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<Abstract>
This paper applies the gravity model to explain Korea's bilateral trade flows. In the standard gravity equation, a trade conformity index and APEC membership are included to identify the peculiarity of Korea's trade patterns. The empirics, for the data of Korea with its 30 major trading countries of 1995, shows that Korea's trade rely on Heckscher-Ohlin pattern with more of inter-industry, not intra-industry, trade. Korea has significant unrealized trade potentials with Japan and China, suggesting that they are desirable partners for an FTA. North-South Korean trade will expand remarkably if bilateral relation normalizes and North Korea participates in APEC.

Keywords: Gravity model, trade conformity index, missing trade, APEC, Korea
JEL Classification: F14, F12, F15

1. Introduction

Most trade theories concerns a qualitative question of identifying the trade pattern, namely which countries trade what goods? However, a quantitative question such that how much of those goods are traded remains as another important concern. In fact, understanding the determining factors of bilateral trade volumes of a country is a practical empirical task, as it opens up an additional horizon for the country's trade policies. Successful empirics of identifying the bilateral trade flows, for instance, can suggest a desirable free-trading partner and can conjecture the volume of a missing trade or unrealized bilateral trade flows.

Gravity model becomes in great fashion as it deals with the bilateral trade flows. The gravity model is so-named in that it copies the equation of gravity theory in Newtonian physics: Bilateral trade volume (physical gravitational force) increases with the product of economic sizes (physical masses) and decreases with geographical distance (physical distance). As such, the gravity equation had no theoretical foundation. The application of the physical gravity model to international trade is simply regarding each country as an organic economic mass. However, the gravity equation fitted data remarkably well. It was the empirical success that made economists search for the theoretical foundations of the gravity model. The gravity equation, thereafter from 1980s, was derived theoretically as a reduced form from various international trade models. Now we are at the position such that the gravity equation appears to be consistent with a large class of trade models.

Indeed the gravity model has remained one of the greater success stories in empirical economics. A number of gravity analyses are used to evaluate various trade policy issues such as the effect of protection (Wall 1999) and openness (Harrigan 1996), the analysis of regionalization trends (Saxonhouse 1993), the merits of proposed regional trade agreements (Frankel 1997) and effect on non-member countries (Wakasugi and Itoh 2003), and the effects of national borders (McCallum 1995, Evans 2000, Anderson and van Wincoop 2003). In recent years the gravity model has extended to explaining the patterns of non-trade policy issues such as migration flows (Helliwell 1997), bilateral equity flows (Portes and Rey 1998), and foreign direct investment flows (Brenton et al. 1999). The gravity equation remains at the center of applied researches on international trade of the day.

We now have plenty of empirical analyses and plenty of theoretical foundations for the gravity model. However it is surprising how little work has been done on examining whether the gravity equation fits to the trade flows of a specific country. Most previous researches dealt with the trade volumes of country-pairs in N×N countries setting, thereby leaving out the single country case of N×1 setting uninvestigated.[1] However, analyzing the bilateral trade volumes in a single country case is a very practical task, as this application of the gravity model can provides an analytical framework for the various trade policy options and tools of the country. The N×N gravity models can more or less deal with symmetric trade policies that will equally applicable to N countries such as free trade areas, whereas N×1 model can engender a country-specific trade policy measures.

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[1] Not exact but somewhat related work is found in Wall (1999). The paper uses a single country case of gravity model to estimate the cost of protection for the United States.

This paper tests to what extent the gravity model is applicable to explain Korea's bilateral trade flows and to extract implications for Korea's trade policy. In doing so, in addition to the standard gravity variables, a trade conformity index and APEC membership are included to identify the peculiarity of Korea's trade patterns. Those added factors would look at the influence of the trade structures and regional economic blocs on Korea's bilateral trade flows. Thus the paper is also to test statistically how the trade structure relates to the trade pattern and trade volumes of Korea and to estimate how positively APEC as a regional trading arrangement affects the Korea's trade flows. The empirical analyses are to be conducted for the Korea's bilateral trade volume data with its 30 major trading countries in an N×1 setting. In trade policy front, selecting a desirable partner country for a free trade agreement (FTA) and conjecturing North-South Korean trade volume are of special interest.

The remainder of this paper is organized as follows: Section 2 concentrates on providing the theoretical foundations of the gravity model. Section 3 introduces the methodology and the data used in the empirical analysis and Section 4 presents the empirical results. Section 5 finds two main trade policy implications from the gravity analyses and finally Section 6 concludes the paper.

II. Theoretical Development

The gravity model states that the bilateral trade flows are positively related to the product of the two countries' economic sizes and negatively related to the distance between them. The simplest version of the gravity model takes the following form.[2]

$$T_{ij} = A \cdot (Y_i Y_j / D_{ij}) \qquad (1)$$

T_{ij} = bilateral trade flows (=exports+imports) between country i and j
Y_i = GDP of country i
Y_j = GDP of country j
D_{ij}= distance between country i and j
A = constant of proportionality.

[2] Deardorff (1998) uses this equation as a standard gravity model.

In addition to the primary basic variables described above, other variables, such as per capita GDP (or population) and land area, can be included in the gravity model as proxies for economic size. Dummy variables such as common language, adjacency, and colonial relationship, etc. can also be included to represent historical and cultural factors.

Since its first application to the international trade area by Tinbergen (1962) and Pöynöhen (1963), most gravity regressions fitted data so well that they typically yielded high R-squared in the range of 0.65-0.95. Although the gravity equation had no theoretical foundation, what was important about these high R-squared is that they have led many researchers to use variants of the gravity equation as an empirical benchmark for the bilateral trade volume.

With the idiosyncratic success in its empirical applications, the gravity model started to attract a reawakening interest in the 1980s. Works by Anderson (1979), Helpman and Krugman (1985) and Bergstrand (1985, 1989) showed that the gravity equation could be derived in trade models with differentiated goods. The product differentiation could arise by country of origin, by economies of scale, or from technological or factor endowment differences. While the reason for the product differentiation may be different, however, they all generate a force of gravity. Thus, gravity equations are derived from all types of product differentiation model: Factor proportion or Heckscher-Ohlin model with an Armington assumption (Anderson 1979; Bergstrand 1985, 1989) and monopolistic competition model with increasing returns and transport costs (Helpman and Krugman 1985).

Feenstra et al. (1998) further derived a gravity equation from a reciprocal-dumping model of trade with homogeneous goods. It showed another kind of product differentiation model coming from factor endowment differences. Deardorff (1998) completed the theoretical foundation of the gravity model by showing that the gravity equation is consistent with Heckscher-Ohlin trade model in homogenous goods with perfect competition. Evenett and Keller (2002) also emphasized that gravity prediction constitutes the most important result regarding the volume of international trade.

