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The Impact of Digital Transformation on Developing Countries' International Trade - An In-Depth Study on Big Data Analysis

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Abstract Against the background of the accelerated digitalization process of the global economy, the impact relationship between digital transformation and international trade has become a part of economic development that cannot be ignored. This paper takes the multiple regression model analysis method and hierarchical analysis method as research tools to further explore the role of digital transformation on the country's international trade path. After clarifying that “Internet Plus” can promote the innovation of international trade model, change the way of international trade information dissemination and improve the efficiency of international trade transactions, 10 developing countries of RCEP organization countries are selected as research objects. At the same time, the export trade volume (EX) is selected as the explanatory variable, and the level of industrial digital transformation (DT) is the core explanatory variable, and the relationship between digital transformation and national export growth and export trade scale is successively discussed. The effect of digital transformation on the country's export growth is significantly positive (P<0.001), indicating that digital transformation is an important wind for developing international trade in developing countries.

Index Terms international trade, multiple linear regression model, developing countries, hierarchical analysis method

I. Introduction

With the progress of the times and the rapid development of the economy, the world economic pattern has undergone obvious changes, the current development of international trade has also been affected by a number of impacts, the development of international trade has entered a completely new stage [1]. Digital innovation as the current international trade development keywords, is the overall overview of international trade in recent years in all areas of development and innovation status, for the next step in the development of international trade is of strategic significance, help the international trade development of the overall situation [2]-[4].

Digital technology as a new product of the new round of technological revolution, its wide range of influence and rapid development speed is unprecedented, digital technology derived from the new industry, new models, but also become a strong engine of economic recovery in the post epidemic era [5]-[7]. The iterative upgrading of digital technology creates favorable conditions for enterprise business communication, operation management, and collaborative production through the advantages of inter-temporal and low-cost [8], [9]. At the same time, digital technology breaks down the information barriers, creates conditions for governments to promote cooperation in the field of economy and trade, improves the external environment of trade to a certain extent, and provides opportunities for enterprises to “go out” and “come in” [10]-[12]. In view of the above factors, digital technological innovation accelerates the reorganization of the international division of labor system, which has a far-reaching impact on the international economic and trade pattern, and also creates conditions for the consolidation and deepening of the industrial chain of countries around the world [13]-[15]. The potential and far-reaching influence of the digital economy have made countries around the world compete to seize the high ground, and many developing countries are also the main participants in the globalization of the digital economy [16]. However, with the deepening of economic globalization, there are more and more multi-perspective and multi-disciplinary discussions, especially in recent years, the emergence of anti-globalization thinking in the West has triggered a more comprehensive and in-depth discussion on economic globalization. Therefore, it is of great significance to explore the impacts on developing countries in the process of digital economic globalization, and how to safeguard the right to life and the right to development of their people [17], [18].

This paper firstly explains the three important influences of the “Internet Plus” era on the country's international trade practice as the theoretical basis of the study. Then it elaborates the basic idea and construction process of multiple regression model analysis method, and adopts hierarchical analysis as the evaluation method.

Subsequently, 10 developing countries in the RCEP organization countries are selected as research objects, and the digital transformation level of industries in the 10 countries is measured and counted. Based on the analysis, the research variables are set, and the relationship between digital transformation and national export growth is analyzed using the benchmark test. Finally, the relationship between digital transformation and the scale of national export trade is further explored.

II. The impact of “Internet Plus” on international trade practices

(1) Promote trade model innovation

“Internet +” breaks the time and space limitations of the traditional trade model, so that international trade is no longer limited to physical trading places and fixed trading time. With the help of the Internet platform, a variety of new trade modes have sprung up, and the booming development of cross-border e-commerce has enabled small and medium-sized countries and even individual merchants to participate in global trade conveniently, reduce the trade threshold and expand the scope of trade subjects. Online exhibitions, virtual trade negotiations and other modes provide buyers and sellers with more efficient and convenient channels of communication and cooperation, reducing intermediate links and lowering transaction costs. The rise of social e-commerce, utilizing the communication power and influence of social media to create new marketing and sales channels, brings unprecedented vitality and opportunities for international trade. Moreover, the use of big data and artificial intelligence and other technologies can accurately match supply and demand, realize personalized customization and precision marketing, and further promote the trade model to the direction of intelligent and personalized development.

