DIGITAL SERVICE TRADE AND GLOBAL VALUE CHAIN DIVISION

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1 Introduction

With Internet technology innovation and digital technology innovation constantly emerging, digital trade has become a typical feature of the current economic restructuring, and has also become a new driving force for countries to participate in the division of the global value chain. Digital service trade has emerged as a pivotal engine for global economic transformation and development. The scale of global digital trade continues to expand, but there are still many restrictions in the regulation of digital trade. When fostering international economic and trade cooperation, economies must strike a balance between comprehensive openness and the implementation of protective policies that limit openness. Additionally, the homogeneity of regulatory laws with multilateral/bilateral trading partners must also be taken into consideration. In promoting international economic and trade cooperation, economies need to strike a balance between full openness and the implementation of protective policies that limit openness. In addition, the homogeneity of regulatory regimes with multilateral/bilateral trading partners need to be taken into account. The existence of digital trade tariff barriers and non-tariff barriers to digital trade, such as restrictions on cross-border data flows, intellectual property infringements and the protection of personal data, will inevitably affect the system of global value chain division.

The dependence of global trade on supply chains is a complex systemic issue. Under the current geopolitical conditions, the security of the global supply chain has become one of the most

important issues in each country in dealing with the relationship between security and efficiency. The new round of scientific and technological revolution triggered by industrial transformation accelerated, the major developed countries have around the core technology to strengthen the deployment, to ensure that in the new round of international science and technology and industrial game to master the initiative, the advantages of resource endowment between different countries change, directly promote the global industrial division of some pattern changes and new trendency. First, especially with the acceleration of iterative innovation in information technology, the global industrial chain shows new characteristics of localisation, digitalisation, platformisation and high value-added. Second, in the pursuit of lower factor prices, the global industrial chain exhibits localisation, regionalisation and intelligence of production. Digital supply chains have emerged in large numbers, and multinational enterprises have applied blockchain technology to build procurement contract systems, which effectively promote the efficient operation of the industrial chain while meeting the demand for risk diversification. Third, platform-based enterprises as the core of the platform through the integration of resources, and the aggregation of multinational upstream and downstream enterprises in the direction of scaling, clustering and specialisation. The international industrial division of labour has changed from factor division of labour to technological division of labour, and the global industrial chain has shown the development of the innovation chain mode from low to high, representing a high-value trend. Through the technological substitution effect and the synergistic penetration effect to improve the country's position in the global value chain, the country's value chain has been upgraded.

Through the technological substitution effect and the synergistic penetration effect to improve the country's position in the global value chain, countries that master digital core science and technology are able to optimise and improve the division of labour in the value chain, with the advantages of higher production efficiency and lower product costs. Therefore, it is necessary to conduct a national assessment of the current status of the industrial system, identify the weak links

in the modern industrial system, and make adjustments in both the industry and product dimensions.

There are three key issues raised in this paper:

First, this paper examines the impact of digital trade barriers on global value chain division. First, this paper evaluates the uniformity of regulatory laws among economies and their digital services trade partners, and investigates the impact mechanism of differences in regulatory homogenization on the scale of digital services trade. 1) This paper constructs a regulatory homogenisation network for digital service trade. 2) the overall structural characteristics of the network are analysed. The concept of homogenisation intensity is then introduced to characterise the relationship between economies. 3) This paper theoretically clarifies the channels through which regulatory homogenization affects exports, and combines mechanism testing and heterogeneity testing to explore the specific characteristics of how regulatory homogenization intensity affects the scale of digital service exports. According to the regulatory homogenization network analysis, economies that are heavily involved in digital trade in services tend to optimise and simplify existing trading partnerships. The diversification restrictions adopted by the world's major economies increase the heterogeneity of regulatory regimes in digital trade.

Second, this study constructs a global general equilibrium model consisting of 10 regions /31 Chinese provinces and 17 sectors and simulates the regulatory homogenisation partnerships in digital trade in services by quantifying the impact of digital trade barriers on member parties and constructing the impact channels of rule changes on the GTAP model in two dimensions of trade costs and production efficiency.