Due to the aforementioned development of theoretical foundation, it is generally accepted that a number of trade models are responsible for the empirical success of the gravity equation. While the Heckscher-Ohlin theory would account for the success of the gravity equation in explaining bilateral trade flows among countries with large factor proportion differences and high shares of inter-industry, the differentiated product model would serve well in explaining the bilateral trade flows among countries with high shares of intra-industry trade in increasing returns with monopolistic competition (Frankel 1997, p53: Deardorff 1998; Evenett and Keller 2002).

Hummel and Levinsohn (1995) conducted a kind of model identifying empirical test with a set of non-OECD countries where monopolistic competition was not so plausible. To their surprise, they proved that the gravity equation is also efficient in explaining the trade flows among developing countries where inter-industry trade is dominant with scarce monopolistic competition. Their findings questioned the uniqueness of the product differentiation model in explaining the success of the gravity equation and proved that a variety of other models, including the Heckscher-Ohlin model, can serve as alternatives. Feenstra et al. (2001) showed that while gravity equations could be derived for both differentiated and homogeneous goods, the different theories underlying the equation lead to measurably different estimation in key parameter values. Evenett and Keller (2002) tackled the model identification problems by trying empirically to separate between Heckscher-Ohlin theory and the increasing returns trade theory as driving forces behind the success of the gravity equation. They argued that little production is perfectly specialized due to factor endowment differences and that as long as the production is not perfectly specialized across countries, both of the Heckscher-Ohlin model and differentiated products model are likely to account for the empirical success of the gravity equation. As a result, estimation parameters of the gravity analyses are critically dependent upon the model identification.

Now we are at the position, quite opposite than before - when we could not provide a theoretical foundation of the gravity model. The gravity equation appears to characterize a large class of models, thus its use for empirical tests of any of them becomes suspect. As all the Heckscher-Ohlin theory, various product differentiation models, and the increasing returns trade theory can generate the gravity equation, attempts are needed at least to identify which trade model fits better for the bilateral trade flows. Now core attention of gravity analyses moves, away from developing its theoretical foundation, to the empirical applications of the gravity model. In particular, the model identification for the empirical applications remains as a greater concern of the gravity analysis of the day.

3. Methodology and the Data

3.1. The Model

After the theoretical foundation of gravity model had been established, from the 1990s further studies concentrated on the empirical application of the gravity model. Frankel (1997) formulated a more advanced yet standardized form of gravity equation where particularly emphasis were given on the role of geographical factors, such as distance, border-sharing and population, as determinants of bilateral trade flows. Dummy variables such as common language, adjacency, and historical ties can also be included to represent geopolitical factors. Regional trading blocs, such as APEC, NAFTA and Mercosur, are also included in the gravity equation to estimate the impact of regional trade integrations on bilateral trade flows.

The basic, standardized empirical gravity equation takes the following form:

$$Ln\, T_{ij} = \alpha + \beta_1 Ln\, [\, Y_i \cdot Y_j\,] + \beta_2\, Ln\, [(Y/P)_i \cdot (Y/P)_j] + \beta_3\, LnD_{ij} + \gamma_k \boldsymbol{Z_{kij}} + \varepsilon_{ij} \qquad (2)$$

T_{ij} = bilateral trade volume (=exports+imports) between country i and j. i and j=1,2,..,N
$Y_i \cdot Y_j$ = product of country i's and country j's GDPs
$(Y/P)_i \cdot (Y/P)_j$ = product of country i's and country j's per capita GDPs,
where P means population
D_{ij} = distance between country i and country j
$\boldsymbol{Z_{kij}}$ = a vector of dummy variables $\boldsymbol{Z_k}$ representing adjacency, common language, colonial relationship, etc. between country i and j. The values of the dummy variables are usually binary: $\boldsymbol{Z_k}$ = 1 for a criteria, otherwise it is 0.

Most previous gravity analyses use this empirical equation to identify the bilateral trade volumes of country-pairs in N×N countries setting. Using the same equation, this paper is to test how significantly the gravity model is applicable to explain Korea's bilateral trade flows and tries to extract implications for Korea's trade policy. The application of the equation to the case of Korea is done simply by fixing country i = Korea, but leaving j=1,2,…,N in a N×1 setting. In the gravity equation, all variables are in natural logarithms of real value terms except dummy variables. Any variables with relatively small numbers are usually exempted from taking the logarithm.

In particular, other dummy variables $\boldsymbol{Z_k}$ representing national border adjacency, common language, colonial relationship or historical ties are not relevant in case of Korea, as those are appropriate for only 1 or 2 trading partners, such as Japan or/and China. Our model thus starts with only three explanatory variables, namely the product of GDPs, the product of per capita GDPs and distance.

Among the explanatory variables, the product of GDP serves as a proxy for the two countries' economic size, both in terms of production capacity and size of market. Larger countries, with a great production capacity, are more likely to achieve economies of scale and increase their exports based on comparative advantage. They also possess large domestic markets able to absorb more imports. Therefore, an increase in the product of the two countries' GDPs is expected to increase bilateral trade volumes. Thus we expect our estimated coefficient of $\beta_1>0$.

Recently many gravity analyses utilize Y_i and Y_j as in separate terms, with T_{ij} representing either export or import of the country i. This model allows the coefficients of the two terms possibly different each other. It implies that there is possibility of significant 'home-market' effect, meaning the advantages of a large home market as a foundation for exports of a good. However, traditional neoclassical model of comparative advantage suggest that, all else equal, a country with extraordinarily strong demand for a good will be an importer of that good, implying a 'reverse' home market effect. The result will depend on the model identification of the empirical analysis: increasing returns leads to a home–market effect in differentiated goods, whereas in homogeneous goods a gravity equation will applies, but without home market effect due to barriers to entry or national product differentiation. As Davis and Weinstein (2003) showed the evidence of the broad home-market effects, it is legitimate to test the effects. However, in our N×1 setting the GDP of Korea remains constant so that the term of GDPs product totally depends on the GDPs of partner countries j: it implies either no affect or neutral affect of the home-market effects.

Per capita GDP is an explanatory variable that serves as a proxy for the income level and/or purchasing power of the exporting and importing countries. As Korea's per capita GDP is fixed, this variable will serve to predict whether Korea's trade flows are dependent on its trading partners' income level.[3] Recently a number of gravity models

[3] Explanatory variables in the form of GDP and per capita GDP or GDP and population are the same.

omit this variable without a specific reason, but it will be better to be kept in an empirical estimation.

Bergstrand (1989), combining economic geography and factor proportions theory, derived the gravity equation at the industry level which predicts that the exports of a good in bilateral trade depend on income and per capita income as well, assuming a constant elasticity of transformation of supplies among different markets. As such, it is recommended to include the per capita GDP variable to avoid the specification problem in the empirical application of the gravity model. Regarding the coefficient to the variable, β_2, we do not have any priori information on its sign and magnitude.

