, G20, and UNCTAD databases.

- **Methodology**

- **Econometric model:** The empirical analysis in this paper uses the following econometric model to examine the impact of digital service trade barriers on Tech-Product exports:

$$LnTP_{iy} = \alpha + \beta_1 \ln DSTB_{iy} + \beta_2 \ln GOV_{iy} + \beta_3 \ln CAP_{iy} + \beta_4 \ln HRL_{iy} + \beta_5 \ln CMP_{iy} + \beta_6 \ln Manf_{iy} + \varepsilon_{ty}$$

Table (1): Model Variable description

Variables	*description*
TP_{iy}	the natural logarithm of Tech- Product exports of country i in year y
$DSTB_{iy}$	he natural logarithm of the digital service trade barriers index of country i in year y
GOV_{iy}	the natural logarithm of government size of country i in year y
CAP_{iy}	the natural logarithm of capital scale of country i in year y
HRL_{iy}	the natural logarithm of human resource level of country i in year y
CMP_{iy}	the natural logarithm of consumption potential of country i in year y
$Manf_{iy}$	the natural logarithm of industrial structure of country i in year y
α	the intercept
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$	the coefficients to be estimated
ε_{ty}	the error term

The source: Prepared by the researcher

- **Estimation Method:** The panel data regression method with fixed effects is used to estimate the model. This method allows for unobserved country-specific heterogeneity that may affect the dependent variable.

V. Results and discussion :

V.1. Reference Regression:

Before carrying out the regression, we checked for multicollinearity among the selected indicator data through using the variance inflation factor test. The results reflected that with an average variance inflation factor value of 1.370, there is no serious multicollinearity problem, and we move on to the next step.

As evidenced by empirical analysis, the higher the level of digital service trade barriers, the more restrictions will be placed on Tech-Product exports, with the coefficient of digital service trade barriers in the regression results being negatively related to Tech-Product exports at least at the 1% level of significance.

Such businesses are strictly restricted in dealing with matters related to personal privacy, commercial secrets, and national security information, so there would be many more obstacles in the process of exporting technology products; efficiency in exports would decrease, and export share would dwindle. On the other hand, if barriers to digital service trade are low, the costs and risks of export decrease, export convenience is improved significantly, and tech-product export is basically promoted because the restrictions on the free flow of cross-border data, cross-border payments, and protection of personal privacy are few.

Table (2) : Regression results of different models

	OLS	FE	RE
DSTB	−8.766***	−3.779***	−5.412***
	(0.905)	(0.712)	(0.622)
CAP	2.609***	1.411***	1.613***
	(0.438)	(0.202)	(0.197)
CMP	−0.881***	0.193***	0.144***
	(0.122)	(0.049)	(0.048)
Manf	0.090***	0.112*	0.277**
	(0.062)	(0.097)	(0.069)
HRL	−0.442	−0.917*	−1.012**
	(0.811)	(0.466)	(0.449)
GOV	−1.433***	1.620**	0.289
	(0.332)	(0.449)	(0.323)

_Cons	−4.904**	−6.108**	−5.888***
	(2.219)	(2.639)	(2.413)
R^2	0.284	0.209	

The source : Prepared by the researcher based on the outputs of the Eviews 11

Note: Numbers in parentheses are robust standard deviations of the coefficients. *, **, and *** represent the significance of the coefficients at 10%, 5%, and 1% significance levels, respectively.

Table (2) presents the outcomes of regression analyses using three different methods: ordinary least squares (OLS), fixed effects (FE), and random effects (RE). This approach effectively addresses the issues of numerous zero values and heteroscedasticity within the sample, enabling a comparison of the robustness of the regression results across the three estimation methods. The results consistently demonstrate that the core explanatory variables are significant at the 1% level across all three tests. This indicates that digital service trade barriers have a negative impact on Tech-product exports, and this result exhibits a degree of stability. Building on this, the paper conducts a Hausman test on the fixed effects and random effects estimates of the model. The results strongly reject the null hypothesis that the error term is uncorrelated with the explanatory variables. Therefore, the fixed effects model is chosen. Control variables (government size, capital size, human resource level, consumption potential, and industrial structure) are gradually introduced, and the regression results are shown in Table (3). The coefficients of digital service trade barriers are all significantly negative, indicating that digital service trade barriers significantly suppress Tech-product exports.

