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Examining the Impact of Korea's Free Trade Agreement (FTA) on Seaborne Trade Cargo Volumes[1)]

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Abstract

This paper aims to estimate the net effect on port cargo volume generated by free trade agreement (FTA) through empirical analysis of port cargo, employing various econometric models. To estimate the change in trade volume, we adopted various models such as gravity model, network model, and modified gravity model. Our test results show that the net effects of the FTA on port throughput estimated by the network model account for 2~6% annual increase in terms of performance in 2012. In contrast, the net effects by the modified gravity model are four to six times higher than those by the network model. Therefore, it implies that there is a large gap in the estimated FTA effect among the applied estimation models. However, this gap can be explained so far as the diversion effect caused by the FTA in trade between countries is taken into consideration. We conclude that the modified network model is the most appropriate for estimating the effect of the FTA in terms of how easily the explanatory variables can be estimated, how exactly the diversion effect of trade can be excluded, and how simple the estimation is.

Key words: gravity model, network model, FTA, port throughput, substitution effect

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1. Introduction

The main purpose of the Free Trade Agreement (FTA) is to foster international trade between countries concerned enabling resource allocation improvement. The influx of foreign direct investment (FDI) is also expected to be encouraged because of the improvement of business circumstances resulting from FTA. With the productivity enhancement and capital accumulation in this process, it will lead to long-term economic growth.

The Korean government has made efforts to conclude the FTA with her key trading partners in the world, responding to the megatrends in the wave of FTA in the world. As a result, as of May 2014 The FTA affects 47 countries and regions including, among others, Chile, Singapore, EFTA (European Free Trade Association), India, European Union, Peru, United States, Australia, and Canada. Furthermore, the FTAs with Columbia, Australia and Canada are scheduled for implementation in near future as the relevant negotiations have been settled through 2013 and early 2014. In 2013, the Korea's share of trade volume with the FTA countries accounted for approximately 25% of the total import and export. If the FTA agreement with China, which is under negotiation is successful, the share of Korea's trade volume with the FTA countries is expected to exceed 50%.

Most previous researches on estimation of FTA's impact on the Korea's trade focused on the trade value rather than the trade volume. The latter is considered more significant in the field of port development and maritime transportation than the former because the trade volume is crucial information for extending the port facilities and determining the shipping schedule for each sea route in maritime transport. Although FTA's net promotion effect on trade volume is an important issue, particularly for those who has interest in the FTA, no research has been done to estimate the net effect directly until now. Estimating the net effect is not an easy task since numerous factors can affect the trade between the countries at the same time. The objective of this paper is twofold. First, through the empirical analysis of seaborne trade cargo, applying network model, gravity model, and modified gravity model, we estimate the net effect on port cargo volume caused by the FTA. Second, we investigate which model is the most reasonable to estimate it based on trade volumes, considering how easy it is to predict the explanatory variables, and each model's ability to take into account the diversion effect on trade from non-member countries to member countries of FTA.

2. Literature Review

Previous research results provided a comprehensive analysis of the FTA's impact on Korean economy (e.g., Bae et al. 2012; Joe and Song, MOFAT-KIEP, 2003, 2005a, 2005b, 2007; MLTMA, 2009; Song, 2011; Jung, 2005; Lee et al, 2013; Kim et al., 2009). Based on the trade data among the FTA partners, various analysis models were developed to estimate the impacts on production, added value, and employment. The impact (benefit) of tariff removal tariffs was introduced item by item through qualitative analysis of the FTA countries. The Ministry of Land, Transport and Maritime Affairs (2009) comprehensively analyzes the Korean domestic port throughput that is affected by changes in the global port volume due to the Korea-EU FTA. Kim et al. (2009) showed the FTA effect between Korea and each country in BRIC (Brazil, Russia, India, and China) through the CGE model. They computed the volatility of the GDP caused by the FTA and analyzed the increasing impacts on imports and exports in 12 industries. They also converted the estimated trade value into trade volume by using conversion coefficients.

Lee *et al.* (2013) estimated the changes in cargo throughput caused by the FTA between Korea and ASEAN using the global computable general equilibrium (CGE) model, namely, Global Trade Analysis Project (GTAP). They selected 13 countries[1] and eight items[2] related to Korea's recent FTA and classified the tariff rates into eight categories based on three tariff scenarios.[3] Bae *et al.* (2012) performed the empirical analysis on the economic effects of the FTAs in terms of trade value between Korea-Chile, Korea-Singapore, Korea-EFTA, and Korea-ASEAN, using the gravity model. They added dummy variables (representing the FTA) to the generalized gravity model to estimate the effect on Korea's economy and examined how the FTA affected Korea's trade and analyzed which factors were responsible for these changes. Primo *et al.* (1994), Frankel (1997), Baier and Bergstrand (2007), and Magee (2008) added a dummy variable representing whether the FTA was undergoing a general type of gravity model. They classified the total Korean trade into two categories: one with member countries and the other with non-member countries of FTA according to the methodology from Cernat (2001), Magee (2008), and Plummer *et al.* (2010).