The distance variable is a trade resistance factor that represents trade barriers such as transport costs, time, cultural unfamiliarity and market access barriers, etc. The distance used in this study is the great circle distance between the capital cities of Korea and its trading partner. Most of previous literature interpreted the coefficient of distance variable β_3 as the elasticity of trade with respect to an absolute level of geographical distance.

In recent review of theoretical foundation of the gravity equation, however, the point that relative as well as absolute distance matters for bilateral trade flows seems much more general and pervasive. In the gravity model, trade volume will be larger between country pairs that are far from the rest of the world than between country pairs that are close to the rest of the world (Anderson and van Wincoop 2003; Harrigan 2003) As a consequence, gravity equations which pool across bilateral pairs without controlling for relative distance are mis-specified in a potentially important way. For the purpose, a centrality index (Anderson and van Wincoop 2003) or remoteness index (Wei 1966) are used. This discussion makes the point that controlling for relative distance is crucial to estimating a well-specified gravity model, and that there are a number of reasonable ways to measure relative distance. On the interpretation of the distance coefficient, Buch et al. (2003) argue that changes in distance coefficients do not carry much information on changes in distance costs over time. Changes in distance costs are to a large extent picked up solely in the constant term of gravity models. The distance coefficient, instead, measures the relative distances of countries: A decrease of the distance coefficient indicates that trade with far away countries increases relative to the trade with closer countries, whereas an increase represents trade with closer countries increases faster than that with far away countries. The notion of relative distance remains significant at the N×N countries setting, whereas its importance drops sharply in our N×1 model because all distances are measured absolutely from Korea. We anticipate the coefficient $\beta_3 < 0$, but its magnitude matters.

We are now at a position where we could add another explanatory variables in addition to the three bottom-line variables. Based on the standard gravity equation (2), we first include a trade structure variable, called trade conformity index (TCI), to identify the Korea' trade pattern: whether our trade pattern is based on the Heckscher-Ohlin model or on the differentiated products/increasing returns model. The resulting equation (3) takes the following form:

$$Ln\,T_{ij} = \alpha + \beta_1 Ln\,[Y_i \cdot Y_j] + \beta_2\ Ln\,[(Y/P)_i \cdot (Y/P)_j] + \beta_3 Ln\,D_{ij} + \beta_4 TCI_{ij} + \varepsilon_{ij} \qquad (3)$$

In the previous section we recognize the importance of model identification, as the different theories underlying the equation lead to measurably different estimation in key parameter values. We thus know that attempts are needed here at least to identify which trade model fits better for the Korea's bilateral trade flows. The TCI variable is designed so as the TCI coefficient β_4 to identify the underlying trade model of our empirical estimation.

The TCI measures the degree of trade complementarities between two countries. TCI between country i and country j is calculated in the following formula:[4]

$$TCI_{ij} = \Sigma\,[\,X_{ki} \times M_{kj}\,] \,/\, \sqrt{[\,\Sigma X_{ki}^{\,2} \times \Sigma M_{kj}^{\,2}\,]}$$

i and j mean a country and its trade partner: i and j = 1, 2,…, N
k means a commodity group: k = 1, 2,…, n
X_{ki} = share of commodity group k in the exports of country i
M_{kj} = share of commodity group k in the imports of country j

The TCI value ranges from 0 (*perfectly competitive* trade structure between the country i and j) to 1 (*perfectly complementary* trade structure): when two countries have same export shares TCI becomes 0, whereas when a country's export shares are identical to

[4] Mathematically, the TCI index measures the cosine value of the sharp angle made between the two vectors, X_{ki} and M_{kj} in the n-dimensional space, where k = 1,2,3,…n. For the actual calculation of the TCI, approximately 260 3-digit SITC commodity

the partner's import shares (i.e., $X_{ki}=M_{kj}$), the TCI is 1. In fact the TCI proxies factor endowment differences between two countries. As it is a value measured between "0"and "1", its distribution among countries can be relatively small to take on a natural logarithm. Therefore, we just include the normal value.

The TCI coefficient β_4 becomes positive when trade volume increases with the rising trade complementarities: it precisely represents the Heckscher-Ohlin trade model of inter-industry trade. On the contrary, β_4 becomes negative when the trade volume increases with the falling trade complementarities: putting it differently, it refers to the case where trade volume increases with increasing competitive trade structures: it represents the differentiated product model with intra-industry trade.

However, here we have to be slightly cautious in interpreting the coefficient β_4 just by either Heckscher-Ohlin trade model or differentiated product model. As the dependent variable T_{ij} (bilateral trade volume) is the sum of inter-industry and intra-industry trades, any trade model could increase the bilateral trade flows. Thus our model identification depends upon the dominant forces between them. For instance, our identification of the Heckscher-Ohlin trade model refers to the situation where there should be both types of trade but inter-industry trade remains as the dominant source of the expanding bilateral trade volume. As a result the estimate of β_4 allows us to distinguish three mutually exclusive hypotheses:[5]

$\beta_4 > 0$ Heckscher-Ohlin trade model with dominant inter-industry trade
$\beta_4 < 0$ Product Differentiation Model with dominant intra-industry trade
$\beta_4 = 0$ Indeterminacy of the Model

The real achievement by introducing the trade structure variable is to combine trade pattern with trade flows. In other words, our model concerns both with a qualitative question of identifying the trade pattern, namely which countries trade what goods, and a quantitative question such that how much of those goods are traded.

As the final step of our empirical model, we include the APEC dummy variable as an explanatory variable in order to determine how much a regional trade arrangement is

groups are used to aggregate into a single number for each trading partners.
[5] Davis and Weinstein (2003 p.8) employ a similar kind of hypotheses for the different intervals of an estimate parameter.

influential in determining Korea's bilateral trade flows. Introduction of a regional trading arrangement into the gravity model remains in great fashion following the exhaustive experiments of Frankel (1997). We follow the tradition and the resulting equation takes the following form:

$$Ln\,T_{ij} = \alpha + \beta_1 Ln\,[\,Y_i \cdot Y_j\,] + \beta_2 Ln\,[(Y/P)_i \cdot (Y/P)_j] + \beta_3\,Ln\,D_{ij} + \beta_4\,TCI_{ij} + \beta_5 APEC_{ij} + \varepsilon_{ij} \qquad (4)$$

In the equation (4), APEC is a dummy variable which takes on a value of "1" if Korea's trading partner belongs to the APEC and a value of "0" otherwise. The 15 countries in the data sample were regarded as being APEC members, taking 1995 as a base year.[6] Once the APEC variable turns out to be highly significant, its effect on trade flows will depend on the sign of its coefficient. A positive sign will imply that Korea's bilateral trade flows will expand through the membership of APEC, while a negative sign means that Korea's bilateral trade flows will decrease as a result of the APEC membership. We expect $\beta_5 > 0$ as did most of model of this kind.