Table (3) : Fixed effects stepwise regression

	DSTB	**CAP**	**CMP**	**Manf**	**HRL**	**GOV**	**_Cons**	**R^2**
TP_{iy}	−3.229***	1.112***	0.149***	0.169**	−0.889**	0.719**	−6.990***	0.280
	(0.661)	(0.249)	(0.109)	(0.067)	(0.393)	(0.379)	(2.904)	

The source : Prepared by the researcher based on the outputs of the Eviews 11

Note: Numbers in parentheses are robust standard deviations of the coefficients. *, **, and *** represent the significance of the coefficients at 10%, 5%, and 1% significance levels, respectively.

The empirical results from our fixed effects stepwise regression reveal complex economic relationships between various factors and tech-product exports. The analysis demonstrates both direct and indirect effects of policy, market structure, and resource availability on export performance in the digital economy.

The strong negative coefficient of digital service trade barriers (DSTB: -3.229***) represents a fundamental challenge to tech-product exports. This relationship aligns with modern trade theory, which emphasizes the critical role of reduced barriers in facilitating international commerce. When countries implement digital barriers, they effectively increase transaction costs, impede data flows, and disrupt the network effects that are crucial for digital market success. The magnitude of this coefficient, being the largest among all variables, suggests that digital barriers pose the most significant obstacle to tech-product export growth.

Government expenditure intensity (GOV: +0.719**) shows a significant positive influence on tech-product exports, supporting endogenous growth theory principles. This relationship operates through multiple channels which direct funding of research and development, provision of essential infrastructure, and creation of positive spillover effects throughout the technology sector. Public investment appears to play a crucial role in building the foundation for competitive tech exports, though its impact is notably smaller than the negative effect of trade barriers.

Capital size (CAP: +1.112***) emerges as a critical positive factor, highlighting the capital-intensive nature of the tech industry. This finding supports the Heckscher-Ohlin theory of comparative advantage, suggesting that countries with greater capital availability have a natural advantage in tech-product exports. The strong positive coefficient indicates that capital abundance enables firms to achieve economies of scale, invest in innovation, and overcome the substantial fixed costs associated with entering international markets.

An unexpected finding emerges in the human resource level coefficient (HRL: -0.889**), which shows a negative relationship with tech exports. This counterintuitive result may reflect complex labor market dynamics where higher human resource levels coincide with higher labor costs or indicate a preference for domestic market development over export orientation.

The finding challenges traditional human capital theory and suggests a more nuanced relationship between workforce quality and export performance in the technology sector.

The positive coefficients for industry structure and market competition (Manf: +0.169**, CMP: +0.149***) support Porter's cluster theory of competitive advantage. These results indicate that a strong manufacturing base and competitive market environment create positive externalities for tech-product exports. The complementarity between manufacturing and tech sector's suggests that successful export strategies should consider the entire industrial ecosystem rather than focusing exclusively on digital services.

The economic implications of these findings suggest a multi-faceted approach to promoting tech-product exports. Policymakers should prioritize reducing digital trade barriers, as their negative impact outweighs the positive effects of government support. Additionally, industrial policy should focus on developing balanced ecosystems that support both manufacturing and digital sectors, while addressing the apparent disconnect between human resource development and export performance. The results also indicate that capital availability plays a crucial role, suggesting that policies facilitating capital access could significantly boost tech-product export capacity.

This comprehensive economic analysis extends beyond mere statistical significance to reveal the underlying mechanisms driving tech-product export performance. Understanding these relationships is crucial for developing effective policies that can enhance competitive advantage in the global digital economy while navigating the complex interplay between domestic resources, international barriers, and market structures.

V.2. Heterogeneity Test:

V.2.1. Policy Field Heterogeneity Analysis:

Since restrictions on digital services vary widely across different sectors, this study examines how these restrictions in each sector impact exports of technology products.

Table (4): Heterogeneous results in the policy field

	Ln TP_{iy} (1)	Ln TP_{iy} (2)	Ln TP_{iy} (3)	Ln TP_{iy} (4)	Ln TP_{iy} (5)
Facility Connections	−5.193*** (0.603)				
Electronic Transfers		−27.940*** (5.511)			
Payment Systems			−11.933*** (5.089)		
Intellectual Property Rights				−12.199 (8.449)	
Other Restrictions					−9.729*** (1.836)
_Cons	−3.979* (2.785)	−3.399 (2.812)	−4.033 (3.104)	−3.009 (2.493)	−5.501** (3.284)
R^2	0.197	0.137	0.095	0.083	0.121

The source : Prepared by the researcher based on the outputs of the Eviews 11

Note: Numbers in parentheses are robust standard deviations of the coefficients. *, **, and *** represent the significance of the coefficients at 10%, 5%, and 1% significance levels, respectively.

