

An empirical study on the impact of e-commerce on economic growth

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Abstract: E-commerce, as the product of information in the new era, is a fundamental revolution of traditional commerce. E-commerce not only reduces the cost of enterprises, but also greatly improves the efficiency of them. At the same time, it brings more choices for consumer investors and promotes the rapid development of economy. This article selects the data from 2003 to 2018 as the research sample, using statistical methods to quantify the level of e-commerce development, by using EG two-step method to conduct co-integration test on the two variables of e-commerce development level and GDP. Above these, error correction model is established to study the relationship between the two variables, testing the impact on the economy of the development of e-commerce. The empirical results show that the development of e-commerce has a long-term positive effect on economic growth.

1. Introduction

In today's economic globalization, information and network have become the main symbol and characteristics of the development of the society, and thus stimulate the emergence and development of e-commerce. E-commerce can greatly promote the sustainable development of China's economy by reducing the cost of business, improving the efficiency of business activities. It takes computer as the medium and electronic payment as the means. With the wide application of the Internet, e-commerce has begun to penetrate into all walks of life. The transaction volume has been increasing year by year, gradually becoming a new sales channel for enterprises to develop new markets and reduce costs. At the same time, it also provides consumers with more choices in the process of consumption, promoting consumption while driving economic growth. In recent years, e-commerce has shown its superiority more and more. In the near future, it will play a more important role in the development of economy.

2. Literature Review

Since the 21st century, with the continuous growth of China's economy and the increasingly mature Internet technology, the development of e-commerce has been promoted. In addition to the continuous improvement and innovation of the infrastructure supporting the development of the Internet, the Internet penetration rate is also steadily increasing, thus promoting the continuous innovation of e-commerce technology. The development of e-commerce has become a new driving force for China's new round of industrial revolution and scientific and technological transformation, providing a new way of trade and injecting new vitality into economic growth.

In the existing literature researching on e-commerce, the measurement method of the level of e-commerce development is constantly innovative. In 2001, the research group of CII e-commerce index research and measurement divided the e-commerce development index into 9 categories, selected 32 indicators, standardized the indicators and calculated their weights, and used comprehensive score analysis method to preliminarily calculate the overall index of e-commerce, and then obtained the development level of e-commerce. Jinghua Huang et al. (2004) established a new e-commerce readiness evaluation index system based on the comparative analysis of various

e-commerce readiness evaluation methods. By constructing the index system of five-layer structure and calculating the weight of the index of each layer, the readiness level of e-commerce in China's retail industry was evaluated and calculated by combining quantitative and qualitative methods. Shudong sun (2006) analyzed the measurement method and weight determination method of representative research on the basis of summarizing the research status of e-commerce level measurement at home and abroad. He proposed an ANN - based method to determine the weight of e-commerce level measurement index. The neural network was established according to the MBP algorithm programming, and the weights of each index were determined through the empirical analysis. Min Liu et al. (2008) compared the representative e-commerce measurement indicators at home and abroad, put forward the ideas involved in the e-commerce measurement indicator system in China, and designed a set of indicator system scheme applicable to the macro statistics of e-commerce. Ye Zhang et al. (2012) obtained the development level measurement model of e-commerce through statistical analysis of relevant data of e-commerce, determined the weight of indicators with the analytic hierarchy process (AHP), gave specific ideas and calculation methods. Fangfang Ma (2015) drew on the theoretical framework of OECD on e-commerce measurement, constructed an index system from three dimensions of readiness, intensity of use and influence, and measured the index with the method of linear weighting. Deshun Xu et al. (2018) constructed a monitoring index system of regional e-commerce development integrating multiple perspectives, and proposed a method combining subjectivity and objectivity based on the principle of minimum distance between the score of the evaluation object and the ideal point, as well as a measurement model of regional e-commerce development index combined with the comprehensive index method.