3.2. The Data

This study is to conduct a cross-country analysis based on data of bilateral trade flows between Korea and its major 30 trading partners, the two countries' GDPs and per capita GDPs, and distance between the two countries.[7] The data on the bilateral trade flows – in total and in 23 sectors' imports and exports - was obtained from the 1995 GTAP statistics,[8] and values are expressed in real terms of billions of U.S. dollars. The data sample consists of most of Korea's major trading partners, including China, Japan, ASEAN, North American countries and some of the South American and European countries. Although the data set was limited by the amount of information available, we tried to select, from all over the world, countries that would well represent the bilateral trade flows with Korea.

We used the GTAP statistics for bilateral exports and imports for two main reasons: Many statistics published by international organizations are often inconsistent as they

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[6] These countries are Australia, Canada, Chile, China, Hong Kong, Indonesia, Japan, Malaysia, Mexico, New Zealand, the Philippines, Singapore, Taiwan, Thailand, and the United States.
[7] See Appendix Table A1 for the data and the list of 30 countries' names.
[8] For the details of GTAP statistics, see http://www. agecon.purdue.edu/gtap/index.htm

depend on statistics derived from two independent sources: reported imports and reported exports. The GTAP statistics, in contrast, provide more consistent and reliable statistics by applying a general procedure to reconcile inconsistent trade flows of all countries and commodities using each country's reliability index, reporting time and transport costs. In addition, the GTAP statistics also provides consistent data for various disaggregated sectors, encompassing agricultures, services and manufacturing industries, thus GTAP data enables us to carry out gravity analysis at the 23 disaggregated industry level. For the base year, we choose the year 1995 because the data after 1997 will be seriously distorted by the Korea's foreign exchange crisis that already started from the mid of 1997.[9]

The data on GDP and population come from Korea's National Account published by the Bank of Korea and also from the IMF's International Financial Statistics. The distance variable is the great-circle distance between Seoul and the capital city of each of its trading partners as in Darell Kindred (1997).

The trade conformity indexes (TCI) are taken from Gormely and Morrill (1998). They report about 80 TCIs calculated from Korea's export structure X_{ki} with trading partners' import structures M_{kj} (see Appendix Table A2). Each of the 80 TCIs is calculated from the aggregation of approximately 260 3-digit SITC commodity groups from United Nations COMRADE database.[10] As explained earlier, the TCI reflects whether two countries are complementary or competitive in their trade structures. In Korea's case, its TCIs with the U.S., China and Japan are 0.642, 0.536 and 0.444, respectively, meaning that Korea maintains a relatively complementary trade relationship with the U.S., a relatively competitive trade relationship with Japan, and China in-between.[11]

[9] It is why the study uses the data from GTAP version 4 (1995 data) rather than updated Version 5 (1997 data).
[10] See Appendix Table A1 and A2 for the TCI values.
[11] The calculation of revealed comparative advantage indexes between Korea and Japan, China and the U.S generate a similar result. Analyzing bilateral RCA structures based on Spearman's rank correlation, we can observe that the trade structure of Korea and Japan are highly competitive with a correlation of 0.5084, while the trade structure of Korea-U.S. is relatively complementary with a correlation coefficient of –0.0576. Korea-China lies in the middle with 0.2852 (Sohn and Yoon 2001, p.48)

4. Empirical Results

4.1. OLS Results of the Gravity Equation

The cross-country OLS regression results for the gravity equations (2) ~ (4) are reported in Table 1. The overall performance of the model seems to be surprisingly good with a R-squared value of around 0.786 for the basic equation and 0.917 for the full equation and with most explanatory variables are highly significant, meaning that the gravity model is effective in explaining Korea's bilateral trade flows and that the gravity model is well applicable to a single country case.

//Table 1 here//

First, let us look at the coefficient on the trade structure variable to empirically identify the underlying trade model of Korea's trade flows. The coefficient β_4 shows a positive value with a high statistical significance in both equation (3) and (4). This means that the Korea's trade pattern follows a Heckscher-Ohlin trade model. Of the two main trade models supporting the gravity equation, the Heckscher-Ohlin model assumes that two countries in a complementary economic relationship are more likely to expand their bilateral trade volume through inter-industry trade, differing from the differentiated products models that two countries in a competitive economic relationship will trade more through intra-industry trade.[12] The Heckscher-Ohlin model also suggests that Korea's trade flows depend more on the factors such as comparative advantage, dissimilarity in income levels, and different development stages than economies of scale or product varieties. In addition to inter-industry trade, the Heckscher-Ohlin theory remains also crucial in determining so-called vertical intra-industry trade, but to a lesser

[12] It is well known that the inter-industry component of trade is explained by the Heckscher-Ohlin trade theory, and the intra-industry trade components are explained by the increasing returns trade theory. Since gravity models try to explain total trade, composed of these components, both of the competing trade theories are behind the success of the gravity model. Evenett and Keller (2002) used factor endowment differences and the share of intra-industry trade for the model identification. Large factor endowment differences make a Heckscher-Ohlin model generate specialization of production and the gravity equation and it predicts inter-, not intra-industry trade. This is why Evenett and Keller used intra-industry trade indices to stratify their sample, despite Davis (1995) demonstrated that the proportion of intra-industry trade has nothing to do with the causes of gross trade volume.

degree, in the gravity model (Kandogan 2003). In sum, the estimate of $\beta_4 > 0$ represents that Korea's trade flows follow a Heckscher-Ohlin trade model with dominant inter-industry trade and some vertical intra-industry trade. This empirical result is in fact consistent with the actual trade patterns of Korea in 1995. Table 2 shows that little Korea's trades depend on the horizontal intra-industry trade.

//Table 2 here//

The log of the product of two countries' GDPs is highly significant in determining the Korea's trade volume. The estimated coefficient β_1 on the GDP variable is stable and about 0.72. This result is consistent with the basic hypothesis of the gravity model that the trade volumes will increase with an increase in economic sizes. However, the estimated coefficient means that, holding constant for other variables, a 1 percent point increase in GDP will result in roughly a 0.72 percent point increase in Korea's bilateral trade flows. Theoretically it is nothing surprising to find the coefficient of the product of GDPs is often close to 1. It is particularly so if the underlying model for the gravity estimation is a Heckscher-Ohlin type (Deardorff 1998; Grossman 1998 p.30). From various gravity equations, Frankel (1998) showed the coefficient lying in the range of 0.75-0.95. Our estimate more or less fit the range, but in a lower level.