Joe *et al.* (2009) assumed different scenarios to analyze the economic impacts of the Korea-EU FTA using a self-established model. His research was designed to solve the weak points of the GTAP model by developing a new and highly reliable CGE model.

1) Korea, ASEAN, China, Japan, Taiwan, India, other Asian Countries, USA, other American countries, EU, other European countries, Oceania, etc.

2) Containerized general commodities, containerized agriculture commodities, major bulk, break bulk, liquid, crude oil, automobiles, and others.

3) Scenario 1: ASEAN+1 (China) FTA. Scenario 2: Korea-EU, Korea-USA FTA. Scenario 3: Korea-ASEAN FTA.

In particular, this model considered whether there was the constraint of capital flow. It showed that the estimated values under the two scenarios were different from each other. Lee et al. (2005) estimated the macroeconomic effect of the FTA among Korea-China-Japan using the CGE model through simulation analysis on the basis of the latest GTAP database. They analyzed also the FTA's ripple effect on each industry in three countries and proposed a counterstrategy for each industry. The Korea Trade-Investment Promotion Agency (2012) analyzes the FTA effect and shows the most beneficial industries in each country. It presents the top ten items that have the highest import growth rate in Korea. Lee et al. (2011) used the CGE model to estimate the port throughput after the Economic Cooperation Framework Agreement (ECFA) between China and Taiwan. They estimated the port throughput by multiplying the result of the post-simulation trade value by the conversion coefficient (ton/dollar) because their GTAP database was built based on the amount of money.

Lee and Lee (2011) applied the similar method to quantify the impacts of India, Brazil, and South Africa (IBSA) trade liberalization on seaborne cargo volumes. The major advantage of the GTAP model is that it can capture the effects of economy wide adaptation and asymmetric structure change in exports and imports caused by trade liberalization for the IBSA. In the literature, the CGE models were most widely used to estimate the FTAs' impacts on trade value. Cheong and Cho (2013) examined the impact of Korea's FTA and predicted the port throughput (including container throughput) referring to Lee and Lee's model to convert trade value to trade volume with GTAP in association with conversion coefficient (Lee and Lee, 2011; Lee et al., 2012). They claimed that the conversion coefficient has improved Lee and Lee's one and then analyzed the trade impact of FTAs, in particular, for 17 items with four main FTA partners (USA, EU, ASEAN, and India) in the short term and long term. They used the GTAP CGE model for estimating the effect of the FTA on each item in each country, and they converted the estimated trade value to trade volume using a containerized coefficient in each item.

However, the CGE model cannot be used to estimate the trade volume effect because the social accounting data that underlie the CGE model are in currency units. Therefore, the result of the CGE model analysis is expressed also in currency. Basically, a social accounting matrix cannot be created in units of volume, which makes it impossible to estimate the direct FTA trade volume effect through the CGE model. Therefore, when using the CGE model to estimate the fluctuations of import and export volume caused by an FTA, the indirect method is commonly used, which converts the trade value into the quantity of traffic by using the conversion coefficients. Moreover, when applying this indirect method, it is impossible to convert value into volume precisely because discrepancies occur when matching trade volume classified by HS (Harmonized Commodity Description and Coding System) codes to port throughput classified by SP-IDC (Shipping & Port − Internet Data Center)[4]. A more critical problem is that the estimated effects

of the FTA, based on trade value and trade volume, appear to be different on the imports and exports of each country. This means that the conversion coefficient may be different not only among commodity types but also among trading routes. Therefore, an error may be made in applying the indirect method that uses the conversion coefficient. In summary, to improve the reliability of estimated effect of the FTA, we need the econometric model, which focuses mainly on the trade volume from the beginning rather than trade value. In addition, few of the previous researchers analyzed econometrically the relationship between the implementation of FTAs and trade volume. Having said that, this paper applies gravity model, network model, and modified gravity model to estimate the net effect on port cargo volume generated by FTA through empirical analysis of port cargo, applying and to investigate which model is the most appropriate to estimate the impact of FTA on the trade volumes.