Most of the studies on the impact of e-commerce on economic growth are focused on theoretical research, but few on empirical analysis. Shan Lu et al. (2007) analyzed the impact of e-commerce on economic development from six aspects, such as promoting the transformation of economic growth model from traditional economy to knowledge economy, promoting the optimization and upgrading of tertiary industry, and facilitating the formation of perfect competition market. From the perspective of micro-analysis, Chengcheng Lu (2012) believed that the impact of e-commerce on economic growth mainly depended on the proportion of the product in the total product. From the perspective of macro analysis, he thought that consumption, investment, government purchase and policy orientation all had a great impact on China's economic growth. Shu Zhu (2014) conducted an empirical analysis of the relationship between e-commerce development and economic growth in Zhejiang province, and constructed a regression equation by taking logarithm of the production function, concluding that e-commerce was not only an important driving force for economic growth, but also an important force for promoting the transformation of economic development mode. Feixiao Yin (2018) studied the impact of e-commerce on economic growth through theoretical analysis and empirical test, he believed that e-commerce promoted regional economic growth, but the growth effect was still far from traditional production factors.

3. Empirical Analysis

3.1. Variable selection and Data description

This paper mainly studies the relationship between e-commerce and economic growth, and analyzes the role of e-commerce in economic growth. Two variables are selected that economic growth is measured by GDP and the development of e-commerce is expressed by the development level of e-commerce. Using Zeng Zhuoshen's method in "Empirical analysis of the impact of e-commerce on China's foreign trade in the new era" for reference to measure the development level of e-commerce which mainly selects variables from four aspects: e-commerce transaction index, e-commerce human capital index, e-commerce infrastructure support index and e-commerce development potential. E-commerce transaction index is measured by e-commerce transaction scale, e-commerce human capital index is measured by the number of direct employees in e-commerce industry, e-commerce infrastructure support index is measured by domain name, international export

bandwidth and China IDC market scale, using China's Internet penetration rate and number of mobile Internet users and the penetration rate of mobile phones to measure the development potential of e-commerce. In general, these eight indicators could reflect the development level of e-commerce well.

This paper selects the data from 2003 to 2018 as the sample. The GDP data comes from the website of the National Bureau of statistics, and the data sources of eight indicators to measure the development level of e-commerce are extensive, including China's e-commerce market data monitoring report, China's Internet development status statistical report, China's IDC industrial development report, and statistical reports published by some data websites, etc. The raw data collected is shown in the following table:

e-commerce time	x1	x2	x3	x4	x5	x6	x7	x8
2003	0.28	13	34	27216	8.7	1.3	0.0214	21.1
2004	0.48	15	185.2	74429	10.6	7.2	0.035	25.9
2005	0.68	18	259.2	136106	13.8	8.5	0.061	30.3
2006	1.02	27	410.9	256696	21.6	10.5	0.17	35.3
2007	1.7	37	1193	368927	34.6	16	0.5	41.6
2008	2.4	45	1682.6	640286.7	48.7	22.6	1.18	48.5
2009	3.7	100	1682	866367	72.8	28.9	2.33	56.3
2010	4.5	160	866	1098957	102.2	34.3	3.03	64.4
2011	6	180	775	1389529	170.8	38.3	3.56	73.6
2012	7.85	200	1341	1899792	210.8	42.1	4.2	82.5
2013	10.2	235	1844	3406824	262.5	45.8	5	90.8
2014	13.4	250	2060	4118663	372.2	47.9	5.57	94.5
2015	18.3	270	3102.1	5392116	518.6	50.3	6.2	92.5
2016	22.97	305	4227.6	6640291	714.5	53.2	6.95	95.6
2017	28.66	330	3846.86	7320180	946.1	55.8	7.53	102.5
2018	28.4	352	3792.8	8946570	1228	59.6	8.17	112.2

Fig 1. Number of raw indicators from 2003 to 2018.

It can be seen from the above table that the eight indicators measuring the development level of e-commerce are all different units of measurement. Therefore, first of all, the indicators are dimensionless to eliminate the differences between different units. The calculation formula is: $t_{ij} = \frac{x_{ij}}{\bar{x}_i}$, x_{ij} is the original index value, \bar{x}_i is the mean value of index I, t_{ij} is standard value after removing the influence of different units. The processed values are shown in the following table:

e-commerce time	t1	t2	t3	t4	t5	t6	t7	t8
2003	0.0298	0.0820	0.0199	0.0102	0.0294	0.0398	0.0063	0.3162
2004	0.0510	0.0946	0.1085	0.0280	0.0358	0.2206	0.0103	0.3882
2005	0.0723	0.1135	0.1519	0.0511	0.0466	0.2604	0.0179	0.4541
2006	0.1084	0.1703	0.2408	0.0965	0.0730	0.3217	0.0499	0.5290
2007	0.1807	0.2333	0.6991	0.1386	0.1169	0.4901	0.1468	0.6235
2008	0.2551	0.2838	0.9861	0.2406	0.1645	0.6923	0.3464	0.7269
2009	0.3933	0.6307	0.9857	0.3255	0.2459	0.8853	0.6839	0.8438
2010	0.4783	1.0091	0.5075	0.4129	0.3452	1.0507	0.8894	0.9652
2011	0.6377	1.1352	0.4542	0.5221	0.5770	1.1733	1.0450	1.1030
2012	0.8343	1.2613	0.7859	0.7138	0.7121	1.2897	1.2329	1.2364
2013	1.0841	1.4821	1.0806	1.2801	0.8867	1.4030	1.4677	1.3608
2014	1.4242	1.5767	1.2072	1.5475	1.2573	1.4674	1.6350	1.4163
2015	1.9450	1.7028	1.8179	2.0260	1.7518	1.5409	1.8199	1.3863
2016	2.4413	1.9235	2.4775	2.4950	2.4136	1.6297	2.0401	1.4327
2017	3.0461	2.0812	2.2544	2.7505	3.1959	1.7094	2.2103	1.5362
2018	3.0185	2.2199	2.2227	3.3616	4.1482	1.8258	2.3982	1.6815

Fig 2. Number of standard indicators from 2003 to 2018.

In this paper, eight indicators are selected to measure the development level of e-commerce. Each indicator has different influence on it. Therefore, the weight of each indicator needs to be confirmed.

Firstly, it is necessary to calculate the variation degree of each index. The formula is: $c_i = \frac{\sigma_i}{\bar{x}_i}$, σ_i is standard deviation of index I, \bar{x}_i is the mean value of index I. Then the weight of each index is: $w_i = \frac{c_i}{\sum_{i=1}^n c_i}$.

The weight of each index and the standardized index value are substituted into the evaluation function of e-commerce development level: $ECl_i = \sum w_i t_{ij}$, here w_i is the weight of index I, t_{ij} is standard value of index J in year I. The calculated e-commerce development level ECl_i in the year of I is as follows:

time	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
level value	0.0480	0.0877	0.1125	0.1610	0.2799	0.4043	0.5589	0.6385	0.7694	0.9498	1.2168	1.4347	1.7941	2.2056	2.5085	2.8303

Fig 3. The calculated e-commerce development level from 2003 to 2018

3.2. Model building and relevant test analysis

3.2.1. Stationarity test

Stationarity test is a test method to test the stationarity of time series data. Due to the strong volatility of macro data, it is possible to return to a long-term trend after a strong vibration, but sometimes it has a trend of random change, and it will appear non-stationary state. The independent variable and dependent variable selected in this paper are time series, and whether the sequence has cointegration and causality has strict requirements on the stationarity of the sequence, so it is necessary to test the data stationarity of the time series first. From the data and the scatter chart below, we can see that the development level of e-commerce and GDP are on the rise with the passage of years, indicating that these two sequences may be non-stationary.

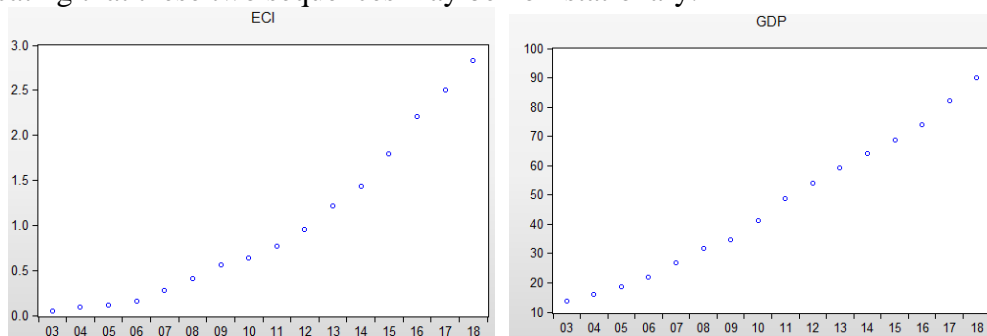


Fig 4. ECI and GDP from 2003 to 2018

In order to judge the stationarity more accurately, we use the ADF unit root test created by Dickey and Fuller to test the stationarity of time series data of serial ECI and GDP and their difference variables. See Table 1 to table 3 for ADF test results.