(2) Changing the way of information dissemination

The Internet builds up a globalized information network, which makes the information in international trade spread at an amazing speed and breadth, and both parties to the transaction get real-time access to market dynamics, product information, price trends and other key information from all over the world, so that they can make smarter decisions, and the information is no longer monopolized by a small number of large countries or institutions, and small and medium-sized traders can equally access and use information, thus enhancing the fairness of the competition in the market. Through various online platforms and social media, countries can quickly release product information and promotional activities to push their brands and products to global consumers, greatly improving marketing efficiency and effectiveness. At the same time, the transparency of information also encourages the country to continuously improve product quality and service level in order to stand out in the fierce market competition. In addition, the development of IoT technology makes real-time tracking and monitoring of goods possible, and buyers and sellers are able to grasp the location and status of goods at any time, which further improves the accuracy and timeliness of information.

(3) Enhance transaction efficiency

Under the wave of “Internet Plus”, the popularization of electronic trading platforms has greatly enhanced the efficiency of international trade transactions. Online trading platforms have greatly simplified the transaction process, from inquiries, quotations to contract signing, payment and settlement, etc. can be completed online, shortening the transaction time. The growing perfection of the electronic payment system provides convenient and safe payment methods and accelerates the flow of funds. The application of intelligent logistics system realizes real-time updating and optimized scheduling of logistics information, improving the efficiency and accuracy of cargo transportation. The application of blockchain technology ensures that transaction data is tamper-proof and safe and reliable, reducing risks and disputes in transactions. Big data analysis can quickly process and analyze huge amounts of transaction data, provide accurate market forecasts and decision-making support for the State, and help the State to better grasp market opportunities. Moreover, virtual office and remote collaboration technologies enable all parties in international trade to communicate and collaborate at any time and any place, without time and space constraints, to further improve work efficiency.

III. Measurement of the level of digital transformation

III. A. Idea and construction of multiple regression models

Multiple regression models are applied to explain the relationship between an explanatory variable and multiple explanatory variables, and for the presence of n variables in the model there is the basic form of the regression function as in equation (1):

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \beta_k X_{ki} + \mu \tag{1}$$

When this is estimated using sample observations, there will be a sample mean $\overline{Y}$ for the explanatory variable, at which point there is equation (2):

$$\overline{Y}_i = \overline{\beta}_1 + \overline{\beta}_2 X_{2i} + \overline{\beta}_3 X_{3i} + \cdots + \overline{\beta}_k X_{ki} \tag{2}$$

And there is also a residual e_i between the actual values of the explanatory variables Y and the sample estimates, resulting in expression (3):

$$Y_i = \overline{Y}_i + e_i \tag{3}$$

After the establishment of the multiple regression model, the inevitable need to use the sample information to establish the sample regression function, so that it is as far as possible to maximize the reduction of the real regression situation, generally more commonly used is the method of least squares, accounted for the principle of the smallest residual sum of squares to determine the sample regression function, that is, formula (4):

$$\sum e_t^2 = \sum (Y_i - \overline{Y}_i)^2 = \sum (Y_i - \overline{\beta}_1 - \overline{\beta}_2 X_{2i} - \overline{\beta}_3 X_{3i} - \cdots - \overline{\beta}_k X_{ki})^2 \tag{4}$$

That is, there are necessary conditions as in equation (5):

$$\frac{\partial(\sum e_t^2)}{\partial \overline{\beta}_j} = 0$$
$$\begin{cases} 2\sum (Y_i - \overline{\beta}_1 - \overline{\beta}_2 X_{2i} - \overline{\beta}_3 X_{3i} - \cdots - \overline{\beta}_k X_{ki})(-1) = 0 \\ 2\sum (Y_i - \overline{\beta}_1 - \overline{\beta}_2 X_{2i} - \overline{\beta}_3 X_{3i} - \cdots - \overline{\beta}_k X_{ki})(-X_{2i}) = 0 \\ \vdots \\ 2\sum (Y_i - \overline{\beta}_1 - \overline{\beta}_2 X_{2i} - \overline{\beta}_3 X_{3i} - \cdots - \overline{\beta}_k X_{ki})(-X_{ki}) = 0 \end{cases} \tag{5}$$

A matrix representation of the above equations has Eqs. (6)-(7):

$$\begin{bmatrix} \sum e_i \\ \sum X_{2i} e_i \\ \cdots \\ \sum X_{ki} e_i \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \cdots \\ 0 \end{bmatrix} \tag{6}$$

$$\begin{bmatrix} \sum e_i \\ \sum X_{2i} e_i \\ \cdots \\ \sum X_{ki} e_i \end{bmatrix} = \begin{bmatrix} 1 & \cdots & 1 \\ \vdots & & \vdots \\ X_{k1} & \cdots & X_{kn} \end{bmatrix} * \begin{bmatrix} e_1 \\ \vdots \\ e_n \end{bmatrix} = X^T e = \begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix} \tag{7}$$