Third, this paper further investigates the transmission mechanism of digital trade barriers that impede global value chain division. This paper uses the latest digital trade barrier index from the OECD database and the global value chain division index based on input-output data 2018 from Asian Development Bank (ADB) to analyses the impact of digital trade barriers on global value chain division.

Methodology and Results

1 The construction of econometric model

We mainly examine the relationship between digital trade barriers and global value chain (GVC) division positions, and construct the baseline regression model as follows:

$$GVC_{i,j,t} = \alpha_0 + \alpha_1 DSTRI_{i,j,t} + \gamma Controls + \lambda_i + \theta_j + \eta_t + \varepsilon_{i,j,t} \quad (1)$$

Where i, j and t represent country, sector, and year respectively. The explained variable is $GVC_{i,j,t}$, which represents the GVC division position of sector j of country i in year t. The core explanatory variable is $DSTRI_{i,j,t}$, which represents the digital trade barriers of sector j of country i in year t。 $Controls$ conclude a series of control variables. λ_i、 θ_j and $\eta_t$represent country, sector and year fixed effects, respectively. $\varepsilon_{i,j,t}$ is the random disturbance term. In addition, to reduce heteroscedasticity, all the control variables except the ratio are taken as logarithms, and the standard errors with cluster robustness are used for regression analysis.

Specification of variables

(1) GVC division position($GVC_{i,j,t}$). Koopman et al. (2014) proposed a specific indicator for assessing division position of the particular sector within a country in the GVC. It is calculated by the logarithm of the amount of intermediate products exported by a country’ s sector to other countries minus the logarithm of the amount of intermediate products imported by that sector in the country. The formula for this indicator is as follows:

$$GVC_{i,j,t} = \ln\left(1 + \frac{IV_{i,j,t}}{E_{i,j,t}}\right) - \ln \quad (1 + \frac{FV_{i,j,t}}{E_{i,j,t}}) \quad (2)$$

In the formula, $GVC_{i,j,t}$ represents the GVC division position of sector j of country i in year t; $IV_{i,j,t}$ denotes the indirect value-added exports of sector j of country i in year t, which refers to the trade value of intermediate goods exported by sector j of country i in year t to other countries. This indicator measures how much value-added is included in the intermediate goods exports of sector j of country i in year t, which are processed in one country and then exported to a third country;

$FV_{i,j,t}$ represents the foreign value-added included in the final products exported by sector j of country i in year t, which indicates the value of foreign intermediate goods included in the final products exported by sector j of country i in year t; $E_{i,j,t}$ denotes the gross export value of sector j of country i in year t. A higher $GVC_{i,j,t}$ value indicates that sector j of country i in year t occupies a position closer to the upstream in the GVC. Conversely, a lower $GVC_{i,j,t}$ value suggests that the sector is positioned closer to the downstream in the GVC.

(2) Digital trade barriers ($DSTRI_{i,j,t}$). The Digital Services Trade Restrictiveness Index (DSTRI) of OECD (Organization for Economic Co-operation and Development) aims to define, classify, and quantify regulatory barriers affecting trade in services that can be delivered digitally. By collecting comparable information from publicly available laws and regulations, the OECD measures the extent to which the country's regulatory policy on digital services trade restricts foreign service providers in five dimensions: Infrastructure and connectivity, electronic transactions, payment system, intellectual property rights, and other barriers. We calculate the input density of imported data factors in the production process of each sector of each country ($IDD_{i,j,t}$) by improving the calculation idea of Van Der Marel and Ferracane (2021) based on the Inter-Country Input-Output Tables (ICIOT) by year of OECD. After the range transformation, $DSTRI_{i,j,t}$ can be obtained by multiplying with the DSTRI of the national dimension. The specific calculation formulas are shown in equations (3), (4) and (5)①.

