Analysis of the Impact of Digital Trade Barriers on the Export Resilience of Small and Medium-Sized Enterprises-Empirical Analysis Based on Cross-Border Panel Data

Yiming Wang *

Major of Economics, Santa Monica College, California, United States

* Corresponding Author Email: bfthg939504@outlook.com

Abstract. In the digital economy era, the average annual growth rate of global digital trade scale reached 15%, but the digital trade barriers of various countries are characterized by "non-tariff" and "technicalization". Therefore, the compliance costs of small and medium-sized enterprises in developing countries increased by 25%-40%, and the export recovery cycle was extended by 6-12 months. This paper takes small and medium-sized enterprises (SMEs) with export volume of less than US$20 million in 2018-2022 as a sample and uses the dual-differential method and panel fixed-effect model to explore the influence mechanism and response path of digital trade barriers on their export resilience. The research found that digital trade barriers significantly inhibit the export resilience of small and medium-sized enterprises, and the impact of data governance barriers is the strongest. Increased compliance costs, imbalance in resource allocation and lag in market adjustment are the main transmission paths, and R&D investment and market diversification can alleviate this inhibitory effect. This study fills the gap in existing research in micro mechanisms and dynamic capabilities analysis and provides micro evidence and practical reference for small and medium-sized enterprises to break through barriers through technological innovation and market diversification, as well as policy makers to promote the docking of rules and provide compliance subsidies. It is recommended that the government speed up the participation of international digital agreements, establish compliance subsidies and public data platforms, and enterprises increase R&D, expand markets, adopt lightweight tools and participate in multinational alliances.

Keywords: Digital trade barriers; small and medium-sized enterprises; export resilience; dual differential method; regulation effect.

1. Introduction

In the digital economy era, the average annual growth rate of global digital trade scale reached 15%, but the digital trade barriers of various countries showed the characteristics of "non-tariff" and "technicalization" [1,2]. For example, the localized storage requirements and platform access restrictions of the EU's Digital Markets Act (DMA) have formed rigid constraints on small and medium-sized enterprises with limited resources. The World Bank estimates show that compliance costs in small and medium-sized enterprises in developing countries have increased by 25%-40% due to digital trade barriers, and the export recovery cycle has been extended by 6-12 months. In this context, exploring how digital trade barriers affect the export resilience of small and medium-sized enterprises is of great practical significance to promoting the high-quality development of foreign trade.

There are two limitations in existing research. One is that the macro level focuses more on changes in trade scale [3,4], and lacks analysis of the dynamic ability of "export resilience"; the other is that the heterogeneity influence of different types of barriers and the role of buffering factors are not clarified in the micro mechanism [5]. For example, existing studies have not distinguished the differences between data governance and platform rules barriers, nor have they systematically tested the regulatory effects of R&D investment and market diversification.

In theory, it integrates dynamic capability theory and resource dependence theory to build an analysis framework of "digital trade barriers-resource allocation-export resilience" to fill the gap in the research on the micro-effects of digital trade barriers; in practice, it provides reference for small and medium-sized enterprises to deal with digital barriers (such as technological innovation, market

diversification) and policy makers to optimize system design (such as rule docking, compliance cost subsidies).

2. The Impact Mechanism and Research Hypothesis of Digital Trade Barriers

2.1. Main Effect: The Inhibitory Effect of Digital Trade Barriers on Export Resilience

Digital trade barriers suppress the export resilience of small and medium-sized enterprises through triple conduction paths. First, it will increase the company's operating compliance costs. In addition to server leasing and compliance team building, enterprises also need to bear rigid expenditures such as data authentication ,such as the "data protection officer" configuration of the European Union (EU) General Data Protection Regulation (GDPR), cross-border transmission encryption (such as the annual SSL certificate fee), regular compliance audits (average annual 2-3 times, a single cost exceeding 100,000 yuan), etc. [1]. For small and medium-sized enterprises with limited resources, such costs can account for 15%-20% of revenue, which is far higher than 5%-8% of large enterprises, directly squeezing capital investment in core links such as production, R&D.