Table.1. ADF test results of original sequences

Test sequence	ADF test result	5% critical value	Prob.	Conclusion
ECI	0.934	-1.97	0.90	Nonstationary
GDP	1.63	-1.97	0.97	Nonstationary

It can be seen from the above table that the test values of ADF test for sequence ECI and GDP are greater than the critical value of 5%, and the P values are greater than 0.05. So we should accept the original hypothesis, which also verifies the sequences are non-stationary. Therefore, the ADF test results of the two first-order difference sequences are as follows:

Table.2. ADF test results of first-order difference sequences

Test sequence	ADF test result	5% critical value	Prob.	Conclusion
D(ECI)	0.37	-1.97	0.78	Nonstationary
D(GDP)	0.33	-1.97	0.77	Nonstationary

It can be seen from the above table that, at the 5% significance level, the ADF test values of the first-order difference series of the sequence ECI and GDP are all greater than the 5% critical value, and the P values are all greater than 0.05. The original hypothesis is accepted, so the conclusion that the sequence is non-stationary is drawn. Then the second-order difference of the two sequences are carried out, and the following results are obtained:

Table.3. ADF test results of second-order difference sequences

Test sequence	ADF test result	5% critical value	Prob.	Conclusion
D(ECI,2)	-4.01	-1.97	0.00	Stationary
D(GDP,2)	-3.88	-1.97	0.00	Stationary

It can be seen from the above table that, at 95% level, the ADF test values of the second-order difference between sequence ECI and GDP are less than the critical value - 1.97, and the p value are less than 0.05, so these two sequences are second-order single integer sequences.

3.2.2. Cointegration test

The significance of cointegration is to test whether the causality described by their regression equation is a pseudo regression, that is, to test whether there is a stable relationship between variables. Therefore, the causality test of non-stationary sequence is cointegration test. Although some time series are not stationary, their linear combination is stationary. If the linear combination of non-stationary time series is stable, the combination reflects the long-term stable proportion relationship between variables, which is called cointegration relationship. Cointegration analysis is a modeling method and theoretical analysis method based on the vector autoregressive analysis of time series, which combines spatial structure with time dynamics.

In this paper, Engle- Granger two-step method is selected to test the relationship between e-commerce and economic growth. Engle- Granger two-step method is a co integration test based on regression residual sequence, which is often used to test whether there is cointegration relationship between two variables. Since the development level of e-commerce and GDP in 2003-2018 are both second-order single integration sequences, the Engle Granger two-step test method can be used to test their cointegration.

The first step is to establish the cointegration equation between ECI and GDP. Let Y be the value of GDP, and X be the value of ECI. By means of OLS regression, the cointegration relationship between them is obtained, that is the long-term trend model between them.

$$Y = 26.34 * X + 20.31 + \varepsilon_i$$

$$(16.65) \quad (9.63)$$

$$R^2 = 0.95 \quad F = 277.38$$

The second step is to test whether the residual sequence ε_i is stationary.

Table.4. ADF test result of sequence ε_i

Test sequence	ADF test result	5% critical value	10% critical value	Conclusion
ε_i	-1.971	-1.968	-1.604	Stationary

The residual value fluctuates around 0 and the ADF value is less than the critical value of 5% and 10%, so the residual sequence is stable. Therefore, according to the data from 2003 to 2018, there is a long-term common trend between the development of e-commerce and economic growth, that is, there is a long-term equilibrium relationship.

