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Analysis of Trade Effect in Post-Tpp Era: Based on Gravity Model and Gtap Model

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Abstract

The trade effect, in this article, mainly refers to the trade impacts of member countries and non-member states. This article first summarises the empirical analysis methods of trade effects of regional economic integration and then combines the methods widely used in the current research, proposes research methods suitable for Trans-Pacific Partnership (TPP) trade effect analysis, establishes models and conducts empirical analysis and then analyses empirical evidence, by which to predict the trend of post-TPP and its future influence.

Keywords: TPP; GTAP; gravity model; regional economic integration.**AMS 2010 codes:** 45G15

1 Introduction

Combined with the basic theory of the trade effect of regional economic integration, in general, there are mainly three empirical methods for the trade effect of regional economic integration. One is the partial equilibrium analysis method represented by the gravity mode [1, 2]. After examining the conclusion of the integration agreement, what factors affect the bilateral trade volume, or the relationship between trade volume and economic factors and non-economic factors, as well as the trade potential between countries? The second is a general equilibrium analysis method represented by global trade analysis project (GTAP) to predict the economic impact on the member states and non-member countries after the conclusion of the integration agreement, including terms of trade, GDP and welfare. In various aspects, because GTAP is a typical representative of computable general equilibrium (CGE), the integrated effects can be accurately and intuitively quantified, so it is widely used. The third is to use various indexes to analyse countries in one. Before and after the formation of the agreement, the direct impact of the integration agreement on trade, including trade share, trade dependence, competition index, market share, and so on. [3, 4] because the data and results used in the index analysis are relatively easy to obtain, so in practice, it is mainly used to analyse the degree of trade integration of a country, but it is mainly

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used for country and comparative analyses, which requires a large amount of data support, while Trans-Pacific Partnership (TPP) does not have a long time from origin to large-scale development, and there are not many data samples., not suitable for the analysis here, so the TPP trade effect, in this article, the analysis mainly uses the first two empirical methods [5].

2 Relation work

2.1 Partial equilibrium analysis of gravity model

The form of the gravitational model and its theoretical basis are usually the focus of scholars' scrutiny [6]. An empirical study of the application of gravity models has emerged since the 1950s. Isard and Pack (1954) and Beckerman (1956) used the gravity model to analyse trade patterns and found that geographically close regions showed enhanced trade flows. Tinbergen (1962) and Pyhnen (1963) further developed the model. They found that the GDP and distance of trading partners were important determinants of trade flows. They initially believed that the trade flows were inversely related to the distance between the two countries. The economic strength is in a positive relationship. Linnemann (1966) portrayed the effects of economies of scale by adding demographic variables and found that the size of the trading partner's population played a large negative role in trade flows and proposed improved gravity models; instead, Brada and Mendez (1983) found that the role of population in trade flows is positive; Leamer (1974) quantifies per capita income and exchange rate factors into the model and uses it as a major factor in describing economic growth to analyse the interaction between trade and its use, while using the gravitational model to test the importance of factor endowments and other national characteristics as they serve as important explanatory variables in the analysis of trade flows. Graci and Prewo (1977) used the gravity model to verify the direction and level of bilateral trade flows of 18 OECD countries in 1970. He found that tariffs as a trade resistance factor had a significant impact on the trade flows between countries considered. Although the gravitational model has achieved empirical success in explaining trade flows, it has still been criticised for its lack of theoretical basis, and many questions have been raised about the applicability of the model to the interpretation of trade drivers and expected trade trends. Helpman and Krugman (1985) proposed that the gravitational model can be repaid from scale inferred from the incremental differentiated product trade model [7, 8].

2.2 General equilibrium analysis of the GTAP model

Applying the gravitational model to the ongoing assessment of regional economic integration trade effects is actually an after-the-fact analysis using historically occurring data. The trade promotion role of the agreement is also a trade hindrance effect [9]. The disadvantage is that the integration agreement must be effective for a period of time before it can be judged whether it is positive or negative. The foreign trade policy makers, as the leading countries in regional integration, can predict the most likely outcome of their integration strategy in advance. Therefore, based on the local analysis of the traditional gravity model, the main evaluation tool, using the modern regional integration effect, is the pre-prediction analysis using the CGE model (the general equilibrium model can be calculated), and the general equilibrium is continuously improved over time. The validity and theoretical nature of the analytical method [10].