$$IDD_{i,j,t} = \frac{\sum_{c \neq i} Z(t)^{ci}_{info,j}}{\sum_k \sum_c Z(t)^{ci}_{kj}} \quad (3)$$

$$IDDensity_{i,j,t} = \frac{IDD_{i,j,t} - \min_j IDD_{i,j,t}}{\max_j IDD_{i,j,t} - \min_j IDD_{i,j,t}} \quad (4)$$

$$DSTRI_{i,j,t} = IDDensity_{i,j,t} \times DSTRI_{i,t} \quad (5)$$

(3) Controlling variables. This paper includes a series of control variables in the baseline model to avoid the issue of omitting important explanatory variables. 1) lnGDP, specifically refers to GDP of each country processed by natural logarithm in current U.S. dollars; 2) MHTECH,

① $Z(t)^{ci}_{kj}$ represents the amount of imported intermediate products by sector k of country c consumed in the production process of sector j of country i in year t; $info$ is the department in the OECD ICIOT: IT and other information services

indicates share of medium and high-tech manufactured exports in total manufactured exports by natural logarithm; 3) FDI, denotes foreign direct investment by net inflows which is the percentage of GDP processed by natural logarithm； 4) GOV, indicates the government effectiveness in percentile rank processed by natural logarithm; 5) EDU, specifically refers to the percentage of population ages 25 and over that attained or completed upper secondary education processed by natural logarithm; 6) Labor, denotes the labor force participation rate processed by natural logarithm;7) VA, specifically refers to value added of each sector in the input-output table divided by output processed by natural logarithm. The above data comes from the World Development Indicators of World Bank.

2 Sample Selection and Description

Through matching the databases involved and considering data integrity and continuity, we select sample data from 44 sectors in 59 countries from 2014 to 2020. Multiple collinearity tests reveal that the variance inflation factors (VIF) of the core explanatory variables and each control variable are all less than 10, with an average VIF of 1.40, indicating a low level of collinearity between the core explanatory variables and the control variables. The selection of variables meets the basic requirements of regression analysis. The descriptive statistics of the main variables are presented in Table 1.

Table 1. Descriptive Statistics

	Obs.	Mean	Std. Dev.	Min	Max
GVC	18172	0.1376	0.2030	-0.5703	0.6681
DSTRI	18172	0.0179	0.0397	0.0000	0.6471
ln *GDP*	18172	26.6031	1.6231	23.1569	30.6935
MHTECH	18172	0.4918	0.2031	0.0178	0.8723
FDI	18172	0.0416	0.1699	-1.1737	2.3425
GOV	18172	62.4861	23.9440	9.5238	99.0476
EDU	18172	0.6202	0.2287	0.0571	0.9740
LABOR	18172	0.6192	0.0648	0.4549	0.7799
VA	18172	0.4438	0.1780	-0.2501	0.9733

3 Empirical results

（1） Baseline results

This paper uses panel data from 45 industries of 59 countries from 2014 to 2020 and focuses on testing the impact of DSTRI on GVC. Table 2 shows the benchmark regression results based

on regression Eq. (1). The core explanatory variable in the column (1)-(5) of Table 2 is DSTRI. Column (1) controls the year, country, and sector fixed effects without adding other control variables. The regression coefficient of DSTRI is -0.2036, which is significant negative at the 5% statistical level. On the basis of column (1), column (2) - column (5) adds the control variables to further test the impact of DSTRI on GVC. And the signs of the coefficients of the core explanatory variable are robust and unchanged. It can be seen from column (5) that DSTRI will significantly inhibit the promotion of GVC after controlling for the year, country, sector fixed effects and other control variables.