3.2.3. Causality test

As there is a long-term cointegration relationship between GDP and EDI, there may be a causal relationship between them. However, whether the economic growth promotes the development of e-commerce or the development of e-commerce promotes the economic growth cannot be determined directly. In theory, the growth of GDP indicates that the economic development momentum is good, and the economic growth will drive the development of the Internet, thus providing more convenient conditions for the development of e-commerce, which will inevitably promote its development. On

the other hand, the development of e-commerce reduces the cost of traditional trade, provides a new form of trade, improves the level of trade development, and then brings the growth of GDP. Therefore, the relationship between the two needs to be further verified. In this paper, Granger causality test would be used for further analysis. Take logarithm of X and Y without affecting test results and choose three lag values for Granger causality test, as shown in table 5:

Table.5. Granger causality test results

Null Hypothesis	Obs	F-Statistic	Prob.	Conclusion
lnX does not Granger Cause lnY	13	5.40	0.04	Refuse
lnY does not Granger Cause lnX		0.70	0.59	Accept

It can be seen from the table that at the level of 5% significance, Granger causality exists between X and y. That is to say, the development of e-commerce has a significant role in promoting economic growth which is consistent with the theoretical analysis.

3.2.4. Fitting regression equation

From the cointegration test and Granger causality test, we can see that there is a long-term cointegration relationship between the development of e-commerce and GDP, and the impact of e-commerce on GDP growth is more significant, so it is meaningful to fit the two equations. As the improvement of e-commerce development level is the cause of GDP growth, the development level of e-commerce is taken as the explanatory variable, and GDP is taken as the explanatory variable, and the OLS single linear regression model is established:

Table.6. Regression results

Variable	Coefficient	Std.Error	t-Statistic	Prob.
ECI	26.34	1.58	16.65	0.00
c	20.31	2.11	9.63	0.00
R-squared	0.9520	Mean dependent var		46.6492
Adjusted R-squared	0.9485	S.D. dependent var		24.5781
S.E. of regression	5.5766	Akaike info criterion		6.3915
Sum squared resid	435.3712	Schwarz criterion		6.4881
Log likelihood	-49.1319	F-statistic		277.3775
Durbin-Watson stat	0.2538	Prob(F-statistic)		0.000000

Then we get the sample regression model.

$$GDP_t = 26.34 * ECI_t + 20.31 + \varepsilon_t$$

$$R^2 = 0.9520 \quad F = 661.0973 \quad DW = 0.2538$$

From the analysis of regression results, the adjustment coefficient R^2 is 0.9520 which is more than 0.95, indicating that the fitting effect of the equation is very good. Both the t-test value of each parameter and the F-statistic value of the whole equation show a good significance and the P-value of which are far less than 0.05, indicating that the significance is very strong, but DW value is 0.2538, far lower than the DW critical value 1.106 at the significance level 0.05, indicating that the residual term of regression equation has a significant positive correlation. In order to make the regression equation more reasonable, the influence of autocorrelation of residual term should be eliminated, so the model should be further modified.

3.2.5. Establish the error correction model

In order to further improve the quality of the equation and eliminate the autocorrelation of the equation, the lag term should be added properly. At the same time, the residual sequence obtained in the first step of cointegration test is added to the error correction module as an unbalanced error term. In the model, the regression equation is constructed and the corresponding parameters are obtained, which can be expressed as follows:

$$\Delta GDP_t = \beta_1 \Delta ECI_t + \beta_2 residGDP_{t-1}$$

Where ΔGDP_t refers to the first-order difference of GDP, ΔECI_t refers to the first-order difference of ECI, $residGDP_{t-1}$ refers to the residual series of GDP which is the residual of the first step in cointegration test. The results are shown in table 7:

Table.7. Regression results

Variable	Coefficient	Std.Error	t-Statistic	Prob.
ΔECI	22.5428	3.1626	7.1280	0.0000
ResidGDP (-1)	-0.1365	0.1328	-1.0278	0.3228

The error correction model is a kind of econometric model with specific form which provides the explanation of long-term equilibrium and the way of short-term adjustment. The above error correction model reflects the impact of e-commerce on the short-term fluctuation of economic growth. From the above table and the above equation, we can see that the short-term fluctuation of economic growth can be divided into two parts: ΔECI shows the impact of e-commerce on the short-term fluctuation, ResidGDP (-1) shows the impact of deviation from the long-term equilibrium. From the perspective of regression coefficient, e-commerce has a positive impact on economic growth in the short term, and the relatively large regression coefficient indicates a large impact. The error correction coefficient represents the adjustment speed after the dynamic relationship between the representative variables deviates from the long-term equilibrium. From the above table, it can be concluded that the error correction coefficient of the model is -0.1365 which is negative, indicating that the non-equilibrium error could be corrected. When the short-term fluctuation of China's economic growth deviates from the long-term equilibrium, it will approach a stable state at the adjustment range of -0.1365.