This article also uses the combination of gravity model and GTAP model to try to guess the future expansion path of the US TPP and the resulting trade effects and provide reference for the formulation of China's regional integration policy.

3 Empirical analysis of trade effect of TPP

On the basis of previous studies, this article uses the gravity model and the GTAP model to empirically analyse the trade effect of TPP from the perspective of partial and general equilibria [11, 12]. Then, the following will use the conclusion of the gravity model is used as a basis for the simulation of the GTAP model [13]. Further analysis is carried out to determine the trade effects of TPP, including the specific impact on member countries and non-member countries, and to predict the future development of CPTPP [14].

3.1 Analysis of trade relations between the United States and TPP members verification based on gravity model

3.1.1 Mathematical basis of gravity model

The basic idea of the gravitational model is derived from Newton's law of universal gravitation found in physics, that is, there is a certain attraction between an object and another object in the universe, and the magnitude of gravity between the two is determined by the mass between the two objects. Distance decision. Specifically, the magnitude of gravity changes positively with the respective masses of the two objects, and the distance between the two objects changes inversely, and is expressed as follows:

$$F = GM_1M_2/D^2 \quad (1)$$

F in the formula represents the magnitude of gravity between two objects, M_1 and M_2 represent the mass of two objects, D is the distance between two objects and G represents gravitation, which is a constant, indicating that when the mass of two objects is exactly equal to the unit mass and the distance between the two objects is exactly equal to the unit distance, the mutual attraction between the two.

In 1962, Tinbergen first used Newton's gravity model for international trade research and added parameters related to international trade [15], changing the original gravity model to the following form.

$$X_{ij} = A(Y_i^{\beta_1}Y_j^{\beta_2})/D_{ij}^{\beta_3} \quad (2)$$

This model became the original model of gravity model introduced into the field of economics. Later, domestic and foreign scholars also used this model to analyse the trade effects of various regional free trade arrangements. In the formula, the physics formula of the gravity model is fine-tuned. The economic meaning of replacing F with X_{ij} is the trade gravity between two economies or countries, that is, the size of trade volume, and Y_i and Y_j replace two objects. The quality, meaning the economic size of the two economies, is usually expressed in terms of the GDP of the economy. The meaning of D_{ij} is similar to D in (1), which means the distance between the two economies, usually between the capitals of the two countries. The distance indicates that the distance between the important economic cities of the two countries is also expressed in practice, which is mainly related to the needs of the research objects. And β_1 , β_2 and β_3 respectively indicate the degree of influence of economic scale and distance variables of two economies on the change of trade volume, and A is a trade constant, meaning similar to G in (1), which is also a constant, indicating the economy of two economies. The scale is exactly one unit size, and the trade volume between the two is just one unit. Later, scholars continued to perfect the basic gravity model of Tinbergen. The refined model is as follows:

$$X_{ij} = C(Y_i)^{\beta_1}(Y_j)^{\beta_2}/(1 + eD_{ij})^\gamma \quad (3)$$

The improved model is similar in economics to (2), but adding the coefficients of the distance variable will make the operation more accurate. To facilitate the solution, the nonlinear equation is linearised by logarithm. When the random error term is added, the following form is obtained, which also becomes the basic form commonly used in the future gravity model and the basis for studying international trade-related issues:

$$\ln X_{ij} = \ln C + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_j) + \gamma \ln(D_{ij}) + \mu_{ij} \quad (4)$$