3. Impact of FTA on Seaborne Trade Volume

3.1 Data Set for the Analysis

To achieve a meaningful statistical analysis, we limited the targeted countries with Korea to those of which the FTA came into effect quite long before. Accordingly, Chile (April, 2004), Singapore (March, 2006), and ASEAN (June, 2007) were chosen for the analysis. To confirm whether the FTA with these selected countries made a significant impact on Korea's' trade, we examined if there were meaningful differences in the actual trade volume between the periods before and after the FTA. Additionally, we select the most appropriate model for estimating the effect of the FTA, not only on the trade value but also on the trade volume. We obtained the records for the import and export throughputs from SP-IDC and trade value data from the Korea International Trade Association. The differences between trade volume (import and export throughput) and trade value resulted from that air cargo is included or not. Here, the import and export trade volumes were only the maritime traffic cargo.

Since Korea's imports and exports have steadily increased over the last decades, examining only the absolute trade numbers could not determine the true significant difference in trade volume or trade value before and after the FTA. Rather, we examined the share of each country's imports and exports for Korea. That is, if the share variation of a certain country before and after the FTA was statistically significant, it could be said that there was an additional increase in imports and exports caused by the FTA with that

4) Shipping & Port - Internet Data Center (www.spidc.go.kr).

country. When calculating the share variation between two periods, the length before the FTA should be considered. It might be long enough to secure statistical reliability of any statistics during the periods examined.

We used observed data since 2000, in consideration of recording history of SP-IDC and reliability of significance test for calculated statistics. We conducted a t-test to determine the significance of the variation between the two periods and set up the confidence interval at 5%. However, if the t-statistics is not much different from a 5% error bound, it is regarded as significant also. We assumed that the variances in the two periods were equal. If the result of the t-test for one nation was significant, it was determined that an obvious effect of the FTA existed.

From the result of the t-test of trade volume for the three countries, the exports between Korea and Chile, imports and exports between Korea and Singapore, and imports and exports between Korea and ASEAN proved to be significant. On the other hand, based on trade value, it could be judged that the following trades were significant: imports and exports between Korea and Chile, exports between Korea and Singapore, and exports between Korea and ASEAN. From the t-test, it can be inferred that the result based on trade value was quite different from the one based on trade volume. The discrepancies resulted from the difference of the FTA effect on goods among each country. It is natural that the large deviation between the two different units occurs when the FTA effect happens to be noticeable in luxury goods that are small in volume or liquid bulk goods of great size. Therefore, a severe error may happen in estimating the trade volume by applying the indirect method that uses the conversion coefficient which converts value into volume. For this reason, we need the econometric model focusing mainly on the trade volume from the beginning rather than trade value.

Table 1. The results of the significance in the three FTA groupsa

(a) Korea-Chile

Item	Based on volume (share)				Based on value (share)			
	Import		Export		Import		Export	
	2000–2004	2005–2012	2000–2004	2005–2012	2000–2004	2005–2012	2000-2004	2005–2012
Average	0.5063	0.4395	0.4384	0.9802	0.6008	1.0006	0.3100	0.5709
Variance	0.0004	0.0136	0.0029	0.0853	0.0230	0.0171	0.0024	0.0242
Number of observations	5	8	5	8	5	8	5	8
Pooled variance	0.0104		0.0553		0.0192		0.0162	
Degree of freedom	11		11		11		11	
T-statistics	1.1480		-4.0402		-5.0507		-3.5854	
P-value	0.1376		0.0009		0.0001		0.0021	

(b) Korea-Singapore

Item	Based on volume (share)				Based on value (share)			
	Import		Export		Import		Export	
	2000–2006	2007–2012	2000-2006	2007–2012	2000–2006	2007–2012	2000–2006	2007–2012
Average	0.908	1.2193	3.006	3.5417	2.1316	1.9497	2.6754	3.6704
Variance	0.0462	0.0022	0.332	0.5086	0.0261	0.0628	0.1191	0.1347
Number of observations	7	6	7	6	7	6	7	6
Pooled variance	0.0353		0.4123		0.0428		0.1262	
Degree of freedom	11		11		11		11	
T-statistics	-2.975		-1.668		1.5795		-5.0335	
P-value	0.0126		0.086		0.1425		0.0003	

(c) Korea-ASEAN

Item	Based on volume (share)				Based on value (share)			
	Import		Export		Import		Export	
	2000–2007	2008–2012	2000–2007	2008–2012	2000–2007	2008–2012	2000–2007	2008–2012
Average	11.3453	13.6783	10.3126	12.2571	10.3477	10.0889	10.4743	12.3469
Variance	0.6358	1.0622	1.7311	1.0411	0.6042	0.1916	0.6444	1.8089
Number of observations	8	5	8	5	8	5	8	5
Pooled variance	0.7909		1.4802		0.4541		1.0679	
Degree of freedom	11		11		11		11	
T-statistics	-4.6015		-2.8034		0.6738		-3.1785	
P-value	0.0007		0.0171		0.5143		0.0087	

[a]Using data since 2002.