The reason why the increase in bilateral trade volume is less proportionate to the increase in GDP may come from three possible sources: One is the existence of relatively larger home-market effect. As Trefler (1995 p.1032) points out, the factor content of trade remains much smaller than its Heckscher-Ohlin prediction. McCallum (1995) demonstrates that a home-bias effect, such as localized taste or local distribution networks, play a greater role in trade. As such, there is possibility of a 'home-market' effect, meaning a smaller trade than the theoretical prediction.[13] The other is a lower level of intra-industry trade. There is some evidence that the volume of trade is higher in sectors characterized by a monopolistic competition and/or scale economies (Harrigan 2003). Thus a country enjoying a lesser scale economies will trade a smaller volume,

[13] It is particularly true for a small country. Theoretically the home-market effect can be interpreted as an elasticity of exports with respect to domestic income that exceeds the importing country's income elasticity (Schumacher 2003 p.4). This implies possibly an asymmetric income elasticity of export and import for a country, thus engendering the gravity analysis utilizing Y_i and Y_j as in separate terms more appropriate.

meaning a lower level of (horizontal) intra-industry trade. The third is the extent of trade barriers: The higher and wider are the trade barriers, the smaller will be the trade volume.

According to the three possible sources, the lower level of intra-industry trade may be the most relevant reason for a less-than-proportional trade volume of Korea's bilateral flows. Korea's trade pattern, identified as a Heckscher-Ohlin model, depends more on inter- industry than intra-industry trade. Neither there will be any particular reason for Korea's trade has a bigger home-market effect, nor Korea faces a higher level of trade barriers in a multilateral trading regime with the most-favored-nation principle.

In contrast, the estimation shows that the per capita GDP variable is not a significant factor in determining Korea's bilateral trade flows. The estimated coefficient β_2 on per capita GDP variable continued to be insignificant in all equation as seen in Table 1.[14] We, nonetheless, keep the variable to avoid any specification problem in the empirical estimation of gravity models as theoretically developed in Bergstrand (1989).

The empirical result is different from the regression analyses of Frankel (1997) that predicted that a 1% increase in per capita GDP leads to about 0.1% increase in bilateral trade flows. This implies that Korea's trade patterns follow a GDP pattern rather than a per capita pattern, relying more on its trading partner's overall economic size than its income level. Combining with our identification of Heckscher-Ohlin trade pattern and less-than-proportional volume of Korea's trade, we conjecture that Korea's trade depends more on exporting of quantity-based standardized products that are sensitive to the overall market size, rather than exporting quality-based high value-added products that are sensitive to the trading partner's income level.

In all estimations, as shown in Table 1, the distance variable is statistically significant with the expected negative sign, showing that geographical distance is an important

[14] There have been many debates whether or not the PPP-based data for GDP or per capita GDP are better to use in the gravity analysis. Particularly, many argue that per capita GDP be more appropriate in PPP-based as it reflects the income level of a nation–purchasing power of consumer. While the PPP-based per capita GDP may have its own advantage, it is also subject to large measurement error as demonstrated in Srinivasan (1995 p.58 and pp.61-62). However we tried the use of the PPP-based per capita GDP: it did not change our regression results; the coefficients are again insignificant and it did not affect other coefficients either.

resistance factor for Korea's bilateral trade flows. The coefficients β_3 of the log of the distances turned out to be very similar to those estimated by other previous studies (Frankel 1997; Wall 1999; Buch et al. 2003, Table 1). Grossman (1998) points out that most empirical gravity studies show a surprisingly large size of the estimated coefficient on the distance variable. Our result, -0.924 in the basic model, is no exception. However, we cannot simply compare this value with that of GDP coefficient, 0.728. To evaluate the relative contribution of each variable in determining Korea's bilateral trade flows, we need to employ a unit-free estimates by the so-called standardized regression coefficient (ß-coefficient).[15] The ß-coefficients in the basic model show that about 60% of Korea's bilateral trade volume is explained by GDP variable (coefficient=0.657) and the remaining 40% by distance (coefficient=-0.448). As we add the TCI variable, the ß-coefficients for the GDP, distance and TCI variables were estimated at 0.657, -0.385 and 0.271, respectively. It shows that GDP is the most influential factor, explaining almost 50% of the variability of Korea's bilateral trade flows, 29% by distance, then 21% by the trade structure variable; the relative influence of per capita GDP seems to be almost 0 as it proved to be an insignificant factor.

The size of coefficient on distance shrinks sharply, from –0.924 to –0.794 then –0.492, as TCI and APEC variables are added. However the coefficients do not imply that the influence of distance on trade volume decreases by the magnitudes. The coefficient does not reflect a simple elasticity of absolute distance on trade volume, but the effect of both absolute and relative distance. Deardorff (1998), Harrigan (2003), Anderson and van Wincoop (2003) and Buch et al. (2003) demonstrated that relative, as well as absolute, distance and trade costs matter for understanding bilateral trade volume in the gravity model. On the interpretation of the distance coefficient, Buch et al. argue that changes in distance coefficients do not carry much information on changes in distance costs over time. Changes in distance costs are to a large extent picked up solely in the constant term of gravity models. The distance coefficient, instead, measures the relative difference. A decrease of the distance coefficient indicates that trade with far-away countries increases relative to the trade with closer countries, whereas an increase represents trade with closer countries increases faster than that with far away countries.

Finally let us look at the coefficient β_5. The APEC variable is highly significant, with

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[15] The standardized coefficient (β-coefficient) is a coefficient that is estimated from the equation where all variables are converted into z-scores. The method is used to compare the relative weight of explanatory variables when they are measured in different units.

positive coefficient of 1.1, which means that if Korea's trading partner belongs to APEC, Korea's bilateral trade flows with that country will be 3 times as much as those with a non-APEC country.[16] This estimate is very similar to the regression results obtained by Frankel (1997. p.103) where the APEC coefficient was estimated to be 1.2 (3.3 times).

Although the APEC variable shows significant empirical evidence in explaining the Korea's trade flows, its inclusion into the gravity equation calls for a caution in its interpretations. First, APEC is not an FTA, thus the coefficient β_5 does not reflect the effect of a preferential trading bloc on bilateral trade flows; it rather reflects the increasing market integration of APEC. The significant and positive coefficient means that there exists a larger intra-APEC trade flows which primarily comes from private businesses activities in the extended intra-regional production and/or distribution networks, independent from any government efforts of institutionalizing the integration: putting it differently, market mechanism enhances trade integration in APEC thereby APEC evolves as a uninstitutionalized, yet effective trade bloc. This type of trade bloc is known as a natural trading bloc (Krugman 1991). Many researches, including Polak (1996) and Scollay and Gilbert (2001), also find significant market integration effect in APEC like this empirical result. Thus it is necessary to include the APEC variable so as to avoid a specification error in the gravity estimation.

Second, the inclusion of APEC generates large changes in the estimated coefficients of other variables as in Table 1. While this could reveal possibly a multicollinearity of APEC variable with other explanatory variables, there is no *a priori* reason to have it. It rather reflects a possible systematic interdependence with the distance variable. Frankel (1998 p. 104) indicates a link between the two: for instance, if transport costs in the APEC region is overstated by distance measure, the estimated APEC coefficient would be biased upwards. Figure 1 shows our relationship between APEC and the distance variables. The gravity estimations of 23 disaggregated sectors (its explanation in next section) depict the beta coefficients of distance variable are systematically affected when we add the APEC variable; in contrast the impact on the beta coefficients of trade structure variable remain minimal as we expect.