In 1966, H. Linnemann proposed that the parameters of (4) basic forms are too simplified, which is not conducive to the analysis of specific problems in international trade. It is suggested to add demographic variables to the model. However, many scholars have since opposed the inclusion of models, such as McCallum, Anderson, Wei Shangjin, and many more. They believe that the population does not determine trade as compared with important factors such as the output level that determines the volume of trade. The necessary factors are considered for change, so whether population variables should be included in the gravity model has always been the object of scholars' arguments. Instead, people usually add per capita GDP to the model. Because this article examines the determinants of the trade relationship between the United States and TPP member states, it is logically considered that the trade volume is mainly determined by the market size of TPP member countries, and there are many determinants of market size, but it does not include population factors, so the following. There is also a view that there is no absolute direct correlation between demographic factors and trade volume, and population factors are not included in the model. In addition, Linnemann (1966) also included preferential trade agreement (PTA) as a dummy variable into the equation, mainly to investigate the impact of regional trade liberalisation on bilateral trade flows. At this point, the gravity model includes quantitative variables like GDP and distance and also includes regional economic integration, openness, whether to use the same language, whether the common boundary is used and the virtual variables that are expressed in a non-formal form. The form of the model is also based on actual needs. Continuous improvement and complementation, for example, of the equations that are established by Franke (1997) and Freund (2000) are given as follows:

$$\begin{aligned} \ln T_{ij} = & a + \beta_1 \ln(GDP_i GDP_j) + \beta_2 \ln(Dist_{ij}) + \beta_3 \ln(PC_i PC_j) + \beta_4 \ln|PC_i - PC_j| + \alpha_1 ADF_{ij} + \alpha_2 RTA_{ij} \\ & + \alpha_3 Open_{ij} + \mu_{ij} \end{aligned} \quad (5)$$

Among them, in Eq. (5), T_{ij} represents the total trade between economies i and j ; $Dist_{ij}$ represents the measure of distance; PC_i is the per capita GDP of country i , PC_j is the GDP per capita of j ; $PC_i PC_j$ is the GDP per capita of both countries i and j Product, representing the importance of "wealth" (corresponding to scale) as a determinant of trade; $|PC_i - PC_j|$ is the absolute value of the difference in GDP per capita, representing the difference between economies; α and β are parameters; ADF_{ij} represents the existence of a boundary; RTA_{ij} represents the existence of a regional trade agreement (if the economies i and j are members of the regional trade agreement being discussed, the value is 1); $open_{ij}$ represents the degree of openness of the member states (if the countries i and j are positive). The member of the regional trade agreement being discussed has a value of 1); μ_{ij} is the error term. This article also adds relevant dummy variables based on the extended gravity model and strives to establish a model that conforms to the actual trade relationship between the US and TPP members.

3.1.2 Model building

The application of the gravity model in this article is mainly to determine the determinants of the trade volume between the United States and other TPP members. Therefore, all the factors that may affect the volume of US trade when building a model must be considered.

(1) Economic factors

The first consideration in the model is the GDP of the TPP member countries that trade with the United States. As a measure of the economic size of the trading partner countries, it is a necessary parameter in the gravity model, so it is directly incorporated into the model according to the requirements of the classical form. Another necessary parameter in the gravity model is the distance factor. As the trade cost, it will also be directly included in the model. It is logically believed that the greater the distance between the two countries, the greater the transportation cost, and thus the greater the trade cost. Measuring the cost of transportation through the distance between the United States and TPP members is an important factor in determining the volume of trade with the United States. Besides the above quantitative factors, this article also includes the degree of trade liberalisation in economic factors as a dummy variable, that is, considering which countries in the US and TPP countries have previously signed a free trade agreement because generally, the two countries that sign the free trade agreement will promote the trade volume between the two parties. To verify the determinants of the trade

relationship between the United States and the TPP member states, other trade agreements other than the TPP signed by the United States will naturally become an important consideration factor.

On the basis of the aforementioned analysis, an extended gravity model is established, which is shaped as follows:

$$\begin{aligned} \ln T_{0j} = & \alpha_0 + \alpha_1 \ln Y_0 + \alpha_2 \ln Y_j + \alpha_3 \ln D_{0j} + \alpha_4 UCFTA + \alpha_5 UAFTA + \alpha_6 UPFTA \\ & + \alpha_7 USFTA + \alpha_8 NAFTA + \mu_{ij} \end{aligned} \quad (6)$$

Among them, T_{0j} represents the bilateral trade volume between the United States and various TPP member countries, Y_0 represents the US GDP, Y_j represents the GDP of the US trading partners, D_{0j} represents the distance between the United States and the trading partners, UCFTA, UAFTA, UPFTA, USFTA, NAFTA is a dummy variable representing the United States–Chile Free Trade Agreement, the US–Australia Free Trade Agreement, the US–Peru Free Trade Agreement, the US–Singapore Free Trade Agreement, and the North American Free Trade Agreement, which are signed in the year of non-effectiveness. The year in effect is 1.