Table 2. Baseline Regression

	(1)	(2)	(3)	(4)	(5)
	GVC	*GVC*	*GVC*	*GVC*	*GVC*
DSTRI	-0.2036**	-0.2059**	-0.2062**	-0.2082**	-0.2315***
	[0.0914]	[0.0917]	[0.0917]	[0.0920]	[0.0848]
ln *GDP*		0.0456***	0.0433***	0.0447***	0.0322***
		[0.0095]	[0.0094]	[0.0096]	[0.0084]
MHTECH			0.0199*	0.0201*	0.0188*
			[0.0116]	[0.0115]	[0.0109]
FDI			0.0031**	0.0030**	0.0028**
			[0.0015]	[0.0014]	[0.0010]
GOV				0.0002	0.0002*
				[0.0001]	[0.0001]
EDU				0.0629***	0.0593***
				[0.0096]	[0.0108]
LABOR					0.0995***
					[0.0337]
VA					0.5539***
					[0.0308]
constant	0.1413***	-1.0706***	-1.0200***	-1.1095***	-1.0818***
	[0.0016]	[0.2534]	[0.2503]	[0.2534]	[0.2221]
FE Year	Yes	Yes	Yes	Yes	Yes
FE Country	Yes	Yes	Yes	Yes	Yes
FE Sector	Yes	Yes	Yes	Yes	Yes
Observations	18172	18172	18172	18172	18172
R^2	0.6831	0.6834	0.6834	0.6835	0.7675

Note: Data in parentheses are robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

(2) Heterogeneity regression results

1) Types of DSTRI

We further distinguish five types of DSTRI to investigate the impact of DSTRI on the GVC. The test results in Table 3 show that among the five categories of DSTRI, infrastructure and connectivity, as well as other barriers, significantly inhibit the promotion of the GVC, while

electronic transactions, payment system, and intellectual property rights have no significant impact on the GVC (see Figure 1).

The main reason is that advanced digital infrastructure and connectivity are the foundation of digital trade development, directly impacting enterprises' digital transformation, cross-border trade, and participation in the global value chain. If a country's level of infrastructure and connectivity is not high, it will limit the digital capabilities of enterprises and the convenience of cross-border trade, further posing significant obstacles to enhancing a country's position in the global value chain. Additionally, digital trade barriers also include policies and regulations related to data privacy protection and e-commerce regulations. These barriers may increase operating costs for enterprises, lower market access thresholds, and affect the smooth conduct of cross-border trade. Especially in cases where policies related to digital payments and data privacy protection are unclear or restrictive, enterprises may find it difficult to engage in cross-border transactions, leading to a strong inhibitory effect on the upgrading of the global value chain.

Table 3. Heterogeneity analysis based on the types of digital trade barrier

	(1) Electronic transactions(Elec)	(2) Infrastructure and connectivity(Infr)	(3) Intellectual property rights(Inte)	(4) Payment system(Pay)	(5) Other barriers(Other)	(6) Overall DSTRI(Overall)
DSTRI	-0.8657	-0.3034**	-1.3179	-1.0373	-0.8965**	-1.0373
	[0.5182]	[0.1171]	[0.8218]	[0.6707]	[0.4148]	[0.6707]
constant	-1.0236***	-1.0745***	-1.0634***	-1.0377***	-1.1197***	-1.0377***
	[0.2226]	[0.2228]	[0.2207]	[0.2247]	[0.2200]	[0.2247]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
FE Year	Yes	Yes	Yes	Yes	Yes	Yes
FE Country	Yes	Yes	Yes	Yes	Yes	Yes
FE Sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18172	18172	18172	18172	18172	18172
R^2	0.7668	0.7674	0.7666	0.7667	0.7672	0.7667

Note: Data in parentheses are robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