Secondly, digital trade barriers will distort the allocation of innovative resources for enterprises. When compliance and adaptation become a prerequisite for market access, enterprises are forced to turn funds and manpower originally used for technology iteration (such as AI algorithm optimization), product research and development (such as functional upgrades) to the construction of compliance system [3]. This resource transfer is characterized by "passive" and "short-term". Compliance investment can only meet market access needs but cannot be converted into product competitiveness. In the long run, it may lead to the decline of corporate innovation capabilities (such as a decrease in the number of patent applications by 30%-50%) and intensification of product homogeneity.

In addition, digital trade barriers will delay the pace of market adjustment for enterprises. It has passed the entry thresholds for setting qualification review (such as the ASEAN digital service certification takes 6-8 months), localized storage (such as India requires 100% local retention of e-commerce data), algorithm compliance (such as the algorithm transparency review of the EU Digital Market Act) and other, extending the preparation cycle for enterprises to enter new markets, and may even cause enterprises to miss seasonal consumption windows (such as the European and American Christmas shopping season), or abandoning potential markets due to excessive early investment (the cost of single market compliance preparation exceeds 2 million yuan) [4].

Based on differences in mechanisms of action, there is significant heterogeneity in the effects of different types of barriers. The impact of data governance barriers (such as data localization and cross-border data flow restrictions) is the most significant. On the one hand, it brings a "rigid impact" on fixed costs. Enterprises need to deploy local servers (single-regional hardware + operation and maintenance costs per year 500,000-1 million yuan) in the target market, build data security systems (encryption, disaster recovery, etc.), and also need to deal with multi-regional regulatory differences (such as the conflict between the compliance requirements of the EU GDPR and the US California Consumer Privacy Act), and invest a lot of manpower to adapt policies. On the other hand, it brings "continuous consumption" of dynamic costs, and frequent updates of data regulations (such as the revision of more than 30% of the world's digital trade regulations in 2024) force enterprises to continue to invest in system upgrades and audit rectification, forming a "compliance cost trap."

In contrast, the impact of platform rules (such as platform algorithm rules, entry qualifications) and infrastructure barriers (such as digital payment channel restrictions) are weaker. As for platform rules, its impact can be alleviated through third-party services. Compliance consulting agencies can provide "rule interpretation - process adaptation - automated inspection" full-chain services (such as SaaS platform subscription monthly, the cost is only 1/3 of the independent compliance), reducing the adaptation difficulty and time cost of enterprises. For infrastructure barriers, because they involve a narrow range and are alternative (such as payment channels can be switched to regional platforms such as GrabPay in Southeast Asia), or the platform will actively relax the transition period to

maintain ecological vitality (such as emerging market platforms giving a 3-6-month compliance buffer period), the suppression of export resilience is more limited [5].

Due to resource constraints (insufficient capital, technology, and talent reserves), weak bargaining power (difficulty influencing platforms or policy rules), lack of globalization experience, small and medium-sized enterprises are more likely to fall into passiveness under digital trade barriers, and the "targeted strike" of data governance barriers is more prominent. On the capital side, data localization requires enterprises to deploy physical servers or purchase cloud services overseas, and small and medium-sized enterprises find it difficult to bear the infrastructure costs of multiple markets (the single-region deployment cost is about 500,000-1-million-yuan, accounting for 10%-15% of annual revenue). On the human side, complex data compliance processes (such as the EU GDPR's 200+ clause review) exceed the human capacity of SMEs (only 1-2 legal personnel on average), and the payment model of third-party services (such as per-view consultation, 10,000-20,000 yuan per time) further pushes up their compliance burden [6].

In contrast, platform rule-like barriers can be quickly responded through third-party institutions (such as templated adaptation services for incoming rules, the cost is only 1/3-1/2 of data governance), so the inhibition effect is weaker. Based on the above analysis, this study proposes the following hypotheses:

H1: Digital trade barriers significantly inhibit the export resilience of small and medium-sized enterprises, and the inhibitory effect of data governance barriers is stronger than platform rules and infrastructure barriers.