3.2 Applied Models for Impact Estimation of Korea's FTA on Seaborne Cargo

In this section network model, gravity model, and modified gravity model are applied for the estimation of net effect on port cargo volume generated by FTA. Through these empirical analyses we also are to investigate which model is the most appropriate to estimate the impact of FTA on the trade volumes.

3.2.1 Network Model Estimation

In international trade theory, Linder (1961) considers the GDP of trade-participating countries and changes in non-participating third nation's economic conditions in trade networks to be important factors in making an impact on trade volume. In the globalized

world in tandem with FTA, Asian countries have come to form complex trade networks. Therefore, the persuasive power of Linder's logic has become stronger. A network theory considers the synergistic effect caused by the interactions among network members and the network externality, as described in Linder's theory. The network externality is defined as positive in the case of an increase in activities between two particular members influenced by an increasing number of activities among the network members. In an international trade network where Korea has played an important role, this positive network externality has been generally observed recently. In other words, as the number of Korea's trade partners and global trade volume increases, the amount of trade volume between Korea and other countries also rises. This means that Korea's trade receives positive external effects from international trade networks.[5)]

We constructed a network model to forecast the port throughput using traffic and other economic-related data between Korea and the 17 other groups (a total of 51 countries including nine ASEAN countries and 27 EU countries). To achieve this, an international network was formed of the 17 groups with Korea. With the exception of Singapore and Croatia, ASEAN and EU were each considered a single group. We estimated the impact of the FTA on Korea port throughput based on economic-related variables like the tariffs and GDP of the network countries.

- The throughput function is defined as $Q_{it} = F(G_{it,}\ K_{it,\ 1,}\ t)$ based on the theory of international trade.
- $Q_{it,}\ G_{it,}\ K_{it}$ are the nations' yearly port throughput, trade potential index, and tariff index, respectively, according to nations (i = 1,2,3,..., N) and years (t = 1,2,3,...,T).
- In addition, Kit represents the trends of the tariff rates between Korea and other countries and is calculated by multiplying the Korean tariff rates by the other countries' yearly tariff rates.
- A regression analysis is applied using the trade potential indexes and port traffic data between Korean and other countries. $Q_{it,}$ is the trade volume and can be calculated by the following equation:

$$\log Q = \alpha + \lambda_t + \beta_G \log G + \beta_T \log K + \nu_i + \epsilon \qquad (5.1)$$

λ_t is the year dummy variable calculated by using the time effect.
ν_i is the country-specific effect invariant over time.
ϵ is a random error term.

5) The Ministry of Land, Transport and Maritime Affairs (2009) predicted the trade volume between Korea and the EU after the FTA by using these features of network theory. T is the increased trade volume between Korea and other particular nations caused by the externality, and S is the size of the international trade network. Therefore, T is equal to f(S), and we can assume that f(0) = 0 and f'(s) ≧ 0.

In the case of the fixed effects model, such as Eq. (5.1), ν_i, which is the country specific effect, is generally calculated by using dummy variables for each country. However, it is difficult to obtain statistically significant results if there are too many dummy variables because there are as many variables to be estimated. Therefore, this paper transformed Eq. (5.1) to solve this problem by removing ν_i and introduced the following within-countries regression Eq. (5.2):

$$\log Q - \log Q_{i\cdot} = \beta_G(\log G - \log G_{i\cdot}) + \beta_T(\log K - \log K_{i\cdot}) + \epsilon - \epsilon_{i\cdot} \qquad (5.2)$$

$$\log X_{i\cdot} = 1/T \cdot \sum_{t=1}^{T} \log X$$

In Eq. (5.2), the results obtained by the method of ordinary least squares were technically the same as those derived from the method of least squares dummy variable. We estimated the effect of the FTA using the fixed effects model (5.2).

3.2.2 Trade Potential Index

Seventeen groups (51 countries all belonging to ASEAN and EU) were included in the trade network with Korea. To estimate the trade potentials among all the included countries, we named this network "K-Network." The K-Network consists of the 17 groups that showed the most active trade movement with Korea including nine ASEAN countries and 27 EU countries. The K-Network intersects each 18 point mutually. The trade potential index is represented by the weight of each line connecting two countries. This paper adopted the same procedure used by the Ministry of Land, Transport and Maritime Affairs (2009) to calculate the index.