(2) Political and military factors

Besides economic factors, because the US-led TPP may be for political and military purposes, that is, to maintain stability and absolute dominance in the Asia-Pacific region, it may give priority to whether the United States has signed a military agreement with it when it chooses a country of trade. The alliance agreement, because the United States has a traditional military ally in the Asia-Pacific region, has also considered it as an important dummy variable. Because political and military factors have many considerations, it is difficult to use quantitative parameters. Therefore, this article only includes the dummy variable of military–political alliance as the main indicator of political and military factors. At present, the US military and political allies in the Asia-Pacific region mainly include Japan, ASEAN countries, Australia and other countries, so they join the three dummy variables of Union1, Union2 and Union3, representing the US-Japan military alliance, the US–ASEAN partnership, and the US-Australia. The alliance, the effective year is 1, and the remaining years are 0, the final gravitation model is obtained:

$$\begin{aligned} \ln T_{0j} = & \alpha_0 + \alpha_1 \ln Y_0 + \alpha_2 \ln Y_j + \alpha_3 \ln D_{0j} + \alpha_4 UCFTA + \alpha_5 UAFTA + \alpha_6 UPFTA \\ & + \alpha_7 USFTA + \alpha_8 NAFTA + Union_1 + Union_2 + Union_3 + \mu_{ij} \end{aligned} \quad (7)$$

Therefore, (7) is used as the gravitational model, in this article, to analyse the factors affecting the bilateral trade flows between the United States and TPP member countries, and to introduce the future development trend of the United States to further lead the TPP.

3.2 Empirical analysis process and results analysis

In this article, the indicators collected by countries are based on the above-mentioned national models, using Eviews8.0 for overall regression, and then the insignificant variables are eliminated one by one (but the distance cannot be eliminated), until finally all variables of the whole model are at a significant level of 0.01. Pass the test. The results are shown in Table 1.

Regression analysis was performed on the extended trade gravity model (7). The regression results in Table 1 showed that some of the variables in the results (1) did not pass the significance test, that is, they did not reach the 1% significance level, such as Y_0 , D_{0j} , UPFTA, should use the “backward method” to eliminate the explanatory variables with inconspicuous and minimal t values, until new results are obtained. However, since the distance variable is an important variable in the gravity model, it cannot be eliminated. In the first round of adjustment, the Y_0 variable is first removed, and the result (2) is obtained. After that, the same reason is adjusted in turn, and a total of five regressions are obtained until Table 1 is obtained. The result of -2 (3) finally yielded a good fitting result and a remarkable result. Then, the result (3) is used to simulate the trade gravity model of the US and TPP members. This model only considers the economic factors. Then, the variables, such as Union1, Union2 and Union3, which represent political factors, are added, and then the regression is performed. Variables with the final result are shown in Table 2.

Table 1 Results of regression analysis considering only economic variables.

	Results (1)	Results (2)	Results (3)
C	13.43533 (1.275376) -0.627265 (-1.770844) *	-4.648183 (-1.796719)*	0.994369 (0.435299)
LnY_{0t}	0.968379 (22.07976) ***	0.952661 (22.18039) ***	0.886442 (21.35394) ***
LnY_{jt}	0.399613 (1.902863) *	0.358309 (1.716804) *	-0.063559 (-0.337587)
LnD_{0j}	0.760355 (2.624008) ***	0.626964 (2.240704) **	
UCFTA	-0.931363 (-2.905161) ***	-1.015221 (-3.201859) ***	
UAFTA	0.967220 (2.310400) **	0.785001 (1.934479) *	
UPFTA	1.108001 (4.108361) ***	1.017336 (3.842051) ***	1.159911 (4.200554) ***
USFTA	2.172070 (7.698747) ***	2.127561 (7.571092) ***	1.738967 (6.446346) ***
NAFTA			
Adjusted R^2	0.882218	0.869761	0.876598
F-statistic	146.0602	164.1042	259.8452
Prob (F-stat)	0.000	0.000000	0.000
DW stat	0.323406	0.297837	0.225315