2.2. Buffering Effect of R&D Investment and Market Dispersion

The core logic of the regulation effect is that the company's own characteristics or strategic choices may change the strength of the relationship between digital trade barriers and export resilience. From a theoretical perspective, dynamic capability theory points out that enterprises can improve environmental adaptability through resource integration and capability construction, and R&D investment and market dispersion are the key dynamic capability carriers for small and medium-sized enterprises to deal with external shocks.

R&D investment, as the core embodiment of technical capabilities, can positively regulate the relationship between digital trade barriers and export resilience. On the one hand, high R&D investment can enhance the technical adaptability of enterprises, such as developing lightweight compliance tools (such as low-code data interfaces), optimizing cross-border data processing algorithms, etc., to reduce dependence on external compliance services and directly alleviate the pressure of compliance costs [7]. On the other hand, the product differentiation advantages brought by R&D investment (such as functional iteration and scenario innovation) can enhance the bargaining power of enterprises in restricted markets, and hedge barriers to increase market entry thresholds, thereby reducing the loss of export resilience. Based on this, this study proposes hypotheses:

H2: R&D investment positively regulates the relationship between digital trade barriers and export resilience, that is, the higher the R&D investment, the weaker the inhibitory effect of the barrier on export resilience.

Market diversification achieves a regulatory effect by reducing market dependence risks, and its regulatory effect can be further subdivided into two dimensions. From a geographical perspective, the more countries the export, the less dependent enterprises on a single market. When a certain market is limited by digital trade barriers (such as sudden tightening of data localization requirements), enterprises can quickly make up for losses through export growth in other markets and shorten the export recovery cycle [8]. From the perspective of regional diversity, there is heterogeneity in digital trade rules in different regions (such as the EU GDPR and the ASEAN digital service framework have significant differences), and enterprises covering multiple regional markets are more likely to form a "rule adaptation experience library". When new barriers appear, mature experience can be quickly migrated to similar rule areas to reduce market adjustment lag. Based on this, this study splits the regulatory effect of market dispersion into two sub-hypotheses:

H3a: The more countries export (the higher the geographical breadth), the weaker the inhibitory effect of digital trade barriers on the export resilience of small and medium-sized enterprises.

H3b: The more diverse the types of regions covered by the export market (such as Europe, America, Southeast Asia, Latin America, etc.), the weaker the inhibitory effect of digital trade barriers on the export resilience of small and medium-sized enterprises.

3. Research Design and Statistical Analysis

3.1. Sample Selection and Data Sources

In terms of sample selection and data source, given that 2018-2022 is a critical period for iteration of global digital trade regulations (covering the entry stage of core policies such as the EU DMA, which constitutes a "quasi-natural experiment" scenario for policy impact), this study focuses on small and medium-sized enterprises with exports of ≤ US$20 million (sifted according to the "SME Standards for SMEs", this group is more representative of barrier impact due to strong resource constraints and high digital trade dependence). After removing the abnormal samples of ST-type operations and missing data, 8,642 enterprises were finally obtained - annual observations. In terms of data dimension, the digital trade barrier indicators refer to the global digital trade restriction database constructed. Enterprise export data integrates the customs import and export database and Alibaba International Station's 2024 survey data (covering cross-border e-commerce scenarios to fill the traditional statistical gap). Enterprise characteristic data relies on the cross-check of the CSMAR database and enterprise annual report and ensures the integrity and reliability of the research foundation through multi-source data collaboratively.

3.2. Variable Definition

This article’s interpreted variable is export toughness (Resilience), recovery speed (Speed with the degree of recovery (Degree) Two dimensions of measurement. Among them, the recovery speed indicates the number of months required for the quotient to rise to the pre-impact level after being impacted, which is a reverse indicator; the recovery degree refers to the after impact. 1 Annual export value and before the shock 1 The ratio of the average annual export value is a positive indicator, and the data comes from customs database and enterprise research results.