There are multiple regression functions expressed in matrix form as in equation (8):

$$\overline{Y} = X\overline{\beta} + e \tag{8}$$

In the computational simplification, both sides of the equation are multiplied simultaneously by the transpose matrix X^T of X, with equation (9):

$$X^T \overline{Y} = X^T X \overline{\beta} + X^T e = X^T X \overline{\beta} \tag{9}$$

From this, the matrix of regression parameters for the multiple regression equation can be calculated as in equation (10):

$$\overline{\beta} = (X^T X)^{-1} X^T Y \tag{10}$$

The multiple regression model constructed on the basis of this least squares method has three remarkable and excellent properties: linearity, unbiasedness, and validity.

Linearity is due to the fact that $\overline{\beta}$ is a linear expression of Y.

Unbiasedness, on the other hand, is based on the zero-mean assumption of the multivariate regression model for randomly perturbed terms as in equation (11):

$$E(\overline{\beta}) = E((X^T X)^{-1} X^T Y) \tag{11}$$

There are always equations (12)-(13):

$$Y = X\beta + U \tag{12}$$

$$E(\overline{\beta}) = E((X^T X)^{-1} X^T (X\beta + U)) = E(\beta + (X^T X)^{-1} X^T U)$$
$$E(\overline{\beta}) = \beta + (X^T X)^{-1} X^T (E(U)) = \beta \tag{13}$$

Validity then exists based on the fact that the least squares estimator is the one with the least variance of all linear unbiased estimators.

After the construction of the completed multiple regression model can be tested for goodness of fit by the multiple decidable coefficients R^2, i.e., the proportion of the total variance in Y that is explained by the explanatory variables explaining part of the variance.

The variance composition has equation (14):

$$\sum (Y_i - \overline{Y})^2 = \sum (\overline{Y}_i - \overline{Y})^2 + \sum (Y_i - \overline{Y}_i)^2 \tag{14}$$

The multiple decidable coefficients are Eqs. (15)-(16):

$$R^2 = \frac{\sum (\overline{Y}_i - \overline{Y})^2}{\sum (Y_i - \overline{Y})^2} \tag{15}$$

$$R^2 = \frac{\sum (Y_i - \overline{Y})^2 - \sum (Y_i - \overline{Y}_i)^2}{\sum (Y_i - \overline{Y})^2} = 1 - \frac{\sum e_i^2}{\sum (Y_i - \overline{Y})^2} \tag{16}$$

At this time, the closer R^2 is to 1, the better the model fits, but at this time when the sample size is unchanged, with the gradual increase in the number of explanatory variables, the total variance and the sum of squares of the residuals will not change, but the sum of squares of the explanatory part of the regression will increase, and at this time, the use of multiple decidable coefficients to compare the two sample sizes are the same but the number of explanatory variables is different from that of the model will show a Bias.

In the case of the same sample size, the increase in the number of explanatory variables will increase the number of parameters to be estimated, the inevitable loss of degrees of freedom, so you can correct the multiple coefficients of determination through the degrees of freedom, in this case, there is a correction of the coefficient of determination of the $\overline{R}^2$ expression for the formula (17)-(18):

$$\overline{R}^2 = 1 - \frac{\frac{\sum e_i^2}{n-k}}{\frac{\sum (Y_i - \overline{Y})^2}{n-1}} = 1 - \frac{n-1}{n-k} \frac{\sum e_i^2}{\sum (Y_i - \overline{Y})^2} \tag{17}$$

$$\overline{R}^2 = 1 - (1 - R^2)\frac{n-1}{n-k} \tag{18}$$

In order to ensure the regression effect it is also necessary to test the regression equation, that is, to test whether there is a significant linear relationship between the explanatory variables and the explained variables, with the assumption of equation (19):

$$\begin{cases} H_0 : \beta_2 = \beta_3 = \cdots = \beta_k = 0 \\ H_1 : \beta_j (j = 2, 3, \cdots, k) \text{Not all } 0 \end{cases} \tag{19}$$

Also based on the decomposition of the variance and the consideration of the degrees of freedom, the F statistic is constructed as in equation (20):

$$F = \frac{\sum (\overline{Y}_i - \overline{Y})^2}{\sum (Y_i - \overline{Y}_i)^2} * \frac{n-k}{k-1} \tag{20}$$

According to equation (15) it is possible to relate the F statistic to the decidable coefficients with equation (21):

$$F = \frac{R^2}{1-R^2} * \frac{n-k}{k-1} \tag{21}$$

At this time there is constructed F statistics obey the F distribution with degrees of freedom $(k-1)$, $(n-k)$, and if at the given level of significance, the value of the computed F statistic is greater than the corresponding boundary value of the F distribution, the hypothesis can be rejected H_0, at which point there is a significant regression equation and the explanatory variables have a significant effect on the explained variables.

