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Research on the Impact of ASEAN Countries' Digital Economy Development on China's Export Trade Benefits

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Abstract: *In the context of the division of labor in the global value chain, China's participation in international trade to obtain less practical benefits, is still in the "low-end locked" situation, the rapid development of the digital economy provides historical opportunities for all countries, ASEAN countries as important trading partners of our country, its digital economy development will undoubtedly affect China's export and export trade benefits, this paper is based on the relevant data of China and ASEAN countries from 2003 to 2018, Empirical examination of the impact of the digital economy development of ASEAN countries on China's exports and export trade benefits. It is found that the digital economy development of ASEAN countries not only significantly expands the scale of China's export trade to them, but also expands China's benefits in export trade, but the digital economy in ASEAN countries promotes China's export trade benefits less than the promotion effect on the total export trade.*

Keywords: *Digital Economy, Export trade benefits, Export*

1. Introduction

At present, the digital economy as a new economic form has become a new driving force and engine for national economic growth. The "2019 Digital Economy Report" released by the United Nations Conference on Trade and Development pointed out that the digital economy includes not only digital industries (information technology industry, etc.), but also industrial digitalization, which refers to the application of digital technology to traditional industries, deep integration with them. Traditional industries upgrade and become the main force to promote the development of the digital economy. The construction of digital economy, the development of digital technology, and the acceleration of digital technology application have risen to the national strategic height, which is crucial for social and economic development and the improvement of people's living standards.

In the context of economic globalization, the free trade area established by China and other countries in the world has strengthened commercial cooperation and trade exchanges between countries in the region. From the perspective of the division of labor in the global value chain, intermediate goods circulate between countries many times, resulting in serious "double counting" problems in traditional trade statistics based on the total value of commodities, so the scale of trade cannot effectively reflect the value added actually created by a country, and the trade benefit index based on value-added trade statistics can better reflect a country's actual profitability in international trade and become an important measure of a trade power (Ma et al., 2022)[1].

ASEAN is an important partner of China's trade activities, China has maintained ASEAN's largest trading partner for 14 consecutive years since 2009, ASEAN has also maintained China's largest goods trading partner for three consecutive years. 2020 was established as the China-ASEAN Year of Digital Economy Cooperation, and the China-ASEAN Initiative on Establishing a Digital Economy Partnership released in the same year made it clear that China and ASEAN jointly seize digital opportunities. What is the current development of the digital economy in ASEAN countries? Does the digital economy development of ASEAN countries affect China's trade benefits? Clarifying the above issues is of great significance for strengthening digital economy cooperation with ASEAN countries.

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2. Literature review

2.1 Review of Digital Economy and Digital Economy Measurement

The term "digital economy" was first proposed by Tapscott (1996) [2]. He believes that the digital economy explains the relationship between the new economy, new business and new technologies, and then the connotation of the digital economy continues to be enriched. Currently, the definition widely used is "to use digital knowledge and information as key production factors, modern information networks as important carriers, A series of economic activities with the effective use of ICT as an important driving force for efficiency improvement and economic structure optimization". For the measurement methods of the digital economy, academia mainly uses three methods: first, the index compilation method, which measures the digital economy by selecting a series of indicators reflecting various dimensions of the digital economy to build an evaluation system (China Academy of Information and Communications Technology, 2017; Zhang & Shen, 2018)[3]; The second is the value-added measurement algorithm, which measures the added value of a country's (or region's) digital economy on the basis of defining the scope of the digital economy or according to the definition of the digital economy (BEA, 2019; Xu & Zhang, 2020) [4]; The third is satellite account construction (OECD, 2017). The three measurement methods have their own advantages and disadvantages, and the academic community is still exploring the methods of measuring the digital economy.

2.2 Review of the Impact of the Digital Economy on Trade and Trade Benefits

Freund and Weinhold (2002) [5] study the relationship between Internet development and service trade by using the US service trade data from 1995 to 1999. They found that Internet development can promote bilateral service trade. Chu and Guo (2019) [6] found that relevant indicators representing ICT, such as mobile phone penetration, have a positive impact on a country's import and export trade. Sun and Zhu (2020) [7] found that improving ICT would promote trade between China and ASEAN countries.