Table 2. The trade potential index between Korea and other main trading partners

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Taiwan	288.5	278.9	290.3	317.7	362.2	405.3	446.2	504.0	560.8	531.1	605.1	680.9	709.7
Russia	274.8	281.3	299.8	343.3	411.8	485.3	566.0	665.6	703.2	623.4	733.4	834.7	856.3
Mexico	331.4	330.1	353.5	390.8	439.4	499.4	560.0	626.8	650.3	592.1	687.3	769.3	798.1
Brazil	340.5	320.8	329.9	366.2	424.1	504.7	581.4	674.8	702.5	655.1	789.5	882.8	904.2
Saudi Arabia	258.0	255.4	262.3	293.2	340.2	392.8	441.1	501.9	573.2	531.0	608.6	698.1	731.1
United Arab Emirates	233.4	233.6	237.3	264.6	309.5	352.7	401.9	467.0	545.4	513.4	580.2	662.3	693.6
Iran	232.4	237.3	239.7	268.5	314.7	356.5	402.2	475.3	549.8	523.8	591.6	664.2	690.5
Japan	660.0	597.9	656.4	725.4	794.8	871.9	919.8	972.2	905.2	840.9	994.5	1,078.9	1,081.5
China	406.8	406.1	453.5	508.8	580.3	674.9	775.3	900.6	888.2	839.0	1,016.4	1,144.5	1,175.5
Australia	305.2	294.4	310.3	350.8	416.0	473.5	525.3	597.8	646.9	596.2	697.8	791.1	819.2
Hong Kong	252.9	251.4	255.1	276.4	315.5	351.7	390.9	450.5	524.6	501.8	564.0	638.4	668.7

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ASEAN	320.9	312.6	339.7	380.1	431.1	489.5	559.9	642.2	673.9	632.4	748.9	829.8	860.0
EU	841.4	799.2	944.0	1,100.8	1,228.3	1,384.9	1,521.9	1,672.6	1,387.0	1,200.4	1,403.3	1,505.1	1,497.4
USA	899.5	861.0	996.8	1,085.2	1,167.9	1,328.0	1,455.2	1,534.5	1,265.9	1,134.8	1,347.8	1,428.9	1,435.7
Singapore	230.5	229.6	229.9	252.5	295.3	331.2	371.5	436.6	512.6	494.7	561.3	637.5	667.7
India	314.9	312.0	333.1	377.4	433.4	497.0	559.5	657.0	663.4	634.9	751.4	833.9	863.1
Chile	222.6	221.4	219.9	243.8	289.7	331.0	377.8	438.4	515.9	493.9	562.0	639.5	672.0

Notes: 1. ASEAN excludes Singapore.
2. EU includes 27 countries except Cyprus.
3. Estimated by using 2012's GDP growth rate from Global Insight
source: the present writer.

4. Estimation Results by Model and Discussions

4.1 Network model estimation

We estimated the regression equation based on the network model by adopting the respective trade potential indices and tariff rates of 51 countries as the main independent variables with 13 years of data (2000 to 2012). By that established model, we calculated the effect of the FTAs of three selected countries. All of the results for the model estimation proved to be significant, showing high correlation coefficients and F-values. Additionally, there was not any multi-collinearity or autocorrelation when checked by Durbin-Watson test statistics. Judging the significance of the coefficients of two explanatory variables, the tariff rates, and the trade potential indexes by p-values, the latter showed to be more significant. In other words, the trade potential index provided a better explanation of the FTA effect than the tariff rate in the network model. This model showed that the potential trade index made positive impacts on Korean trade throughput; however, the tariff rate was negative.

Table 3. The estimation results of the network model between Korea and Chile

Items	(i) between Korea and Chile	(i) between Korea and ASEAN	(i) between Korea and Singapore
β_G	0.6037 (5.293)	0.722 (9.988)	0.695 (4.424)
β_T	-0.0277 (-1.164)	-0.017 (-1.509)	-0.018 (-0.432)
F	30.366	94.710	21.710
$Adj.\ R^2$	0.741	0.849	0.689

Note: ( ) is T-statistics.