Due to the reality of the problem, multiple factors will inevitably be interrelated rather than completely independent, there will be multicollinearity between the variables, resulting in inaccurate fitting effect, it is difficult to realize the analysis of the explanatory variables, so in the following will also use principal component analysis, for the selection of the variables to be extracted and screened again, through the construction of a new regression model with independent principal component factors, so as to see a clearer explanation of the Relationships. The main idea is to linearly transform the explanatory variables X to obtain the principal components F, i.e., equation (22):

$$\begin{cases} F_1 = U_{11}X_1 + U_{12}X_2 + \cdots + U_{1p}X_p \\ F_2 = U_{21}X_1 + U_{22}X_2 + \cdots + U_{2p}X_p \\ \vdots \\ F_n = U_{n1}X_1 + U_{n2}X_2 + \cdots + U_{np}X_p \end{cases} \tag{22}$$

There are several restrictions in the transformation process to ensure the effective realization of principal component extraction as follows.

(1) $u^T u = 1$

(2) F_i and F_j are independent of each other $(i \neq j, i, j = 1, 2, \cdots)$

(3) F_i satisfies the decreasing column and its variance can reflect the degree of response of its original information.

In this way, in the process of statistical analysis can be selected only the main factor with a large variance, has a better response to the original variables, but also more clear and concise.

III. B. Evaluation methodology and data processing

As a systematic analysis method, hierarchical analysis (AHP) provides a concise way of thinking about statistical decision-making. However, due to its greater reliance on qualitative components, it is highly subjective and lacks rigor. The entropy weight method, on the other hand, is an objective empowerment method, and its basic idea is to examine the degree of variation of quantitative data, i.e., the degree of data variation is used to determine the information entropy, which is then used to determine the weights. In the academic world, more and more scholars are beginning to realize that a single assignment method is difficult to ensure the reasonableness of the results, and the combination of the assignment method takes into account both qualitative analysis and quantitative analysis, which is more superior in the practical application. Based on this, the method of combining subjective and objective assignment is adopted, and the hierarchical analysis method is used to determine the weights of the first-level indicators, the entropy weight method is used to determine the weights of the second-level indicators, and finally the comprehensive weights are calculated, so as to make the weights of the indicators as reasonable as possible.

Table 1 demonstrates the determination of the weights of the first-level indicators using hierarchical analysis (based on the square root method), including the construction of the judgment matrix, eigenvectors and weights. After the test, the maximum eigenroot is 3.018, and the corresponding RI value is found to be 0.525 according to the RI table, therefore, $CR = CI / RI = 0.017 \leq 0.100$, which passes the one-time test.

Table 1: The determination of the weights of the first-level indicators by AHP

		Digital transformation			Eigenvector	Weighted value
		Basics	Capacity	Benefit		
Digital transformation	Basics	1.00	0.26	0.34	0.45	12.18%
	Capacity	4.00	1.00	2.00	2.00	55.85%
	Benefit	3.00	0.50	1.00	1.16	31.97%

Standardization of indicators is required in order to eliminate differences in the scales of the indicators and to make the data comparable. Positive and negative indicators are processed separately.

The formula for standardizing positive indicators is equation (23):

$$Z_{ij} = \frac{Y_{ij} - \min(Y_{ij})}{\max(Y_{ij}) - \min(Y_{ij})} \tag{23}$$

The formula for normalizing negative indicators is equation (24):

$$Z_{ij} = \frac{\max\left(Y_{ij}\right) - Y_{ij}}{\max\left(Y_{ij}\right) - \min\left(Y_{ij}\right)} \tag{24}$$

where Z_{ij} and Y_{ij} are the values of the indicator before and after the standardization of the i th indicator in the j th year, respectively, and $\max\left(Y_{ij}\right)$ and $\min\left(Y_{ij}\right)$ are the maximum and minimum values of Y_{ij} the maximum and minimum values.

On the basis of positive indicator processing and negative indicator processing for all the secondary indicators, the entropy weighting method is used to determine the weights, and the results are shown in Table 2.Among them, the weight of digital technology application is the largest, and the weight of enterprise revenue efficiency is the smallest, and there is a great difference in the weights between different indicators. Therefore, the indicators are combined with AHP method for comprehensive calculation.