Source: Analysis results of EVIEWS 8.0. Note: t is the statistical value in parentheses; *** means $p < 1\%$, ** means $p < 5\%$, and * means $p < 10\%$.

Table 2 Regression analysis of political factors.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.47626	2.431079	-4.720645	0.0000
$\text{LOG}(\text{Y}_{jt})$	1.240620	0.062833	19.74471	0.0000
$\text{LOG}(\text{D}_{0j})$	0.346416	0.182043	1.902931	0.0589
NAFTA	1.120052	0.300569	3.726439	0.0003
UNION1	-1.624712	0.323080	-5.028819	0.0000
UNION3	-1.748117	0.247217	-7.071175	0.0000
R^2	0.887926	Mean dependent var		23.84521
Adjusted R^2	0.884402	SD dependent var		2.055424
SE of regression	0.698839	Sum squared resid		77.65168
F-statistic	251.9415	Durbin-Watson stat		0.416290
Prob(F-statistic)	0.000000			

Source: Analysis results of EVIEWS 8.0

From the results of the aforementioned gravitational model, it can be seen that the US-led TPP did not produce the expected results, and its impact was minimal, but from a comprehensive perspective, it did affect the strategic intention of the United States to further expand, so this could be temporary. The results serve as a premise and basis for the GTAP general equilibrium analysis, given in Section 4, to validate the US trade intentions in the TPP strategy.

4 Analysis of TPP benefit effect: prediction based on GTAP model

On basis of the analysis of the aforementioned gravity model, the following is a prediction of the welfare effects that may be generated once the TPP is effective.

4.1 Analysis framework for the GTAP model

The GTAP model is the most important achievement in the development of CGE model application research. It is a multi-countable computable general equilibrium model established by global researchers and policy makers developed by Purdue University in the United States to quantitatively analyse trade policy issues. It has been widely used and accepted since 1993. The model analyses the possible impact of policy adjustment from a relatively static perspective, that is, the policy change as an impact on the original equilibrium market, and then finds new market equilibrium conditions according to the possible outcome of the impact, and the difference between the two equilibrium markets. It is the effect of policy changes. The hypothetical premise of the model is that the market is completely competitive, the scale of production returns is unchanged, the producers pursue the minimisation of production costs, the consumers pursue the maximisation of utility and all products and input factors are cleared.

The factors of production and the actors constitute the basic structure of the GTAP model. The factors of production include land, capital, skilled labour, unskilled labour and natural resources; the actors include private households, government departments and manufacturers. In particular, first, a sub-model to describe the specific behaviours of production, consumption and government in each country or region is established; then, according to the basic logic of international trade, a general equilibrium model including each sub-model is established. The model is called “multinational multi-sectoral model”, so the evaluation of the effect of trade policy aims to change a certain element in the sub-model to evaluate the degree of change of the equilibrium state of the whole model caused by the change. In general, the effect of evaluating the trade integration policy is to use the tariff reduction between members as the main shock variable, and to test the changes in the prices of import and export commodities, the changes in import and export demand, the changes in the expenditures of actors, and further Other changes, resulting in changes in economic size, terms of trade and welfare, and so on, for ease of analysis, simplify the GTAP model analysis process.