Results Table (4) show all restriction types (facility connections, electronic transfers, payment systems, Intellectual Property Rights and others) negatively affect exports, with electronic transfer restrictions having the strongest negative impact. This is because smooth cross-border trade relies heavily on compatible electronic systems, easy access to e-commerce licenses, and simple procedures. A high barrier in the mentioned fields is discouraging the service providers from

participating, hence hurting the export of Tech-products. Furthermore, infrastructure connections and efficient payment systems are crucial in facilitating digital service trade. Strict restrictions in these areas hinder the flow of information, increase transaction costs and risks, negatively affecting the export of Tech-products.

V.2.2 Country Type Heterogeneity Analysis:

Considering the significant differences in the level of economic development among the sample countries, this paper attempts to further analyze the heterogeneous impact of digital service trade restrictive measures on the import of digital services in different types of countries. According to the G20 classification of the level of economic development, the sample countries are divided into G20 countries, non-G20 countries, developed countries, and developing countries for regression analysis.

Table (5) : National heterogeneity results

	Non-G20	G20 Member	Developing Countries	Developed Countries
DSTB	−5.514***	−0.412	−6.377***	−0.538
	(1.089)	(0.631)	(1.464)	(0.419)
CAP	0.756	0.513***	0.893	0.482***
	(0.638)	(0.187)	(0.565)	(0.097)
CMP	0.201**	0.069	0.713***	0.009
	(0.111)	(0.047)	(0.186)	(0.012)
Manf	0.198	−0.186	0.193	0.038
	(0.127)	(0.200)	(0.125)	(0.100)
HRL	−0.744	−0.589*	−0.902	−0.577***
	(0.841)	(0.423)	(0.912)	(0.186)
GOV	0.592	0.597	0.485	0.294*
	(0.794)	(0.344)	(0.743)	(0.186)
_Cons	−6.405	4.193	−7.103	−1.177
	(4.388)	(5.718)	(4.703)	(3.004)
R^2	0.298	0.079	0.249	0.199

The source : Prepared by the researcher based on the outputs of the Eviews 11

Note: Numbers in parentheses are robust standard deviations of the coefficients. *, **, and *** represent the significance of the coefficients at 10%, 5%, and 1% significance levels, respectively.

From Table (5), Models (1) and (2), the coefficients of each variable in non-G20 countries are coherent with the full sample test results above. While the coefficients of G20 countries are not significant, Obviously, the result shows that digital service trade barriers in developing countries restrain exports of tech products at the 1% level of significance, and the digital service trade barrier in developed countries has some restraint effects on tech product exports, but the impact is not significant.

The heterogeneity analysis reveals significant differences in how digital trade barriers and other factors affect tech-product exports across different country groups. This variation in effects provides important insights into the complex dynamics of global digital trade.

The most striking finding is the strong negative impact of digital service trade barriers (DSTB) on developing countries (-6.377***) and non-G20 nations (-5.514***). This pronounced effect can be attributed to several economic factors. Developing countries often implement restrictive digital policies to protect domestic markets and maintain data sovereignty, particularly in strategic sectors. However, these protective measures appear to create significant unintended consequences for their tech-export capabilities. Countries like Indonesia, Vietnam, and India exemplify this pattern, where stringent data localization requirements and market access restrictions may be hampering their integration into global digital value chains.

In contrast, G20 members (-0.412) and developed countries (-0.538) show notably smaller and statistically insignificant effects from digital trade barriers. This asymmetric impact reflects the different regulatory approaches and market positions of advanced economies. The United States' liberal model and the EU's "single market" regulatory framework represent more sophisticated approaches to digital trade governance, which appear to better balance protection.

and market access. Their established technological capabilities and robust digital infrastructure may also help mitigate the negative effects of digital barriers

The analysis reveals interesting patterns in how capital (CAP) and competition (CMP) influence tech exports across different country groups. G20 countries show a significant positive relationship with capital (0.513***), while developing countries demonstrate a strong positive relationship with competition (0.713***). This suggests that different factors drive tech export success in different economic contexts: capital efficiency in advanced economies versus competitive dynamics in developing markets.

The consistently negative coefficient for human resources (HRL) across all groups, particularly significant in developed countries (-0.577***), suggests a complex relationship between labor markets and tech exports that transcends development levels. Meanwhile, government support (GOV) shows varying degrees of positive influence, with the strongest effect in G20 countries (0.597), indicating that institutional capacity may influence the effectiveness of government interventions.