Table 2: The determination of the weight of the index by the entropy weight method

Index	Comentropy	Information utility	Weight
Organizational foundation	0.97	0.03	4.81%
Digital foundation	0.88	0.12	23.59%
Investment in industrial innovation	0.88	0.14	27.43%
Application of Digital Technology	0.82	0.18	41.57%
Enterprise cost efficiency	0.98	0.02	1.56%
Enterprise revenue efficiency	1.00	0.00	1.05%

On the basis of the hierarchical analysis method for the assignment of first-level indicators and the entropy weight method for the assignment of second-level indicators, the comprehensive weight is determined. The specific calculation formula is equation (25):

$$W_i = \frac{\sqrt{X_i Y_i}}{\sum \sqrt{X_i Y_i}} \tag{25}$$

where W_i is the composite weight of the i th indicator, and X_i and Y_i are the weight of the first-level and second-level indicators respectively.

According to the above formula, the comprehensive weights of the indicators are finally calculated: organizational foundation 6.32%, digital foundation 14.01%, industrial innovation investment 32.90%, digital technology application 39.79%, enterprise cost efficiency 5.80%, enterprise revenue efficiency 1.17%, and the results are relatively more reasonable.

IV. Analysis of the impact of digital transformation on the country's international trade

IV. A. Subjects of study

Following the Organization for Economic Cooperation and Development's classification of developing countries, developing countries in the RCEP countries:(C1) China, (C2) Brunei, (C3) Thailand, (C4) Malaysia, (C5) Vietnam, (C6) Philippines, (C7) Indonesia, (C8) Cambodia, (C9) Laos, and (C10) Myanmar are plotted in the 2010-2019 industrial The trend of changes in the level of digital transformation is shown in Figure 1.

The descriptive statistics of the level of digital transformation of industries in the 10 developing countries of the RCEP 2010-2019 are shown in Table 3.

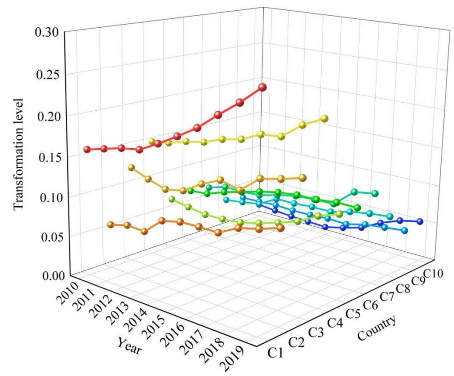

Figure 1: The changing trend of the level of industrial digital transformation

Table 3: Description of the level of industrial digital transformation

Country	Maximum	Minimum	Mean		Average annual growth	
			Value	Ranking	Rate	Ranking
C1	0.2732	0.1591	0.2038	1	0.056	5
C2	0.2236	0.1498	0.18	2	0.0413	8
C3	0.1633	0.1067	0.1317	3	0.032	10
C4	0.1049	0.0691	0.0911	4	0.0433	7
C5	0.1143	0.066	0.0853	5	0.059	4
C6	0.1149	0.0561	0.0848	6	0.0787	2
C7	0.1054	0.0577	0.0728	7	0.052	6
C8	0.0769	0.0404	0.0601	8	0.0696	3
C9	0.0501	0.0357	0.0402	9	0.036	9
C10	0.0534	0.0111	0.0249	10	0.1488	1

Plotting the trends of the data in Table 3 is shown in Figure 2.

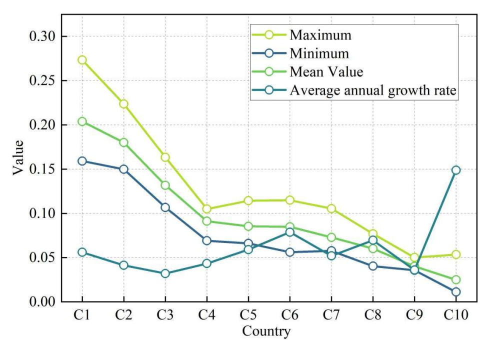

Figure 2: Descriptive statistics of the level of industrial digital transformation

It can be seen that the overall industrial digital transformation level of the 10 developing countries is between 0.0249-0.2038, which is not only the overall level is low and there is an obvious internal gap, but also the level of industrial digital transformation of the country and the comprehensive strength of the country have an obvious correspondence. However, in terms of the annual growth rate of industrial digital transformation level, only (C10) Myanmar exceeds 10%, amounting to 14.88%, which is due to the fact that (C10) Myanmar's original level of industrial digital transformation is relatively low and has not yet formed a large scale, so it has a very considerable room for development.