Table 4 shows the empirical results of the estimated port throughput by using the network model. In case of Chile, the annual average effect of the FTA after implementation was 345,000 tons. Its increasing rate of trade volume compared to 2012's was 6.1%. For the ASEAN, the annual average increased traffic volume affected by the FTA was 489 million tons, which was a 3.4% increase compared to 2012. The effect of the FTA with ASEAN showed very sharp upward trends due to tariff reductions. The smallest effect among the three countries was in the FTA between Korea-Singapore, showing an annual average of 482,000 tons. After implementing the FTA, Singapore's trade volume increased only 2.1% annually on average due to Singapore's duty-free tariff system. It is difficult to determine the common features of the network model by considering only these three results. However, it shows that the FTA effect tends to be more sensitive to changes in the tariff variables of which the statistical significance was rather low because the trade potential index does not change rapidly.

Table 4. The analysis on the FTAs' effects on port throughput between FTA-participating countries

Country	Year	Port throughput in 2012 (thousand tons)	Annual average changes in throughput (thousand tons)	Annual growth rate of empirical result compared to 2012 (%)
Chile	2005~2012	5,699	345	6.1
ASEAN	2008~2012	145,589	4,889	3.4
Singapore	2007~2012	23,308	482	2.1

Source: Compiled by the authors.

4.2 Gravity Model Estimation

The gravity model is one of the most widely applied methodologies for the empirical estimation of the FTA's effect on trade value. We applied gravity model to this study using the following equation and calculated the effect of FTA using dummy variables of 0 or 1.

$$\ln Y_{jt} = \beta_0 + \beta_1 \ln gdp_{jt} + \beta_2 \ln dist + \beta_3 inland_{jt} + \beta_4 FTA_{jt} + \sum_{k=1}^{6} \nu_k region_k + \sum_{t=2000}^{2012} \delta_t year_t + \varepsilon_{jt} \quad (5.3)$$

Y: The total port throughput of Korea between Korea and a trading partner j in year t, as the dependent variable.

j: a trading partner.

t: year.

ln: natural logarithm.

gdp: the log value of GDP (nominal) at the trading partner.

*dis*t: distance between Korea and a trading partner (calculating the distance between, especially, Seoul and the capital of a trading partner).

inland: dummy variable indicating whether the trading partner is an inland country (inland = 1, not inland = 0).

region: dummy variable indicating the continent that a trading partner with Korea belongs to
(divided into six continents).

year: dummy variable for controlling the changes in macroeconomic factors by year.

FTA: FTA dummy variable. If Korea and a trading partner's FTA already came into effect in year t, this variable is presented as 1, if not, it is presented as 0.

In Eq. (5.4), the FTA variable is replaced with other variables, Chile, Singapore, and ASEAN, which indicate the FTA countries with Korea. The explanatory variable "region," which was set for finding the feature of each continent, was divided into six areas: North America, South America, Europe (including Russia), Middle East-Africa, Asia, and Oceania. The variable Chile identifies the FTA between Korea and Chile. Singapore and ASEAN have the same meaning as Chile; therefore, each coefficient of each dummy variable representing the country's FTA can be interpreted as the increase in the trade volume by the FTA,

$$\ln Y_{jt} = \beta_0 + \beta_1 \ln gdp_{jt} + \beta_2 \ln dist + \beta_3 inland_{jt} + \beta_4 Chile_{jt} + \beta_5 Singap_{jt} + \beta_6 ASEAN_{jt} + \sum_{k=1}^{6} \gamma_k region_k + \sum_{t=2000}^{2012} \delta_t year_t + \epsilon_{jt} \quad (5.4)$$

We used the related data between Korea and the 57 other main trading partners for the 2000–2012 in the analysis. We obtained the port throughput data from SP-IDC, GDP from the National (Korea) Statistical Office's international statistics,[6] and World Bank World Development Indicators. These data were in nominal dollar units. The geographic data of the trading partners were extracted from the Centre d'Etudes Prospectives database.

Table 6 shows the results of the estimated coefficients of Eq. (5.4). The average trade volume can be calculated if the actual data for the independent variables is applied to the estimated equation. According to the estimated results in this study, the coefficient

6) National (Korea) Statistical Office (http://kosis.kr/).

of GDP showed a statistically significant positive sign, which means that Korean imports and exports increased as the trading partners' GDP grew. The distance variable "Indist" representing the trade-related costs, such as the distance between trading countries, was negative. This showed that the greater the distance, the less the trade volume. These results coincide well with the basic assumption of the gravity model.

We tried to include as many countries as possible unless a particular country was indifferent to Korea's trade, because the sign and the statistical significance of the estimated coefficients responded sensitively to the number of sample countries. Twenty-four countries were added to the previous 33 samples in the network model to increase the statistical significance and maintain the features of the gravity model.