Regarding the research on the impact of the digital economy development on trade benefits, most scholars study the impact of the digitalization of enterprises on the added value of enterprises (Kee and Tang, 2016; Liu et al., 2022) [8],[9], relatively few studies focus on the impact of the digital economy development of trading partners on trade benefits from the macro national level. Han and Jiang (2022) [10] used dynamic factor analysis to measure the digital economy in EU countries, and found that the EU digital economy can significantly increase the added value of China's export trade with EU countries through three channels: reducing trade costs, improving the technical complexity of export products, and promoting the diversification of China's export products. He et al. (2022) [11] found that the digital economy in both importing and exporting countries significantly promoted the scale of value-added trade.

By combing the existing research, it is found that more research considers the impact of the digital economy on exports from the total amount of trade, and less research study the relationship between the digital economy and trade from the perspective of added value. More research focuses on the impact of the digitalization of enterprises on the export added value of enterprises, and less research studies the impact of the digital economy development of trading partners on their export trade benefits from the national level. Since the establishment of trade relations is a two-way behavior (He et al., 2022) [11], the digital economy development of trading partners will have an impact on their export trade benefits. This paper integrates the digital economy, total export trade and export domestic added value into analysis framework, explores how the digital economy development of ASEAN countries affects China's total export trade and export trade benefits. It will deepen the process of China-ASEAN digital cooperation.

3. Theoretical Analysis and Research Hypotheses

3.1 The Impact of the Digital Economy on Trade Benefits

The digital economy has a broad and far-reaching impact on international trade, not only the scale of trade but also trade benefits. From the perspective of trade venues, the trend of platformization is accelerating, and the rise of Internet platforms has built a bridge of communication for both sides of trade. From the perspective of trade subjects, the trend of small and medium-sized enterprises participating in trade and consumer personalized customization is prominent. From the perspective of trade objects, trade products are becoming increasingly diversified, and new digital products and digital services have emerged, such as electronic books, online education, which are deeply loved by consumers with their

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advantages of low marginal cost, convenient storage. From the perspective of the trade environment, the overall environment is increasingly convenient and intelligent so that it can effectively reduce costs.

3.2 Analysis of Channels for the Digital Economy Affecting Trade Benefits

The digital economy development of trading partners can improve trade benefits by reducing bilateral trade costs in the intermediary and final goods trade links. Although intermediate goods and final goods belong to different production links of a commodity, as long as it is cross-border trade between countries, whether it is intermediate trade or final goods trade, it will produce trade costs, which are presented in the form of information and transaction costs, transportation and logistics costs, cross-border costs and trade policy obstacles, because global supply chain trade has the characteristics of sequential production, intermediate goods need to cross the border many times before the final product production is completed. The trade costs caused by this process, such as transportation and logistics, continue to accumulate and amplify throughout the chain, so the trade costs of intermediate goods that are traded across borders multiple times may be greater than the trade costs of the final goods. The advantages of new international trade over traditional trade come from the vigorous development of digital technology spawned by the information technology revolution, and also from the emergence of digital infrastructure, the development of digital economy in trading partners can significantly reduce the bilateral trade costs in the trade of intermediate and final goods, and improve the trade benefits of exporting countries.

The digital economy development of trading partners can affect trade benefits through the competitive effect and cooperation effect between enterprises in different countries. The global value chain is still based on the principle of comparative advantage to allocate different production links around the world, developed economics rely on capital, technology and other factor advantages in capital-intensive industries and technology-intensive industries have absolute advantages, firmly occupy the high-end of the global value chain, obtain most of the division of labor and trade benefits, while China and other developing economics can only rely on low labor cost advantages to engage in processing and assembly business, falling into the dilemma of "low-end locking", value appreciation is very limited. One of the most important reasons is the low technological content of developing economics' exports. The digital economy development of trading partners will not only intensify the competition between enterprises in different countries to promote technological innovation through the competitive effect, but also strengthen the synergy and cooperation to make technological progress through the cooperation effect. Therefore, technological complexity of domestic exports is increasing. Technological complexity is a key factor in value-added competitiveness. High technological complexity and high-quality products are conducive to enhancing the export competitiveness of economics (Liao & Li, 2017) [12], making it climb along the "smile curve" to both ends and obtain more trade benefits.

Based on the above analysis, this paper puts forward the following assumptions: the digital economy development of ASEAN countries will enhance China's export trade benefits.