IV. B. Selection of variables

(1) Explained variables

Export trade volume (EX): China's export trade volume to the other nine RCEP developing countries from 2010 to 2019 is selected as a measure of China's export trade, and this variable is an explanatory variable.

(2) Core explanatory variables

Level of industrial digital transformation (DT): this paper constructs the evaluation index system of the level of industrial digital transformation from five aspects: digital users, digital infrastructure construction, industrial digital environment, industrial digital input, industrial digital output, and measures the level of industrial digital transformation of 10 RCEP developing countries from 2010-2019, and this variable is the core explanatory variable.

(3) Control variables

Trade openness (OPEN): trade openness has an obvious promotion effect on China's manufacturing exports, this paper adopts trade dependence as a proxy indicator for trade openness, expressed as the percentage of the country's total imports and exports and GDP, the larger the percentage value, the higher the trade openness.

Weighted most-favored-nation (MFN) tariff rate for all products (TAR): Higher tariffs in the export destination country will significantly reduce the average export value of the exporting country. In this paper, a country's tariff level is expressed in terms of its total product-weighted MFN tariff rate. The higher a country's all-product-weighted MFN tariff rate is, the higher the tariff cost of its exports to other countries and the less profitable its exports are.

Quality of political system (POL): The political stability of export destination countries is an important factor affecting China's total export trade. Since the political systems of the 10 countries are different, and the foreign trade policies they implement are also different, the impact of the quality of the political systems of the two trading sides on the development of bilateral trade should not be ignored. In this paper, the quality of a country's political system is represented by the average of the six indicators included in the Worldwide Governance Index (WGI): voice and accountability, political stability and nonviolence, government efficiency, regulatory quality, rule of law, and control of corruption. The higher the quality of a country's political system, the better the market stability, which is conducive to China's export trade to it.

Tax burden level of export destination countries (TAX): Increasing the pre-tax deduction for residents' personal income tax, reducing the VAT rate for necessities, and easing the tax burden on basic living material and spiritual products can boost residents' consumption demand. A reasonable level of tax burden can not only directly regulate the price of goods and services to enhance residents' consumption demand, but also affect the distribution of residents' income and thus promote the overall consumption of society. A high tax burden in the export destination country will lead to the reduction of consumers' purchasing ability and willingness to purchase goods, weakening market vitality, which is not conducive to the sale of goods in the country. In this paper, the total domestic tax rate of the export destination country is used to measure the level of the country's tax burden.

IV. C. Data sources and descriptive statistics

The data in this paper was obtained from the official website of the RCEP organization and was cleaned after matching the variable data. Interpolation was used to fill in some of the missing data to get the final data used in this paper. The final sample interval is 2010-2019, and the descriptive statistics of the main variables are shown in Table 4.

Table 4: Descriptive statistics of the main variables

Types of variables	Variable	Mean	Standard deviation	Minimum	Maximum
Variable being explained	EX	9.975	2.9171	3.913	20.393
Core explanatory variable	DT	0.12	0.1461	0	1.498
Control variable	OPEN	9.298	1.1511	5.808	12.259
	TAR	0.764	0.1151	0.038	1.516
	POL	3.5127	5.48	0	33.587
	TAX	2.629	0.437	1.098	3.913

IV. D. Analysis of the relationship between digital transformation and national export growth

IV. D. 1) Benchmarking

Based on the theoretical analysis and model construction, the relationship between digital transformation and national export growth was tested as shown in Table 5. Where column (1)(3) regresses digital transformation on national export growth without the inclusion of control variables, and column (2)(4) includes control variables based on column (1)(3). Meanwhile, column (1)(2) controls only for country and year fixed effects, and the results show that the effect of digital transformation on country export growth is significantly positive ($p<0.001$). Since the data used in this paper are country-export destination-product level data, columns (3)(4) further incorporate country-export destination-product level fixed effects, and the results remain unchanged, suggesting that the country's digital transformation is able to contribute to the growth of the country's export size.

Table 5: The benchmark test results of digital transformation for developing countries

Variable	(1)	(2)	(3)	(4)
EX	0.306****	0.221***	0.273***	0.079**
	(6.277)	(4.449)	(6.998)	(1.995)
DT		0.398***		-0.494***
		(7.223)		(-9.125)
OPEN		0.012		0.308***
		(0.495)		(15.298)
TAR		0.028		0.082***
		(1.367)		(4.599)
POL		-0.032***		0.005
		(-4.175)		(0.591)
TAX		0.297**		-0.007
		(12.145)		(-0.556)
Constant		8.815***		3.915***
		(23.196)		(10.872)
Observations	524429	522039	408407	406455
R-squared	0.235	0.236	0.827	0.828

Note: The values in () represent the t-statistic of the coefficient. ***, ** and * respectively indicate significance at the 1%, 5% and 10% levels, the same below

IV. D. 2) Robustness Tests

In order to ensure the robustness of the above empirical model and test results, this paper does further robustness test results are shown in Table 6.