From the estimated model, it was proven that the trade with non-inland countries was more active than with the inland ones. This result was similar to the generalized gravity model. In terms of continents, the tendency of an increasing trade volume was remarkable in Oceania, South America, middle east Africa (in order). On the other hand, the Asian countries (except ASEAN and Europe-Russia) that were suffering from economic recession showed relatively slow growth rates in trade volume. The slow growth rate in Asia resulted from the European economic recession that began in 2000. In this model, all of the estimated coefficients were within 1% significance level, meaning that everyone was statistically significant. Among the three countries, the effect of the FTA was highest in the ASEAN followed by Singapore and Chile.

Table 5. Gravity model analysis on the FTAs' effects on port throughput among the FTA countries.

	Including all 57 countries	
	Estimated coefficients	P-value
Y-axis intercept	57.7903 (2.2262)	0.0263
ln gdp	0.6520 (15.7799)	4.17233E-48
ln dist	-1.8251 (-10.356)	1.87082E-23
Inland	-4.6667 (-13.5863)	2.04317E-37
Chile	1.3211 (2.9443)	0.0033
Singapore	2.5205 (4.7870)	2.07377E-06
ASEAN	2.6742 (4.7223)	2.81904E-06
North America	3.6672 (6.4669)	1.8973E-10
South America	3.8462 (6.9320)	9.56837E-12
Europe-Russia	1.4539 (2.9570)	0.0032
middle east-Africa	3.8425 (7.9703)	6.58371E-15
Asia	1.3466 (3.2262)	0.001313709
Oceania	4.1393 (9.6377)	1.04971E-20
Year Dummy	-0.0198 (-1.5279)	0.1270
Observations	702	
Adjusted R^2	0.655	

※ ( ) is T-statistics
Source: Compiled by the authors.

4.3 Modified Gravity Model

Since the gravity model controls the impact of the FTA with a dummy variable, the model is suitable for carrying out empirical analysis for past performance rather than expected future effect. Comparing each country's relative FTA effect to some degree, however, is not appropriate for estimating the real future effect of the FTA. Given that the effect of the FTA is estimated by using dummy variables, all of increased trade after the FTA may be recognized as a net outcome of the FTA. Therefore, there is a risky possibility that the gravity model may overestimate the effect of the FTA. To resolve this problem, we made a modified gravity model, Eq. (5.5), which replaced the dummy variables with ones representing the effect of the tariff used in the network model

$$\begin{aligned}\ln Y_{jt} = {} & \beta_0 + \beta_1 \ln gdp_{jt} + \beta_2 \ln dist + \beta_3 inland_{jt} + \beta_4 Chile\_E_t \\ & + \beta_5 Singap\_E_t + \beta_6 Singap\_I_t + \beta_7 ASEAN\_E_t + \beta_8 ASEAN\_I_t \\ & + \sum_{k=1}^{6} \gamma_k region_k + \sum_{t=2000}^{2012} \delta_t year_t + \epsilon_{jt}\end{aligned} \tag{5.5}$$

*Chile_E*t : log*ChileEk*t-log*ChileEk*

*Singp_E*t : log*S*ingap*Ek*t-log*S*ingap*Ek*

*Singp_I*t : log*S*ingap*Ik*t-log*S*ingap*Ik*

*ASEAN_E*t : log*ASEANEk*t-log*ASEANEk*

*ASEAN_I*t : log*ASEANIk*t-logASEAN*Ik*

$ChileE_{kt}$: Import tariff rate to Korea in Chile on *t.*

$SingapE_{kt}$: Import tariff rate of Singapore for Korea on *t.*

$SingapI_{kt}$: Import tariff rate of Korea for Singapore on *t.*

$ASEANE_{kt}$: Import tariff rate of the ASEAN for Korea in on *t.*

$ASEANI_{kt}$: Import tariff rate of Korea for the ASEAN on *t.*

$$\log E_{k\cdot} = 1/T \cdot \sum_{i=1}^{T} \log E_{ki}$$

$$\log I_{i\cdot} = 1/T \cdot \sum_{i=1}^{T} \log I_{ki}$$

Overall, the coefficients estimated in the modified gravity model did not show any particular differences compared to the generalized gravity model. However, the substituted import-export tariff coefficients' statistical significance was lower than those of the dummy variables. Nevertheless, it was obvious that the modified model was more useful for estimating the net FTA effect since it clarified the cause-and-effect relationship between trade volume and each explanatory variable. Table 6 and 7 show the effect of the FTA on port throughput estimated by the modified gravity model. The test results show that the estimated port throughputs are four to six times higher than those of the network model. It can be said that those estimated digits are too high as the FTA net effects. Though modified gravity model complemented the reliability of estimation by introducing the tariff variables, it was still vulnerable to overestimation because it focused on the relationship of two involved FTA countries. Modified gravity model estimates the FTA effect by analyzing the functional equation between trade volume and the variables such as GDP and tariff rates. It limits the utility as estimation model for the absence of considering the substitution effect caused by the FTA. Anyhow, it draws a finding that that there is a large gap in the estimated FTA effect among the applied estimation models