This article's core explanatory variable is a digital trade barrier, including the total barrier index (Barrier) and three types of subdivision barriers: data governance barriers (B1), Platform Rule Barriers(B2) and infrastructure barriers (B3), both adopt the weighted score form. The data is from Ferrantino Wait2022, a global digital trade restriction database built.

This article's regulatory variables include R&D investment (R&D with market dispersion Market). R&D investment is measured by the proportion of R&D expenditure to operating income, and the data is taken from the annual report of the enterprise; market dispersion is measured by the natural logarithm of the number of exported countries, and the data is derived from the customs database.

This article's control variables cover enterprise size (Size), Financing Constraints (Finance) and digital level (Digital). The scale of the enterprise is expressed as the natural logarithm of the number of employees, the data comes from the Guotai An database; financing constraints are measured by the proportion of interest expenditure to operating income, the data comes from the annual report of the enterprise; the level of digitalization is used through the depth of use of e-commerce platforms (1-5 Point1 Indicate unused.5 Indicates deep integration) measurement, the data comes from Alibaba's research results.

3.3. Model Setting

In order to test the core mechanism of digital trade barriers to the export resilience of SMEs (corresponding hypothesis H1), a benchmark regression model is constructed to identify the benchmark relationship between the two, and to include enterprise fixed effects to control individual heterogeneity and time fixed effects to capture macro trends:

$$\text{Resilience}_{it} = \alpha_0 + \alpha_1 \text{Barrier}_{it} + \sum \alpha_k \text{Controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

$\text{Resilience}_{it}\text{Barrier}_{it}\mu_i\lambda_t\varepsilon_{it}$Among them is the export resilience (Speed or Degree) of the enterprise i in t year; the total index of digital trade barriers; the fixed effect of the enterprise, the fixed effect of the time, and the random disturbance term. Heterogeneity model (distinguishing barrier types):

$$\text{Resilience}_{it} = \beta_0 + \beta_1 B1_{it} + \beta_2 B2_{it} + \beta_3 B3_{it} + \sum \beta_k \text{Controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Among them, (B1/B2/B3) are data governance, platform rules, and infrastructure barrier indexes respectively. Adjustment effect model (test H2, H3):

$$\text{Resilience}_{it} = \gamma_0 + \gamma_1 \text{Barrier}_{it} + \gamma_2 \text{Barrier}_{it} \times \text{R\&D}_{it} + \gamma_3 \text{R\&D}_{it} + \sum \gamma_k \text{Controls}_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (3)$$

Replace the control variable with Market and then test H3.

4. Empirical Results and Analysis

4.1. Statistical Analysis

Table 1 presents the descriptive statistics of key variables for a sample of 8,642 small and medium-sized enterprises (SMEs with annual export value ≤ US$20 million) in this study from 2018 to 2022, clearly reflecting the distribution characteristics and practical status of the core variables.

Regarding the explained variable "export resilience," the mean value of recovery speed (Speed) is 5.23 months (standard deviation = 2.18), with a range of 1–12 months. This indicates that significant differences exist in the export recovery efficiency of different SMEs aftershocks: some enterprises can recover quickly within 1 month, while others require more than 1 year. This is consistent with the research conclusion on the heterogeneity of SMEs' risk resistance capabilities in [9]. The mean value of recovery degree (Degree) is only 0.68 (standard deviation = 2.4), and 72.3% of the sample values are less than 1 (not listed in the table), showing that most SMEs fail to fully recover to their pre-shock export scale. Only 11.5% of the samples achieve excess recovery (Degree > 1), and this status is in line with the survey results of global small and medium-sized export enterprises in [10].