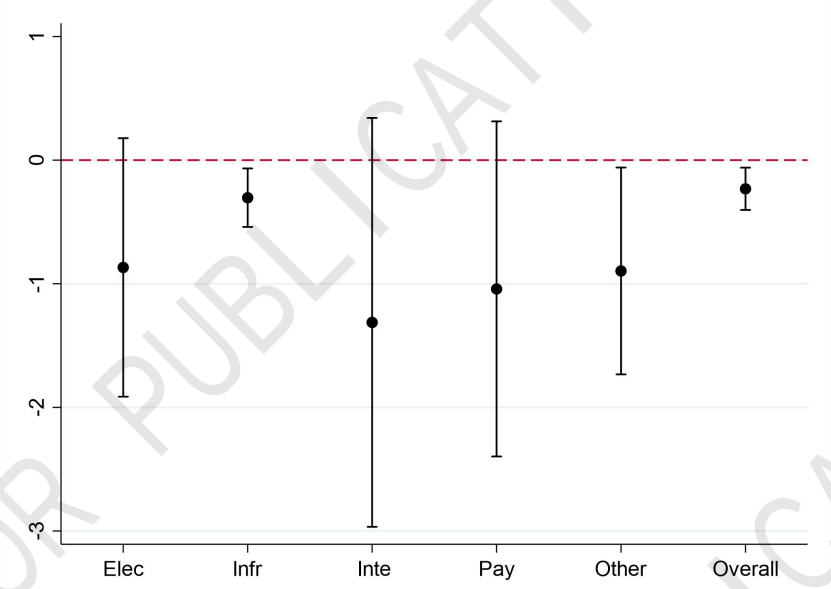

Figure 1. Heterogeneity analysis based on the types of digital trade barrier

2) Types of countries

Basically, considering Gross National Income (GNI) per capita (current US$), we divide the countries into three income groups — high income countries, lower-middle income countries and upper-middle income countries by the World Bank. The results reveal that DSTRI significantly inhibit the GVC of high-income countries (see Figure 2).

The primary reasons are twofold. Firstly, high-income countries like Europe and the United States typically lead in technology and innovation, enabling them to establish technical standards or requirements that may be difficult for other countries to meet. These barriers can impede the entry of digital products and services from other countries into high-income country markets, thus limiting the advancement of their global value chain position. Secondly, high-income countries have transitioned their involvement in the global value chain beyond mere production and processing stages. They have undertaken earlier and deeper digitization upgrades across various industries compared to other countries. Consequently, high-income countries exhibit a greater demand for digital intermediate products, making the negative impact of digital trade barriers on the upgrading of the global value chain more pronounced.

Table 4. Heterogeneity analysis based on the types of countries

	(1)	(2)	(3)

	High income	Lower middle income	Upper middle income
DSTRI	-0.3789***	-0.0616	-0.0886
	[0.1165]	[0.1394]	[0.0680]
constant	-0.6600**	-1.5107***	-1.7499***
	[0.3167]	[0.4557]	[0.4362]
Control variables	Yes	Yes	Yes
FE Year	Yes	Yes	Yes
FE Country	Yes	Yes	Yes
FE Sector	Yes	Yes	Yes
Observations	11396	2464	4312
R^2	0.7839	0.8030	0.7959

Note: Data in parentheses are robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

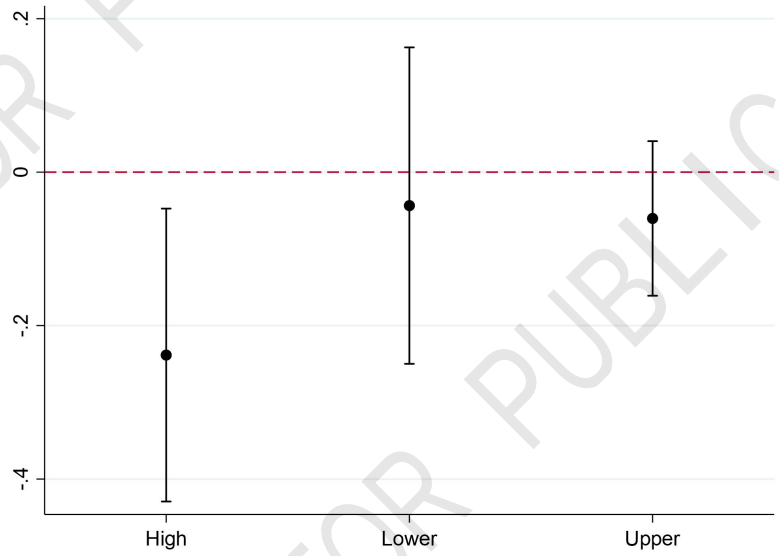

Figure 2. Heterogeneity analysis based on the types of countries

3) Type of industries

Further dividing industries into primary, secondary, and tertiary sectors, it was found that DSTRI significantly enhance the GVC of the primary industry while inhibiting the GVC of the secondary industry, with no significant impact on the global value chain position of the tertiary industry (see Figure 3). The main reasons are as follows:

Products from the primary industry, such as agricultural products and raw materials, typically have lower value-added and standardization levels, so digital trade barriers do not have a significant impact on them. Additionally, products from the primary industry often rely on natural resources and are subject to geographical and climatic factors, making their international trade relatively less affected by digital trade barriers. While products from the secondary industry, such

as manufactured goods and machinery, often have higher value-added and technological content, making them more susceptible to the effects of digital trade barriers. The manufacturing industry typically requires support from multinational supply chains, and digital trade barriers may affect the stability and efficiency of these supply chains, thereby inhibiting the upward movement of the secondary industry in the global value chain.

Table 5. Heterogeneity analysis based on the types of industries

	(1) primary industry	(2) secondary industry	(3) tertiary industry
DSTRI	0.1403**	-0.7572***	-0.0361
	[0.0088]	[0.2133]	[0.0782]
constant	-0.2688	-1.5957***	-0.5318***
	[0.7090]	[0.3840]	[0.1661]
Control variables	Yes	Yes	Yes
FE Year	Yes	Yes	Yes
FE Country	Yes	Yes	Yes
FE Sector	Yes	Yes	Yes
Observations	826	9499	7847
R^2	0.8453	0.7825	0.7971

Note: Data in parentheses are robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

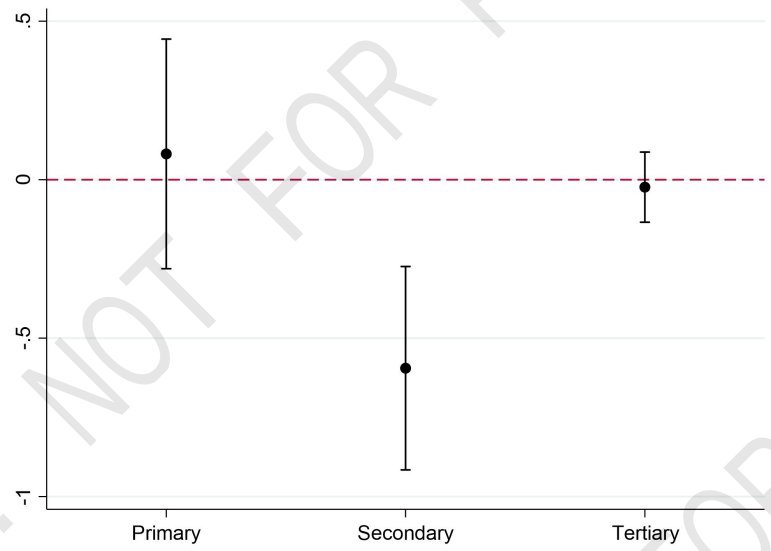

Figure 3. Heterogeneity analysis based on the types of industries

The empirical results also suggest that broadening and deepening regulatory homogenisation partnerships in digital trade in services will promote the export of digital services by major economies. First, this promotion effect is mainly achieved through the reduction of digital trade costs in services and the enhancement of commercial confidence. Overall, the export promotion

effect of regulatory homogenisation partnerships in digital trade in services is superior to the effect of increasing the level of openness in digital services trade . Secondly, from the perspective of national heterogeneity, the digital trade barriers have a greater effect on the global value chain division of developing countries, but a lesser effect on the global value chain division of developed countries; the digital trade barriers have the greatest effect on the global value chain division between small countries, followed by the global value chain from large country to small country, the global value chain division between large countries, the global value chain from small country to large country. Digital trade barriers have a larger obstacle effect on the global value chain division between countries with far institutional distance, and a smaller obstacle effect on the global value chain division between countries with close institutional distance.

Based on the research findings, this paper recommends strategies to strengthen regulatory uniformity in digital services trade, emphasising three key areas: First, leading economies should pursue unified trade rules to reduce barriers to trade in digital service and form international regulations that promote consistency in digital trade. Second, we should increase regulatory harmonisation with Asian and developing countries to expand the global reach of its digital trade practices. In addition, promoting technological innovation and developing export strategies tailored to the specific characteristics of digital services will build commercial confidence.

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