Table 6. Modified gravity model analysis on the FTAs' effect on port throughput of all 57 countries

Variables	All 57 countries	
	Estimated coefficients	P-value
Y-axis intercept	42.3067 (1.6409)	0.1012
ln gdp	0.6687 (16.4881)	5.65E-52
ln dist	-1.4690 (-9.1363)	6.62E-19
Inland	-4.6936 (-13.7092)	3.95E-38
Chile_E	-0.7526 (-1.3095)	0.1908
Singap_I	-0.4087 (-1.0799)	0.2805
Singap_E	-0.6724 (-1.3548)	0.1759
ASEAN_I	-0.4616 (-1.4097)	0.1591
ASEAN_E	-0.2974 (-0.9979)	0.3187
North America	2.8067 (5.1920)	2.72E-07
South America	2.8520 (5.4785)	5.95E-08
Europe-Russia	0.7190 (1.5322)	0.1259
Middle East-Africa	3.1347 (6.8084)	2.1E-11
Asia	1.3758 (3.3093)	0.0010
Oceania	3.3570 (8.3889)	2.63E-16
Year Dummy	-0.0134 (-1.0385)	0.2994
Observations	727	
Adjusted	0.655	

※ ( ) is T-statistics.
source: the present writer

Table 7. Modified gravity analysis on port throughput between the FTA three groups

FTA's trading Group	Year	Port throughput in 2012 (thousand tons)	Annual average changes in throughput (thousand tons)	Annual growth rate of empirical result compared to 2012 (%)
Chile	2005~2012	5,699	823	14.4
ASEAN	2008~2012	145,589	19,291	13.3
Singapore	2007~2012	23,308	2,927	12.6

5. Discussions and Conclusion

This paper has estimated the net effect on port cargo volume generated by free trade agreement (FTA) through empirical analysis of port cargo, applying network model and modified gravity model and to investigate which model is the most appropriate to estimate the impact of FTA on the trade volumes. Our test results show that the net effects of the FTA on port throughput estimated by the network model account for 2%~6% annual increase in terms of performance in 2012. In contrast, the net effects by the modified gravity model are four to six times higher than those by the network model. Therefore, it implies that there is a large gap in the estimated FTA effect among the applied estimation models. However, this gap can be explained so far as the substitution effect caused by the FTA in trade between countries is taken into consideration. Generally, the FTA positively affects trade volume between the countries that are directly involved, but not for all. Sometimes the diversion effect occurs after the FTA, so the other country's trade volume may decrease when the directly involved countries' volumes increase. Therefore, there is a high possibility that bias may happen when performing an analysis on the effects of an FTA by considering only the two countries involved. If we do not consider the diversion effect, the FTA impact may be overestimated. In this respect, the network model may be one step ahead because it considers every trading partner and the mutual interactions among them. In this study, the estimated output from the network model was lower than any other estimator because the estimated FTA effect indicated the net creation value excluding the diversion effect. It is reasonable that the network model estimated FTA effect shows a low level because it considers all countries' mutual interactions regardless of the FTA with Korea. Our test results shows that the gravity model can be useful for analyzing the effect of FTA empirically. However, the model controls all the effects of the analysis such as the FTA effect, continental region effect, and the annual effect by dummy variables, so it is more appropriate for an empirical analysis rather than estimating the future effect of the FTA. In other words, the gravity model is helpful to compare each country's relative effect of the FTA and the trends in changes of the trade volume for each continent than to forecast the FTA's effect on trade volume. This study introduced the modified gravity model, which

replaced the dummy variables in the gravity model with new ones to resolve these weak points. However, it cannot also exclude the substitution effect. The existence of the substitution effect creates the differences in the estimated effect of the FTA between the modified gravity model and the network model.

The comparison of our test results among the three models lead us to conclude that the modified network model is the most appropriate model among the three applied models in this paper for estimating the effect of the FTA in terms of how easily the explanatory variables can be estimated, how exactly the diversion effect of trade can be excluded, and how simple the estimation is.

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