First, replace the explanatory variables. Considering the quantile product level, the country export amount has a large volatility, so this paper through recalculation, summing up to get the country-export destination country-quantile product export size data to replace the export growth data in the baseline test, the test results are shown in column (1) of Table 6.

Second, the core explanatory variables are replaced. First, the regression is conducted using the number of word frequencies (Dig) of keywords about digital transformation as a replacement indicator for the degree of digital transformation, and the results are shown in column (2) in Table 6. Second, considering that the proportion of intangible assets related to digitization in the country can further reflect the implementation of the country's digital transformation, the proportion of intangible assets of international trading companies is used to replace the digital transformation data (dig) for further testing, and the test results are shown in column (3) of Table 6. Finally, taking into account that although the annual report of the international trading company mentions certain keywords of digital transformation, it is not possible to confirm whether the company actually uses the digital technology, and if the company applies for patents on digital technology innovations, then the probability that the country in which the company is located is undergoing digital transformation, based on which, the use of the level of digital technology innovations to replace the country's digital transformation for re-testing, and the results of the test are as shown in column (4) of table The results are shown in column (4) of Table 6. Among them, the national digital technology innovation level is measured by the number of national digital patent applications.

Third, outliers are eliminated. Considering that there are abnormal data will have an impact on the regression results, all variables of the original data are shrink-tailed with bilateral 1% and further tested, and the test results are shown in column (5) of Table 6.

Fourth, the elimination of economic change sample data. Based on the baseline test data, the samples of 2011 and 2012 are excluded from the regression. The test results are shown in column (6) of Table 6.

All of the above test results show that the impact of digital transformation on the country's export growth is significantly positive, which indicates that digital transformation can indeed increase the scale of the country's exports and promote the country's export growth, and the results of the benchmark regression are robust.

Table 6: A robustness test of the Impact of Digital Transformation on National trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)
EX	0.153***				0.024***	0.079**
	(3.378)				(0.543)	(1.995)
DT		0.013**				
		(2.271)				
Control variable	YES	YES	YES	YES	YES	YES
Constant	4.289***	3.899***	4.052***	4.084***	4.053***	3.915***
	(10.916)	(10.923)	(9.303)	(11.511)	(11.420)	(10.872)
Observations	315332	406455	259032	406455	406455	406455
R-squared	0.827	0.828	0.855	0.828	0.827	0.828

IV. E. The relationship between digital transformation and the size of export trade

IV. E. 1) Benchmark regression

In this study, a benchmark regression analysis was conducted using a multiple panel regression model. Before determining the type of model, a Hausman test was conducted to decide whether to use a fixed effect model or a random effect model. The results of the test showed that all p-values were zero, which significantly indicated that the fixed effects model was more appropriate than the random effects model. Therefore, this paper constructs a multiple fixed effects model with individuals, years, industries and provinces to ensure the accuracy and reliability of the regression analysis.

Table 7 shows the regression results in detail. From the table, it can be observed that the level of digitization has a significant positive effect on the country's export size. This finding suggests that as the country's digitization level increases, its export performance is enhanced accordingly. Specifically, the coefficient of the degree of digitization is positive and significant at 1% confidence level, which further confirms the positive relationship between the level of digitization and the country's export size. In addition, the significance of digital transformation in the regression is positive, which may be attributed to the fact that the application of digitization technology has enabled the country to make substantial progress in cost control and efficiency improvement. Digitization not only reduces the country's operating costs, but also improves its competitiveness in the global market.

This result coincides with an effective path for the country's digital transformation. Therefore, the findings of this study provide clear guidance to the country that it can significantly increase the scale of export trade of its products by advancing digital transformation.

Table 7: The benchmark impact of digitalization on national trade

Variable	(1)	(2)
EX	0.109***	0.055***
	(6.06)	(3.62)
DT		0.559***
		(6.87)
OPEN		0.809***
		(19.00)
TAR		0.495***
		(2.95)
POL		0.219
		(1.95)
TAX		0.396*
		(2.29)
N	14978	14978
adj.R^2	0.851	0.879
F	36.579	86.121
p	0.000	0.000

Note: The values in parentheses are robust standard errors, the same below.