// Figure 1 here//

[16] As the trade variable takes the form of a natural logarithm, we should interpret this as [exp(1.10)=3.004], meaning an increase in trade flows of more than 3 times.

The significant positive effect of the APEC variable means that, if a concrete regional trading arrangement such as an FTA emerges in the region, the trade expansion effect is expected to be still greater. The fall in the distance coefficient indicates that, with APEC variable, trade with far-away countries increases relative to the trade with closer countries. This is because Korea, through trade liberalization processes within APEC, is expected to diversify its trade direction, shifting from large economies, such as Japan and the U.S., toward small and middle-sized economies in Southeast Asia and in Latin America.[17] After all, APEC converts the geographical distance into a notion of economic distance.

4.2. Gravity Estimation of 23 Disaggregated Sectors

Most of evidence that gravity model works well comes from aggregate data, where total bilateral trade is regressed on GDP and distance. However it is surprising to see how little work has been done on examining gravity equations in a disaggregated or in an industry level. While there have been several related empirical efforts, most of them aim different targets, such as estimating the size of home-market effect or identifying the underlying gravity model (Hummel and Levinsohn 1995; Feenstra et al. 2001; Evenett and Keller 2002; Davis and Weinstein 2003; Schumacher 2003).[18] Although they have left the application of gravity model into disaggregated levels unexplored, they provided strong rationale for doing that. Most papers find a large estimated difference in the GDP coefficients in the gravity equation across three groups of goods. They also show the trade volumes relative to output are quite diverse across sectors. This observation suggests that we need a sector-specific explanation for trade volumes. Whatever the sector-specific explanation, the large cross-sector variations in trade-output ratio suggest that empirical work on understanding the trade volume should work with disaggregated data.

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[17] Actually, the ratio of trade with the U.S. and Japan, which accounted for almost 1/2 of Korea’s total trade, has been gradually decreasing since the 1990s, while the ratio of trade with ASEAN countries, in Korea’s total trade, increased from 6% in 1985 to 10% in 1995, showing that Korea’s trade with far-away countries increases relative to the trade with closer countries.

[18] Hummel and Levinsohn (1995), Feenstra et al. (2001) and Evenett and Keller (2002) analyze gravity equation by three disaggregated products groups, namely differentiated goods, homogeneous goods and reference priced goods, whereas Davis and Weinstein (2003) and Schumacher (2003) utilize more disaggregated manufacturing sectors.

Responding to the suggestion, this part focuses on how well the gravity equation fits at the disaggregated level. In doing so we break down our total bilateral trade into 23 sectors and conduct gravity estimation for each of 23 disaggregate bilateral trade flows using the full equation. All variables in the equation (4) remain same but the dependent variable. Now the total trade volume T_{ij} is replaced by a sectoral trade volume T_{sij} where s represents a disaggregated sector, s=1,2,….,23. Table 3 summarizes our regression results at the disaggregated level.

// Table 3 here//

Most of the 23 sectors, except for a few primary sectors, show high levels of goodness-of-fit, meaning that the gravity equation is also very effective in explaining the sectoral bilateral trade flows. The heavy and chemical sectors have relatively higher R-squared values than the primary sectors and most light industrial sectors. The GDP variable is statistically highly significant and has a positive coefficient in all sectors. The per capita GDP variable, which was insignificant in the regression analysis of aggregate trade, turned out to be still insignificant in most sectors except textiles and a few resources products. The distance variable is generally significant in most sectors other than the primary sectors. The fact that the distance effect is lower in the primary sectors is consistent with theoretical expectations. While manufactured products represent a great variety of choices and preferences and therefore, are highly affected by distance and cultural unfamiliarity, primary products, by their relatively homogeneous nature across cultures, appear less affected by distance and cultural factors.[19] Among the manufacturing sectors, the distance effect is greater on heavy and chemical products than on light products. This observation may reflect differing transport costs and market access barriers.[20]

The TCI variable is significant and has a positive coefficient in the heavy and chemical

[19] Frankel (1997) argues that the physical transport costs are not necessarily the most important component of costs associated with distance. Rather, the cost associated with transport time and cultural unfamiliarity may be greater, and, according to him, these costs are more important for manufactured goods than for agriculture.

[20] Although Korea's exports of textile and apparel products to EU and the U.S markets face import restriction under MFA (Multi-fiber Agreement), the level of import quota allowed to Korean products are high enough to absorb Korea's production capacity. In contrast, heavy and chemical products such as electric and electronic products and iron and steel products often suffer from high market access barriers in the form of antidumping or safeguard measures by developed countries.

sectors, but insignificant in the primary and light industrial sectors. However, in a sectoral level, the coefficient of TCI is no longer a measure for model identification, but a simple measure of sectoral trade flows with respect to overall bilateral trade structure. Nonetheless it looks interesting that automobile, textiles, apparels, leather products, beverage and tobacco sectors where there will be relatively more intra-industry trades have a negative coefficient. In all sectors, with only exception of livestock, the APEC variable shows a significant positive coefficient, implying that the APEC variable is an important factor explaining the disaggregated bilateral trade flows. As we have seen before this result comes from the interaction with distance variable: in other words, APEC that brings its member economies closer replaces the physical distances.

Our application of gravity equation at disaggregated level shows a promising empirical result. There seem two main reasons for the lack of disaggregated gravity analyses: first, analytical equations for estimation is not well developed theoretically yet; second, when disaggregate there are many zero bilateral trade, because of complete specializations, which in turn may need a special model and analysis. Now we are at the position, quite similar as before - lack of a theoretical foundation of the gravity model; but this time not in aggregate model but in disaggregated model.

5. Trade Policy Applications

5.1. For a Strategic FTA Choice

The gravity model is supposed to provide a long-run equilibrium view of trade patterns. Thus if there is any sort of market intervention that prevent from quickly reaching to a new market equilibrium, the gravity prediction engenders a gap between actual trade flows and its long-run equilibrium value, the trade potential. In fact, in our full equation, Eq. (4), we left out one important variable that intervene markets, namely a variable representing the level of trade barriers. As the variable may encompass various forms of trade barriers such as tariffs, quotas, subsidies and most of all domestic regulations, it is usually unobservable, thereby becoming a left-out variable. Our analysis is no exception. Many gravity analysis include a variable representing exchange rate volatility. In our case the variable has no meaning in the gravity analysis. This is because the invoicing currency of most Korea’s trades is the US dollar, thus any exchange volatility affects equally to all trading partners. Nor other variables, such as adjacency, common language, historical or cultural ties, have any significance as we reviewed at section 3.1. As a result, the trade barrier remains as a single most important left-out variable in our regression of gravity equation.