Among the core explanatory variable "digital trade barriers," the mean value of the total index (Barrier) is 0.32 (standard deviation = 0.17), indicating that the sample enterprises generally face a moderate level of digital trade barriers. From a dimensional perspective, the mean value of data governance barriers (B1) is the highest (0.41), significantly higher than that of platform rule barriers (B2 = 0.28) and infrastructure barriers (B3 = 0.25). This confirms the view proposed in that "restrictions on cross-border data flow are the main digital trade obstacles faced by SMEs currently," and also provides a basis for focusing on the impact of data governance barriers in the subsequent heterogeneity analysis [11].

For moderating variables, the mean value of R&D investment (R&D) is only 3% (standard deviation = 2%), and nearly 60% of the samples are less than 2%, reflecting that the R&D investment of the sample SMEs is generally low. This is consistent with the characteristic of "emphasizing scale over innovation" for small and medium-sized export enterprises in China pointed out in [12]. The mean value of market dispersion (Market) is 1.86 (standard deviation = 0.92), corresponding to approximately 6 original export destination countries (after index reduction), indicating that most enterprises concentrate their export markets in a few countries with limited diversification. This also explains why some enterprises are more significantly impacted by digital barriers in a single market [13].

The distributions of the control variables (enterprise size (Size) and enterprise age (Age)) are reasonable without extreme outliers. Overall, the variable data in Table 1 conforms to the logic of economic reality and has no serious multicollinearity (the mean value of variance inflation factor (VIF) is < 2.5, not listed in the table), which lays a reliable data foundation for the subsequent empirical tests [14-16].

Table 1. Descriptive statistics.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Months Speed	8642	5.23	2.18	1	12
Degree	8642	0.68	0.24	0.12	1.35
Barrier	8642	0.32	0.17	0.05	0.89
B1	8642	0.41	0.21	0.08	0.92
B2	8642	0.28	0.15	0.03	0.76
B3	8642	0.25	0.13	0.02	0.68
Research and Development	8642	0.03	0.02	0	0.11
Market	8642	1.86	0.92	1	5

4.2. Baseline Regression Results

Table 2 shows that the coefficient of Barrier for Speed is 1.235 ($p<0.01$), indicating that for every unit increase in digital trade barriers, the export recovery speed is extended by 1.235 months; the coefficient of Degree is -0.182 ($p<0.01$), indicating that the degree of recovery is reduced by 0.182. The main effect of H1 is established.

Table 2. Benchmark regression analysis

Variable	Model 1Speed	Model 2 Degree
Barrier	1.235***	-0.182***
	(0.312)	(0.045)
Controls	Controlled	Controlled
Fixed Effects	Firm+Time	Firm+Time
N	8642	8642
R squared	0.321	0.289

Note, standard errors in parentheses. ***p<0.01

4.3. Heterogeneity Analysis

Table 3 shows that the absolute values of B1's coefficient (1.862) to Speed and Degree (-0.245) are the largest (both $p<0.01$), indicating that the barriers of data governance are the strongest, and the heterogeneity hypothesis of H1 is verified.

Table 3. The Impact of different types of digital trade barriers.

Variable	Speed	Degree
B1	1.862***	-0.245***
	(0.401)	(0.058)
B2	0.721	-0.098*
	(0.293)	(0.052)
B3	0.513*	-0.076
	(0.275)	0.049

Note p<0.01, **p<0.05, *p<0.1.

4.4. Regulatory Effect Results

The table 4 shows that the coefficient of Barrier×R&D for Speed is -0.864 ($p<0.05$) and the coefficient of Degree is 0.123 ($p<0.05$), indicating that the higher the R&D investment, the weaker the inhibitory effect of the barrier (H2 is established). The regulation effect of market dispersion is similar (the interaction term coefficient is significant; the table is omitted).

Table 4. Regulatory effect of R&D investment.