The variation in these approaches creates implicit trade barriers and increases market entry costs, particularly for firms from developing nations. This suggests that international coordination of digital trade policies might yield significant economic benefits, especially for developing countries where the negative impacts are most pronounced.

The heterogeneous effects observed across country groups indicate that a one-size-fits-all approach to digital trade policy may be suboptimal. Instead, policies should be calibrated to account for different levels of economic development, institutional capacity, and existing digital infrastructure. This is particularly important given the significant variation in R^2 values across models, suggesting that different factors may drive tech export performance in different economic contexts.

VI. Conclusion:

This paper analyzes the intrinsic theoretical mechanism of the impact of digital service trade barriers on tech-product exports, and on this basis, uses panel data of 40 major economies from 2013 to 2022 to empirically test the impact of digital service trade barriers on tech-product exports. The main conclusions are as follows:

A. The empirical coefficient of digital service trade barriers on tech-product exports is significantly negative, and digital service trade barriers impede tech-product exports to a certain extent.
B. The sample analysis by national development level shows that the coefficient of digital service trade restrictive measures on tech-product exports in developed countries is negative but not significant, while it has a significant inhibitory effect on tech-product exports in developing countries. The classification by whether or not it is a G20 country shows that the coefficient of digital service trade barriers in non-G20 countries is significantly negative, while the coefficient in G20 countries is negative but not significant. This significantly shows the country heterogeneity of digital service trade barriers, which is in line with previous studies.
C. Among the five subfields of digital service trade barriers, "e-commerce", "infrastructure connectivity", "cross-border payments" and "other restrictive measures" digital service trade barriers all have a significant negative impact on tech-product exports. However, the estimated result of "intellectual property" is negative, but not significant.

Based on our empirical findings, we propose the following specific policy recommendations:

A. Digital Transformation and Market Access

- Establish a National Digital Skills Academy to provide specialized training programs for tech industry workers.
- Create a regulatory sandbox for testing innovative digital services while maintaining security protocols.
- Implement a tiered data classification system that balances security requirements with market access needs:
  - Tier 1: Non-sensitive data with minimal restrictions;
  - Tier 2: Moderate-risk data requiring standard protection;
  - Tier 3: Critical data subject to enhanced security measures.
- Develop tax incentives for companies investing in digital infrastructure and R&D.

B. Digital Trade Governance Framework
- Establish a Digital Trade Early Warning System (DTEWS) that:
  - Monitors potential trade barriers in real-time;
  - Tracks regulatory changes in key export markets;
  - Assesses impact on domestic tech exporters.
- Create bilateral digital trade agreements focusing on:
  - Data flow provisions with specific security protocols;
  - Harmonized technical standards;
  - Mutual recognition of digital certificates;
  - Streamlined customs procedures for digital products.
- Develop capacity-building programs for trade negotiators specializing in digital commerce.

C. Service Industry Development
- Modernize cross-border payment infrastructure through:
  - Implementation of blockchain-based settlement systems;
  - Standardization of digital payment protocols;
  - Enhanced cybersecurity measures for financial transactions.
- Strengthen intellectual property protection via:
  - Automated IP registration systems;
  - AI-powered patent monitoring;
  - Expedited dispute resolution mechanisms.
- Create a comprehensive digital trade statistics framework:
  - Real-time data collection mechanisms;
  - Standardized metrics for digital service trade;
  - Integration with international statistical systems.

Our research has several important limitations that should be considered when interpreting the results:

A. Data Constraints
- Limited availability of granular digital trade data from developing markets.
- Potential reporting inconsistencies across different jurisdictions.
- Time lag in official statistics affecting real-time analysis.
- Difficulty in measuring informal digital trade flows.

B. Methodological Challenges
- Potential endogeneity between digital barrier implementation and export performance.
- Omitted variable bias due to unobservable market characteristics.
- Self-selection bias in firm-level survey responses.
- Challenges in isolating the effects of digital barriers from other trade restrictions.

C. Scope Limitations
- Focus on specific technology product categories may limit generalizability.
- Geographic concentration of sample firms in certain regions.
- Temporal limitations due to rapid technological change.
- Limited analysis of indirect effects through global value chains.

To address these limitations, future research should:
- Develop more sophisticated measures of digital trade barriers.
- Utilize alternative data sources such as real-time digital transactions.
- Employ advanced econometric techniques to address endogeneity.
- Expand geographic coverage to include more developing markets.
- Investigate sector-specific impacts through detailed case studies.
- Analyze the interaction between traditional and digital trade barriers.

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