4. Quantitative measurement of the development level of digital economy in ASEAN countries

4.1 Establishment of Index System

Table 1: Evaluation index system of digital economy development level of ASEAN countries.

tier 1 indicator	tier 2 indicators	tier 3 indicators	Metric properties
The level of the digital economy	Digital infrastructure	Fixed broadband subscriptions (per 100 people)	+
		Fixed telephone subscriptions (per 100 people)	+
		Mobile cellular subscriptions (per 100 people)	+
		Individuals using the Internet (% of population)	+
	Digital development environment	ICT goods exports (% of total goods exports)	+
		ICT goods imports (% total goods imports)	+
		Medium and high-tech exports (% manufactured exports)	+
		School enrollment, tertiary (% gross)	+

Source: Compiled by the author from WDI.

Nowadays, many institutions and scholars quantitatively measure of the development level of digital economy at the national level (Zhang and Tang, 2020) [13]. The index system which measures the

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development level of digital economy in the ASEAN countries includes two dimensions: digital infrastructure and digital development environment (Table 1), in order to comprehensively examine the digital development of ASEAN countries.

4.2 Data Sources and Processing

This paper selects the relevant data of ASEAN countries based on the above indicator system, and the sample data is obtained from WDI. Some missing data are imputed by linear interpolation. This paper studies the impact of the digital economy development in ASEAN countries on China's export trade benefits, which are measured by export domestic value-added and the data from OECD's TiVA database. The data is currently updated to 2018 so that the time span of this study is 2003-2018.

4.3 Measurement Methods

This paper uses the entropy value method to measure the level of digital economy development of ASEAN countries. The entropy method is a method of objectively weighting the index according to the size of the entropy of the indicator information, the smaller the information entropy, the greater the degree of discreteness of the index, and the greater the weight given. This method can avoid the arbitrariness of subjective empowerment and be more scientific and reasonable. The specific steps are as follows:

First, due to the different units and attributes of the selected indicators, in order to ensure the comparability of the indicators, it is necessary to carry out dimensionless treatment of all indicators:

$$\text{Positive indicators: } Z_{tij} = \frac{x_{tij} - x_{min}}{x_{max} - x_{min}} \tag{1}$$

$$\text{Negative indicators: } Z_{tij} = \frac{x_{max} - x_{tij}}{x_{max} - x_{min}} \tag{2}$$

where t is the year, i is the country, j is the indicator, and t=1,2,3,..... h,i=1,2,3..... m,j=1,2,3,..... n; x_{tij} is the value of the j^{th} indicator of country i in the t year; x_{max}, x_{min} are the maximum and minimum values of the j^{th} index of all evaluation subjects (all countries in all years); Z_{tij} is the value after dimensionlessness of the j^{th} index of country i in the t year.

Second, the normalization of indicators:

$$P_{tij} = \frac{Z_{tij}}{\sum_{t=1}^{h}\sum_{i=1}^{m} Z_{tij}} \tag{3}$$

Third, calculate the information entropy of indicator j:

$$e_j = -\frac{1}{ln(h \cdot m)}\sum_{t=1}^{h}\sum_{i=1}^{m}\left(P_{tij} \cdot \ln P_{tij}\right) \tag{4}$$

Fourth, calculate the redundancy of the index j entropy value:

$$d_j = 1 - e_j \tag{5}$$

Fifth, calculate the weight of indicator j:

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{6}$$

Sixth, calculate the development level of digital economy in various countries in each year:

$$score = \sum_{j=1}^{n} W_j Z_{tij} \tag{7}$$

5. Empirical analysis

5.1 Model Setting and Variables

5.1.1 Model Setting

Considering the availability of data, this paper takes ASEAN countries from 2003 to 2018 as a research sample, and examines the relationship between the digital economy development of ASEAN countries and China's export and export trade benefits based on the extended trade gravity model. The metrological benchmark model formula is as follows:

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$$lnexport_{it} = \beta_0 + \beta_1 digital_{it} + \beta_2 cont_{it} + \varphi_i + \mu_t + \varepsilon_{it} \quad (8)$$

$$lnex\_dva_{it} = \beta_0 + \beta_1 digital_{it} + \beta_2 cont_{it} + \varphi_i + \mu_t + \varepsilon_{it} \quad (9)$$

where i represents the country and t represents the year. $export_{it}$ indicates the total amount of China's export to i in t year; ex_dva_{it} indicates the domestic added value of China's export to i in t year; $digital_{it}$ indicates the level of digital economy development of i in t year; φ_i is a national fixed effect that does not change over time; μ_t is a time-fixed effect; ε_{it} is the classical error term. The control variable $cont_{it}$ controls for other factors at the national level that may affect regional trade.