Now we compare the trade potential that is but the predicted trade volumes, estimated from of our full equation, with the actual trade volume. Then the difference between the actual and the predicted trade flows can be interpreted as an un-exhausted trade potential. Similarly the residual of the estimated equation can be interpreted as the difference between potential and actual bilateral trade relations. In any case if the left-out variable is the trade barrier only, the un-exhausted trade potential is the result of trade barriers. Baldwin (1994) and Nilsson (2000) considered the ratio of potential to actual trade as a measure of the degree of trade integration. Following their wisdom, but to focus more on the unrealized trade potential, we take the ratio of actual trade to predicted trade.[21]

//Table 4//

Table 4 shows the ratios. For example, China, Japan and Mexico show relatively lower ratios: 85%, 67% and 29%, respectively. This means that there are significant trade barriers that lead to a considerable level of un-exhausted trade potentials with the countries: 15%, 33% and 71% respectively.[22]

Accordingly, if Korea is to seek a desirable FTA partner, a lower ratio country may be better. When forming an FTA with the country, Korea can enjoy a large trade expansion from a recovery of the unexhausted trade potential, through institutionalized elimination of trade barriers by the FTA, in addition to the benefits of trade creation and trade diversion.

2. For North-South Korean Trade

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[21] Egger (2002) pointed out that convenient OLS estimates are very likely to result in inconsistent estimates and are also affected by a severe specification error problem. But if we assume that there is a left-out variable, trade barrier, that will explain major part of the remaining irregularity of error term, and if the variable is orthogonal to the other explanatory variables, the OLS estimates are consistent and free of a specification error. As our gravity estimation has a high goodness-of-fit, it has less likelihood of having a specification problem. Baldwin (1994) and Nilsson (2000) assume the orthogonality.

[22] Some examples are Korea’s import sources diversification program vis-à-vis Japan, Mexican import ban for Korean automobiles, Japan’s complicated distribution channels and business practices, and China’s safeguard measures against Korean exports, etc.

Another policy implication from our gravity analysis can be found by conjecturing the potential trade volume between South and North Korea. In fact, the volume remains as an important figure for it could serve as a benchmark for various policies; nonetheless few attempts have been made to estimate it. Due to the unavailability of data, we use GNP instead of GDP for North Korea's economic size. Assuming four different values of TCI with North Korea, Table 5 shows the actual and predicted trade volumes.[23]

//Table 5//

Comparing with TCIs of other countries, we regard that TCI=0.6 is the most appropriate number to describe the current bilateral trade structure. Assuming TCI=0.6 and that North Korea is not a member of APEC, the predicted trade volume will be about US$ 1.43 billion. Further, if we assume that North Korea will join in APEC, the trade flows between North and South Korea is expected to expand three times that before the APEC membership, reaching to US$ 4.3 billion.

6. Concluding Remarks

Korea, a small economy scarcely endowed with natural resources, has emerged as a major exporter and producer in the world economy. Its rapid economic growth has primarily been achieved through an expanding trade flows. Thus it is important to test to what extent the gravity model is applicable to explain Korea's bilateral trade flows.

The empirical results show that the gravity model is very effective in explaining Korea's bilateral trade flows and that the gravity model is well applicable to a single country case. The coefficient on the trade structure variable identifies that the Korea's trade pattern follows a Heckscher-Ohlin type. Thus Korea's trade flows depend more on the factors such as comparative advantage and different development stages than economies of scale or product varieties. The trade flows will mainly depend on inter-industry trade, and on vertical intra-industry trade, but to a lesser degree.

APEC variable shows a significant positive effect on Korea's trade volume, meaning that there exists a large intra-APEC trade flows which may come primarily from private market activities. According to our empirics, APEC evolves as a natural trading bloc.

[23] Refer to Appendix Table A3 for data on North Korea.

The gravity estimations of 23 disaggregated sectors depict that the distance variables are systematically related to the APEC variable in explaining the Korea's bilateral trade. Responding to the suggestion that empirical work on understanding the trade volume should work with disaggregated data, we statistically tested how well the gravity equation fits at an industrial level. Disaggregating total trade flows into 23 sectors, our application of gravity equation shows a promising empirical result. Now we are at the position of investigating a theoretical foundation of the gravity model in disaggregated levels.

Successful empirics of identifying the bilateral trade flows of Korea, we can practice some trade policy suggestions: For instance, the selection of a desirable free-trading partner by the country of a large unrealized trade potential; the conjecture of the potential trade volume between South and North Korea.

Although the gravity model becomes in great fashion in analyzing various trade issue, it still needs much development. In particular, the problems of the gravity model lie on the dependent variable. The total bilateral trade volumes can be decomposed into: (1) sum of export and import, (2) sum of intra-industry and inter-industry trade, (3) sum of primary commodity, intermediate goods and final products trade, and (4) sum of disaggregated industrial sectors. Further theoretical developments are in great need in distinguishing the different determining factors for the decompositions.

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<Table 1> Regression Results of Gravity Equations

Explanatory Variables	Basic Gravity Model: Eq. (2)		With TCI variable: Eq. (3)		Full Gravity Model: Eq. (4)	
	OLS coefficient	Standardized Coefficient (β-coefficient)	OLS coefficient	Standardized Coefficient (β-coefficient)	OLS coefficient	Standardized Coefficient (β-coefficient)
Constant	5.234* (2.623)	-	5.111** (2.275)	-	1.659 (1.857)	-
Product of GDPs	0.728*** (0.121)	0.657	0.727*** (0.105)	0.657	0.721*** (0.078)	0.651
Product of per capita GDPs	0.08977 (0.141)	0.069	-0.04882 (0.130)	-0.037	0.007482 (0.098)	0.006
Distance	-0.924*** (0.208)	-0.448	-0.794*** (0.174)	-0.385	-0.492*** (0.145)	-0.239
TCI	-	-	3.038*** (0.982)	0.271	1.933*** (0.771)	0.173
APEC	-	-	-	-	1.100*** (0.240)	0.330
Numbers of observation	30		30		30	
R^2	0.786		0.845		0.917	
Adjusted R^2	0.761		0.821		0.900	

Note: 1) The numbers in parenthesis are standard deviations.

2) *** and ** and *mean significant at 1%, 5% and 10% level, respectively.

<Table 2 > Composition of Trade Patterns: 1995

	Japan	U.S.	China	ASEAN
Inter-industry Trade	68.2	73.1	78.7	86.6
Intra-industry Trade				
Horizontal*	4.3	1.3	6.9	1.3
Vertical**	27.5	25.6	14.4	12.1

Source: Sohn (2003 p. 46; Table VII-1) *The Trends of Intra-industry Trade in East Asia*, unpublished internal research report, KIEP: Seoul.

Note: * Intra-industry trade in varieties or product differentiation.