4. Research conclusion

4.1. The overall development level of China's e-commerce tends to be stable and Improved

In this paper, based on the 8 indicators of China's e-commerce transaction scale, the number of direct employees in China's e-commerce industry, the number of domain names, the number of international export bandwidth, the size of China's IDC market, China's Internet penetration rate, the number of mobile Internet users, and the mobile phone penetration rate, the data from 2003 to 2018 are selected, and the calculation method of mathematical statistics is adopted from a quantitative perspective to calculate the e-commerce development level. According to the calculation results, the development level of e-commerce in China tends to rise since 2003. As one of the important indicators to measure the development level of e-commerce, the scale of e-commerce transactions has increased to 28.4 trillion yuan by 2018, showing a rapid growth trend.

4.2. The development of e-commerce has a long-term positive role in promoting China's economic growth

This paper uses Engle-Granger two-step method to test whether there is a long-term equilibrium relationship between e-commerce and China's economic growth. The test results show that there is a long-term equilibrium relationship between the development level of e-commerce and economic growth. At the same time, according to the obtained long-term trend model, we can judge that the development of e-commerce in China has a long-term positive role in promoting economic growth according to the positive coefficient. E-commerce is gradually becoming a new driving force for China's economic development, which is consistent with China's actual situation.

4.3. The current development of e-commerce has a great impact on China's economic growth

From the regression results of the long-term equilibrium model and the error correction model, we can see that the regression coefficient values of e-commerce development level as the explanatory variable are large, which shows that e-commerce has a great impact on China's economic growth. If

the level of e-commerce is improved, it will stimulate the economic growth to a large extent, which will inject new impetus into China's economic growth.

5. Conclusion

Based on the data collected from 2003 to 2018, this paper studies the relationship between the development level of e-commerce and economic growth through empirical analysis. The empirical results show that the development of e-commerce plays an important role in economic growth, and there is a long-term equilibrium relationship between them. This shows that e-commerce has gradually become the key factor to promote economic development and change the mode of economic development. It can not only effectively promote the economic growth of our country, but also is more conducive to the protection of energy and environment. Therefore, the core position of e-commerce technology should be established through a series of means and measures to promote the application and promotion of e-commerce technology to create more space for its development. Based on this, the following suggestions are given:

5.1. The government should strengthen the formulation of laws and regulation

The support of the government will be the most powerful guarantee. Compared with the traditional trade, e-commerce involves more departments and more complicated procedures. The applicable legal provisions and relevant provisions are also different. Our government should introduce more practical e-commerce trade, tax system and other e-commerce related laws and regulations. Above these, our government should also strengthen the construction of laws and regulations in terms of network security, information management, intellectual property protection, etc. We should establish an e-commerce legal system suitable for China's national conditions and in line with international standards as soon as possible.

5.2. Speed up the construction of information infrastructure

Information infrastructure construction is the most basic condition for the development of e-commerce. We should speed up the construction of high-speed information transmission backbone network and Internet broadband, and reduce the cost of Internet access while improving the speed of Internet access. Pay attention to the introduction and development of electronic information hardware and software, shorten the distance with Internet developed countries as soon as possible and provide strong support for the development of e-commerce.

5.3. Enterprises should seize the opportunity to develop e-commerce

Enterprises should realize that e-commerce has gradually become the driving force of economic development in the future. It is necessary to learn more about e-commerce and put it into practice. Enterprises should keep up with the trend, take promoting information construction as one of the important breakthroughs in their own development, and increase the investment in information. In addition to purchasing necessary infrastructure such as software and hardware, they also need to organize technical and R & D personnel to tackle technical problems, so as to lay a solid foundation for promoting the development of e-commerce.

5.4. Pay attention to the cultivation of e-commerce talents

As a new business model, e-commerce requires more talents. Therefore, the government should strengthen the training and introduction of e-commerce professionals while creating a good external environment for e-commerce. In the aspect of talent training, we can teach relevant knowledge by setting up e-commerce specialty in colleges and universities. We should train talents according to the characteristics of e-commerce post.

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