IV. E. 2) Robustness Tests

In the process of constructing the indicator system of the country's digitization level, this paper meticulously evaluates the characteristics of the variation of the text length of the management's in-depth discussion and analysis section of the annual report on the country's situation and future, and at the same time, this paper selects the total frequency of the country's digitization-related vocabulary and uses the ratio of it to the text length of the management's discussion and analysis section of the annual report as a metric for the level of the country's digitization (referred to as Dig). For ease of presentation and analysis, this study multiplies the Dig indicator by 100.The larger the value of the Dig indicator, the higher the level of digitization of the country.

The original core variable was adjusted by extracting the word frequency of the annual reports of listed companies, dividing it by the length of the “Management's Discussion and Analysis” section of the annual report, and multiplying the indicator by 100. By re-running the baseline regression test shown in Table 8, the results show that the coefficient on the country's digital transformation remains significantly positive at the 1% confidence interval. That is, when the measure of digital transformation is adjusted, digital transformation can still have a positive impact on the size of a country's exports.

Table 8: Robustness test

Variable	(1)	(2)	(3)	(4)	(5)	(6)
EX			0.115***	0.058***	0.105***	0.055**
			(6.01)	(3.59)	(5.38)	(3.17)
DT	0.142***	0.086***				
	(4.92)	(3.52)				
OPEN		0.488***		0.564***		0.565***
		(5.78)		(6.55)		(6.00)
TAR		0.795***		0.791***		0.733***
		(18.22)		(17.49)		(15.68)
POL		0.548**		0.519**		0.536**
		(3.15)		(2.98)		(2.76)
TAX		0.247*		0.199		0.128
		(2.06)		(1.77)		(1.02)
N	14315	14315	14955	14955	11675	11675
adj.R^2	0.829	0.859	0.826	0.859	0.836	0.863
F	24.092	80.581	35.942	73.666	28.823	58.871
p	0.000	0.000	0.000	0.000	0.000	0.000

IV. E. 3) Heterogeneity analysis

This subsection further explores the specific impacts of the country's digital transformation on the scale of export trade, with a particular focus on the heterogeneity across regions and industries. Through an in-depth analysis of these differences in geographical and industry characteristics, this paper aims to explore the heterogeneity at the regional and industry levels more comprehensively, so as to provide a theoretical and empirical basis for policy formulation on how the country can promote the growth of the scale of export trade more effectively in the process of digital transformation. In order to verify that regional differences may have a heterogeneous effect on national digitalization performance, a heterogeneity test for eastern, central and western China was conducted.

Table 9 delves into the effects of national digitalization performance on different regions in the eastern, central, and western regions, and rigorously tests the variability of regression coefficients between groups. The study shows that firms in the Eastern region significantly enhance the size of their product exports by implementing a digitization strategy, and this enhancement effect is statistically significant and positively significant at the 1% level. Similarly, in the Central region, the country's digitalization changes equally significantly boosted the size of exports, a result that also showed statistical significance at the 1% level. As for the Western region, the digital transformation of the country also had a significant positive impact on the size of exports, which was verified at the 1% level of significance. This suggests that countries in all regions are able to show an increasing trend in the size of their export trade, led by digital transformation.

Table 9: The impact of regional heterogeneity on digital international trade

Variable	(1)	(2)	(3)
EX	0.094***	0.246***	0.170***
	(8.55)	(8.63)	93.53)
DT	0.832***	0.794***	-0.248*
	(21.68)	(10.76)	(-1.98)
OPEN	0.852***	0.804***	1.098***
	(62.72)	(23.22)	(22.57)
TAR	1.179***	0.491*	1.556***
	(13.58)	(2.48)	(5.52)
POL	0.384***	0.292	1.154**
	(2.97)	(1.04)	(2.87)
TAX	0.137***	0.514***	0.173
	(3.54)	(5.53)	(1.20)
N	11795	2115	1285
adj.R^2	0.418	0.368	0.413
F	1205.363	176.161	129.049
p	0.000	0.000	0.000

V. Conclusion

This paper takes 10 developing countries of the RCEP organization countries as the research object, and explores and analyzes the role of digital transformation in relation to the country's export growth and the scale of export trade with the support of the multiple linear regression model and the method of hierarchical analysis, so as to reveal the important positive impact of digital transformation on the international trade of developing countries.

By controlling the research variables, the study found that the effect of digital transformation on the country's export growth is significantly positive ($p<0.001$). In addition, the coefficients of the level of digitization of the country and the degree of digitization are positive and significant at the 1% confidence level, and have the same performance in different regions.

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