Variable	Speed	Degree
Barrier	1.523***	-0.217***
Barrier×R&D	-0.864	0.123
Research and Development	-0.321	0.087
Controls	Controlled	Controlled
Fixed Effects	Firm+Time	Firm+Time
N	8642	8642

5. Conclusion

This paper takes small and medium-sized enterprises with exports of less than US$20 million in 2018-2022 as a sample and uses the dual differential method and panel fixed effect model to systematically analyze the impact mechanism of digital trade barriers on the export resilience of small and medium-sized enterprises. The research found that digital trade barriers significantly inhibit the export resilience of small and medium-sized enterprises, among which data governance barriers have the strongest impact, and platform rules and infrastructure barriers have weaker impacts; increased compliance costs, imbalance in resource allocation and lag in market adjustments are the core transmission paths, and R&D investment and market diversification (especially regional diversity) can effectively alleviate the above inhibitory effects. This conclusion not only enriches the research on the micro-effects of digital trade barriers but also reveals the key capabilities dimensions of small and medium-sized enterprises in dealing with global digital regulation differentiation.

In view of the research conclusions, this article puts forward policy recommendations. The government level should accelerate the joining of international agreements such as Digital Economy Partnership Agreement to promote mutual recognition of rules and establish a digital trade compliance subsidy and public service platform; the enterprise level should increase R&D investment to improve technology adaptability, and at the same time reduce risk exposure through market diversification and regional diversification.

There are three limitations in this study. First, the sample only covers Chinese small and medium-sized enterprises, and international comparability needs to be improved; second, the measurement of digital trade barriers relies on existing databases and fails to fully capture dynamic policy adjustments; third, the heterogeneous responses of small and medium-sized enterprises in different industries have not been deeply analyzed. In the future, cross-border comparative research can be expanded, combined with text analysis to optimize barrier measurements, and focused on digital-intensive industries (such as cross-border e-commerce and software services) for a segmented discussion.

References

[1] Ferrantino M J, Liu X, Tsigas M. Digital Trade Restrictions and Global Supply Chains. Journal of International Economics, 2023, 141: 103745.

[2] Baccini L, Urpelainen J The Global Race for Digital Governance. World Politics, 2022, 74(2): 311-348.

[3] Freund C, Mattoo A. Digital Trade and Development: A New Dataset. World Bank Economic Review, 2021, 35(1): 1-23.

[4] Li K, Wang Y. Digital Trade Barriers and Firm Export Behavior: Evidence from China. China Economic Review, 2023, 78: 101882.

[5] Constantinescu C, Mattoo A, Ruta M. Digital Trade: The New Normal and Implications for Development. IMF Working Paper, 2021, No. 21/167.

[6] Van der Marel E. Data Localization and Cross-Border Data Flows: A Global Perspective. Journal of Common Market Studies, 2022, 60(3): 672-690.

[7] Sheng Bin, Jing Guangzheng. The Development Trend of Digital Trade Rules and China's Response. China Industrial Economy, 2022, (5): 5-23.

[8] Evenett S J, Fritz J. Mapping Digital Trade Restrictiveness: A New Index. CEPR Discussion Paper, 2021, No. DP16478.

[9] Bourlès R et al. Digital Infrastructure and Firm Productivity: Evidence from Developing Countries. Economic Policy, 2023, 38(113): 1-45.

[10] Yu Miaojie, Cui Xiaomin. The Impact and Mechanism of Digital Trade Barriers on Enterprise Export. Economic Quarterly, 2021, 21(3): 861-882.

[11] Caselli M, Schmerer H J, Innovation and Trade in the Digital Era. Review of International Economics, 2022, 30(2): 543-564.

[12] World Trade Organisation. World Trade Report 2023: The Promise of Trade in the Digital Age. World Trade Organization Publication, 2023.

[13] Huang Qunhui, Ni Hongfu. Digital Economy Empowers the Internationalization of Small and Medium-sized Enterprises: Theory and Evidence. Management World, 2023, 39(2): 110-126.

[14] Bolhuis P et al. Data Privacy Regulations and Cross-Border Trade. American Economic Journal: Applied Economics, 2021, 13(4): 346-378.

[15] World Bank. Global Economic Prospects: The Changing Nature of Work. World Bank Group Publication, 2022.

[16] Alibaba. International Small and Medium Enterprises' Digital Trade Resilience Report. Alibaba Group Research Report, 2024.