4.2 Simulation scheme design

TPP is the prototype of the Asia-Pacific Free Trade Area. Its future regional economic integration is very purposeful, and the lack of China’s regional integration is incomplete. Just as the lack of China’s WTO is also unsound, so whether China can join TPP/CPTPP is only a matter of time. In view of the aforementioned analysis, a simulation of the following scheme will be made:

- (1) The United States continues to attract South Korea to join the TPP on the basis of attracting Japan.
- (2) On the basis of (1), the United States successfully attracted all 10 ASEAN countries to join the TPP (i.e., the United States absorbed all East Asian countries except China to join the TPP).
- (3) The United States attracts all APEC countries to join the TPP (including China)

In this simulation, “tariff” is the only impact variable, that is, the tariffs within the TPP member countries will be reduced to 0, while the countries keep their current tariffs unchanged, and examine the tariffs of the TPP members under various simulation schemes. When the reduction is 0, the impact on the internal members of the

Table 3 The United States attracts all Asia-Pacific countries to join (including China).

	GDP change	Import change %	Export change %	Trade difference million dollars	Welfare changes millions of dollars	Terms of trade %
USA	0.35	0.91	1.19	-2085.54	8926.35	0.60
CHN	-1.20	5.15	4.28	-1125.30	-2114.70	-0.97
JPN	0.52	3.69	3.13	616.26	10,324.23	0.77
KOR	0.55	4.84	4.11	300.87	2,372.89	0.28
P4	1.35	1.11	1.13	247.22	1835.84	0.81
ROASN	0.68	1.99	1.79	599.94	2308.79	0.47
ROAPC	-1.60	0.55	-0.02	-2354.28	-2345.19	-0.84
OPTPP	0.04	0.87	0.87	1.96	191.54	0.05
RestofWorld	-0.51	-0.63	-0.56	3798.88	-9243.84	-0.10

Source: Rungtap results

TPP and the countries in the outside world mainly includes policy effects such as trade flows, terms of trade and welfare levels. After comparison, the most logically possible solution is obtained, which provides a basis for the following policy recommendations.

4.3 Empirical analysis process and results analysis

The simulation analysis is based on the aggregated national database and departmental database. The detailed results are shown in the following paragraphs.

The result (as shown in Table 3) shows that when all Asia-Pacific countries (including China) join the TPP, most of the indicators as simulated members have been positively growing, especially in the US. Changes in exports and changes in welfare and terms of trade are more prominent than the previous two programmes. China has also increased in terms of imports and exports, which is in stark contrast to the results of TPP marginalisation in the above two programmes. However, there has been a negative increase in GDP, trade balance and terms of trade. To a certain extent, this also shows that whether China's participation in the TPP is good or bad for China remains to be considered. Although it may increase the degree of trade links and trade liberalisation between China and the countries in the region, it is for the status of the country that is currently dominant in the region's economy. The follow-up effect of TPP has yet to be tested by time, and it is still unknown. Other ASEAN countries, other Asia-Pacific countries, TPP associate members and founding members have also achieved various improvements in trade effects. As expected, the rest of the world, without the TPP, has a negative trade effect.

In summary, the analysis results analysed by the above three simulation schemes are summarised as follows:

First, as the TPP member states continue to grow, members of the region may receive a more significant increase in trade effects, including a certainty increase in welfare in the leading country, so logically, the United States continues to support the TPP.

Second, the signing of the TPP will have irreversible negative effects on non-member countries and countries outside the region, and this negative effect will become increasingly obvious as the TPP continues to grow. This is also the general use of the GTAP model.

Third, under the aforementioned three schemes, the United States has received a relatively significant increase in effects, which just confirms the "axle-spoke" effect, that is, under a regional integration agreement, the core position is the axle country, other countries. For spoke countries, the axle countries will get a larger increase in welfare, while spoke countries will have more welfare, but the effect is far less than that of the axle country.

5 Conclusion

TPP is essentially a form of regional trade integration, and of course it will have an impact on trade and trade-related economic sectors. Therefore, before conducting an empirical analysis of the TPP trade effect, this article first integrates the regional economic integration trade effect. The empirical analysis method is used to sort out the three methods: the partial equilibrium analysis method of gravity model, the general equilibrium analysis method of GTAP model and the trade index analysis method. Determine the main basis of the US TPP expansion path and then use the GTAP model to simulate the TPP expansion scheme according to the conclusion of the gravity model, so as to examine the trade effect of the expanded TPP, and then predict the development trend of the later CPTPP.

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