5.1.2 Variables

Dependent variables $lnexport_{it}$ and $lnex\_dva_{it}$ indicate China's total export and export domestic added value to i in t year respectively, as dependent variables of this paper.

Core independent variables digital represents the digital economy development level of ASEAN countries, which is calculated by the entropy method.

Control variables. According to the extended trade gravity model, export trade will be affected by economic scale, geographical distance, common language of both economics and so on. This paper introduces the following control variables: i)ASEAN countries' economic scale lnpgdp and China's economic scale lnpcgdp. In general, the country's economic size reflects potential trade demand, the larger the market size, the higher the level of economic development, the greater the trade demand, This article uses GDP per capita to measure level of market size. ii) Geographical distance. Trade between two countries needs trade costs, geographical distance is an important factor affecting trade costs, the farther the geographical distance between the two countries, the greater the transportation cost, this paper uses the distance between the two capitals to express. iii) Official language. It is more convenient for the two countries to have common official language, Official language is a dummy variable, when China and country i have the same official language, it is 1, otherwise it is 0. iv) Landlocked country. If the country is landlocked, lack of maritime trade channels, not conducive to the expansion of trade. This variable is also a dummy variable. When country i is landlocked, it is 1, otherwise 0.

5.1.3 Data Sources

The total export data comes from the National Bureau of Statistics. The domestic added value of China's export comes from the OECD's TiVA database. The level of the digital economy development is calculated by the entropy method. The per capita GDP data of each country comes from WDI. The geographic distance, whether there is a common official language and whether it is a landlocked country data are all from the CEPII-GeoDist database. In the empirical process, the data on total exports, export domestic value added and per capita GDP of each country are all taken as natural logarithms.

5.1.4 Descriptive Statistics

Table 2 shows the statistical characteristics of the variables involved in this paper from 2003 to 2018.

Table 2: Descriptive statistics

Variables		mean	sd	Min	max	N
Dependent Variables	lnexport	13.425	1.856	8.128	15.942	160
	lnex_dva	8.186	1.917	3.140	10.890	160
Independent Variable	digital	0.297	0.221	0.012	0.840	160
Control Variables	lnpgdp	8.320	1.342	6.057	11.025	160
	lnpcgdp	8.623	0.396	7.936	9.172	16
	lndistance	8.156	0.236	7.754	8.560	160
	language	0.2	0.401	0	1	160
	landlocked	0.1	0.301	0	1	160

5.2 Benchmark Regression Results

Table 3 reports the results of the two-way fixed-effect model, where columns (1) and (2) take China's total export to ASEAN countries as the explanatory variable, while (3) and (4) take the domestic value added of China's export to ASEAN countries as the explanatory variable. Columns (1) and (3) is regression based on the trade gravity model, (2) and (4) is based on the extended trade gravity model. It can be seen that all results show the estimated coefficient of the core explanatory variable digital is

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significantly positive at least 5%, indicating that the development of the digital economy of ASEAN countries will increase China's export trade to ASEAN countries, and will also increase China's export domestic added value, thus verifying the hypothesis. It is known from columns (2) and (4) that the development of the digital economy of ASEAN countries has a slightly smaller effect on the domestic added value of exports than China's export trade volume.

Columns (3) and (4) show that the economic development level of ASEAN countries is significantly positive at the level of 1%, indicating that the larger the economic scale, the more conducive to promoting export domestic added value, consistent with theoretical analysis. In all the regression results, Chinese GDP per capita is significantly positive at the level of 1%, which has a greater impact coefficient on exports than the export domestic added value, indicating that only part of the effect of digital economy on total export trade has converted into export domestic added value, so China's trade benefits cannot be characterized by the total export alone. Geographic distances are significantly negative, in line with expectations. In columns (2) and (4), common languages were significantly positive and landlocked were significantly negative, in line with theoretical expectations.

Table 3: Fixed-effect model estimates

Variables	(1)lnexport	(2)lnexport	(3)lnex_dva	(4)lnex_dva
digital	2.985*** (0.545)	2.985*** (0.545)	0.714* (0.427)	0.714* (0.427)
lnpgdp	-0.207 (0.260)	-0.207 (0.260)	2.345*** (0.361)	2.345*** (0.361)
lnpcgdp	1.763*** (0.186)	1.763*** (0.186)	0.989*** (0.269)	0.989*** (0.269)
lndistance	-21.486*** (3.145)	-21.486*** (3.145)	-51.067*** (4.486)	-51.067*** (4.486)
language		6.344*** (0.566)		9.830*** (0.659)
landlocked		-6.843*** (0.349)		-10.325*** (0.431)
constant	173.851*** (24.506)	173.851*** (24.506)	394.693*** (35.379)	394.693*** (35.379)
Country Variables	YES	YES	YES	YES
Year Variables	YES	YES	YES	YES
Observations	160	160	160	160

Note: *, ** and **** indicate significant rejection of the null hypothesis at the 10%, 5% and 1% levels, respectively, and the values in parentheses are the standard deviation of the parameter estimate.

5.3 Endogenous testing

There may be endogenous problems in the model so that we use the instrumental variable method for two-stage least squares regression to alleviate the endogenous problem. The selection of instrumental variables needs two conditions, one is correlation, the other is exogenous, this paper refers to Huang et al. (2019) [14] and Nunn et al. (2014) [15], and selects the multiplication of fixed telephone subscriptions per 100 people in ASEAN countries in 1994 and the Internet penetration rate in the previous year as the instrumental variable for the level of the digital economy. Due to the large difference in the degree of economic development between ASEAN countries, the number of multiplications of fixed telephone subscriptions per 100 people in 1994 and the Internet penetration rate in the previous year ranged from 0 to thousands, considering that there is a value of 0-1 directly logarithmic will become negative, so it is processed according to $IV = \ln(IV + \sqrt{IV^2 + 1})$. Data on fixed telephone subscriptions per 100 people and Internet penetration rate in ASEAN countries are from WDI.

Table 4 reports the two-stage least squares regression results. It can be seen that in the first phase of the regression results, the estimated coefficient of the instrumental variable is significantly positive at the level of 1%, which is in line with expectations: indicating that the more fixed telephone subscriptions, the more likely the country's level of digital economy development is higher. The regression results of the second stage show that the estimated coefficient of digital economy development level is significantly positive at the level of 1%, whether it is export trade volume or export domestic added value. The unidentifiable test shows that the Kleibergen-Paap rk LM statistic is 9.285 and the P value is 0.0023, strongly rejecting the null hypothesis of unrecognizability. The Kleibergen-Paap rk Wald F statistic is

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11.135 greater than the critical value of 8.96, indicating that the model passes the weak tool variable test, which once again proves that the instrumental variable meets the correlation requirement.

Table 4: Tool variable estimation results

	Fisrt stage	Second stage	
	digital	lnexport	lnex_dva
digital		10.699*** (2.723)	7.167*** (2.633)
IV	0.030*** (0.009)		
Control Variables	YES	YES	YES
Country FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	160	160	160
R-squared	0.971	0.961	0.966
F-statistics	/	11.136	11.136

5.4 Robustness test

After considering the endogeneity problem, this paper tests the robustness by replacing explanatory variables and modifying samples. The replacement explanatory variables are the values calculated by using factor analysis to measure the level of digital economy in ASEAN countries. The revised sample was due to the fact that there was only one developed country among the ASEAN countries, Singapore, and the economic development of other countries was far from Singapore, considering that the estimation results may be affected by the special value of the sample, the sample of Singapore was removed and re-estimated. The estimation results of the robustness test are shown in Table 5. Columns (1) and (2) respectively show the estimation results of the regression of the digital economy level of ASEAN countries to China's total export trade and trade benefits after replacing the explanatory variables by using factor analysis. Columns (3) and (4) are estimates of the regression of the new sample after excluding the Singapore data. It can be seen that whether the explanatory variables are replaced or the samples are modified, the estimated coefficient of the digital economic development level of the core explanatory variables is still significantly positive, which is consistent with the conclusions obtained by the benchmark regression model, indicating that the results are robust.

Table 5: Robustness test results

Variables	(1)lnexport	(2)lnex_dva	(3)lnexport	(4)lnex_dva
digital_f	1.154*** (0.153)	0.317** (0.122)		
digital			3.633*** (0.371)	1.045** (0.470)
Control Variables	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	160	160	144	144
R-squared	0.982	0.981	0.986	0.980

6. Conclusions

Taking ASEAN countries as the research object, this paper constructs an extended trade gravity model, and examines the impact of the digital economy development of ASEAN countries on China's export trade benefits and China's total export trade. The results show that the digital economy development of ASEAN countries can significantly promote not only China's total export trade scale but also China's export trade benefits, but the promotion effect of the digital economy development of ASEAN countries on China's export trade benefits less than the promotion effect on the total export trade. The conclusion of the study is still true after overcoming the endogenous problem and performing the robustness test.

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