** Intra-industry trade in different qualities and prices.

The classification between horizontal IIT and vertical IIT is based on the price differential at 15%.

The classification of UUT from inter-industry trade depends on trade overlap at 10%.

All numbers are calculated from HS 10-digit commodities.

<Table 3> Regression Results of 23 Disaggregated Sectors: Full Gravity Model

Sectors	Constant	Product of GDPs	Product of per capita GDPs	Distance	TCI	APEC	R^2 (Adjusted)
Agriculture	0.5569 (7.1721)	1.2412 (0.3150)	-0.8063 (0.3774)	0.0433 (0.5660)	0.8167 (3.0973)	2.8433 (0.9451)	0.6594 (0.5698)
Livestock	-13.7335 (8.032)	0.6780 (0.384)	0.7650 (0.441)	-0.7330 (0.661)	-0.6374 (3.6333)	-0.0510 (1.0985)	0.4356 (0.2790)
Forestry	-12.6227 (10.5473)	-0.1566 (0.4774)	-0.0395 (0.5671)	1.2050 (0.8284)	-1.3348 (4.6583)	4.0453 (1.4576)	0.3483 (0.1310)
Fisheries	-10.0942 (8.7717)	0.2137 (0.3853)	0.2404 (0.6923)	-0.4058 (3.7881)	-0.4058 (3,7881)	2.5016 (1.1559)	0.2644 (0.0708)
Minerals	0.0546 (6.5476)	1.0483 (0.2876)	-0.7767 (0.3445)	0.3036 (0.5168)	0.3426 (2.8276)	3.4997 (0.8628)	0.6913 (0.6101)
Foods	-1.3759 (4.3806)	0.6742 (0.1924)	-0.0957 (0.2305)	-0.2472 (0.3457)	0.8288 (1.8918)	1.5193 (0.5773)	0.6520 (0.5603)
Beverages and Tobacco	-21.42 (6.2403)	1.4800 (0.2722)	0.3059 (0.3320)	-0.2001 (0.4934)	-1.9062 (2.6777)	1.1690 (0.8266)	0.7256 (0.6749)
Textiles	10.9175 (2.7814)	0.7479 (0.1222)	- 0.573 (0.146)	-0.5433 (0.2195)	-0.7235 (1.2012)	0.9085 (0.3665)	0.8256 (0.7797)
Apparel	-3.533 (4.5103)	1.002 (0.1981)	0.0369 (0.2373)	-0.7117 (0.3560)	-0.2695 (1.9478)	0.3446 (0.5944)	0.7287 (0.6573)
Leather Products	3.7132 (2.8104)	0.8834 (0.1234)	-0.2500 (0.1479)	-0.6410 (0.2218)	-1.9734 (1.2137)	0.7533 (0.3703)	0.8442 (0.8032)
Wood Products	-5.5387 (5.3524)	0.6755 (0.2351)	0.0340 (0.2816)	-0.1325 (0.4224)	1.4460 (2.3115)	2.4881 (0.7053)	0.6862 (0.6036)
Paper Products and Publishing	-5.1378 (4.8845)	0.6969 (0.2145)	0.0554 (0.2570)	-0.1790 (0.3855)	0.6064 (2.1094)	1.6437 (0.6437)	0.6266 (0.5283)
Petroleum and Coal Products	-1.5459 (8.3698)	1.1933 (0.3821)	-0.4940 (0.4631)	-0.8186 (0.7047)	5.1363 (3.8301)	3.7964 (1.1167)	0.7355 (0.6529)
Chemicals, Rubber & Plastic	4.0610 (2.0885)	0.7661 (0.0917)	-0.1107 (0.2099)	-0.8267 (0.1648)	1.3662 (0.9019)	0.917 (0.2752)	0.9175 (0.8958)
Non Metal Minerals	1.6153 (2.8274)	0.7203 (0.1242)	0.0533 (0.1488)	-1.2850 (0.2231)	3.1407 (1.2210)	0.8238 (0.3726)	0.8966 (0.8694)
Iron and Steel	4.8827 (4.1413)	1.0780 (0.1819)	-0.4355 (0.2179)	-0.9065 (0.3268)	3.1089 (1.7885)	1.1028 (0.5457)	0.8265 (0.7809)
Non-Ferrous Metals	-7.7284 (6.0968)	0.8560 (0.2665)	0.0280 (0.3193)	-0.1756 (0.4789)	0.5194 (2.6207)	3.2404 (0.7997)	0.7097 (0.6333)
Metal Products	-0.5943 (1.9441)	0.7240 (0.0854)	0.0238 (0.1023)	-0.7806 (0.1534)	2.7992 (0.8396)	0.6459 (0.2562)	0.9250 (0.9050)
Automobiles	-6.6670 (4.4935)	0.8154 (0.1974)	0.1002 (0.2364)	0.0671 (0.3546)	-1.8802 (1.9406)	0.3730 (0.5921)	0.5807 (0.4704)
Other Transportation	-4.4527 (6.8431)	0.8703 (0.3005)	0.0280 (0.3601)	-0.6233 (0.5401)	3.6871 (2.9552)	0.0888 (0.9018)	0.5131 (0.3849)
Electric and Electronic Products	-4.5647 (1.9765)	0.7493 (0.0868)	0.0496 (0.1040)	-0.2449 (0.1560)	3.3037 (0.8536)	0.7836 (0.2605)	0.9105 (0.8869)
Machinery	0.4636 (2.5752)	0.7670 (0.1131)	0.1154 (0.1355)	-0.9214 (0.2032)	4.0025 (1.1121)	0.4619 (0.3394)	0.8978 (0.8709)
Other Manufacturing	-2.4553 (2.3051)	0.8901 (0.1012)	-0.1208 (0.1213)	-0.3014 (0.1819)	0.9122 (0.9955)	0.7919 (0.3038)	0.8825 (0.8516)

Note: The numbers in parenthesis are standard error.

<Table 4 >Actual and Predicted Trade Flows

(Unit: US$ billion, %)

Country		Actual Trade Flows(T_{ij})	Predicted Trade Flows($\hat{}T_{ij}$)	$T_{ij}/\hat{}T_{ij}$ (%)
1	Indonesia	6118	2452	249
2	Sri Lanka	291	120	242
3	Chile	1583	668	237
4	Singapore	7617	3775	202
5	Germany	10897	6328	172
6	Brazil	2439	1593	153
7	Italy	4400	3293	134
8	France	5620	4271	132
9	Malaysia	5001	4105	122
10	Turkey	662	583	114
11	U.S.	50184	45845	109
12	Australia	5039	4717	107
13	England	4087	3867	106
14	Taiwan	6166	6123	101
15	New Zealand	989	1003	99
16	Sweden	1116	1137	98
17	Hong Kong	6401	6666	96
18	China	19165	22343	86
19	Columbia	262	310	85
20	Philippines	2003	2530	79
21	Denmark	668	868	77
22	Finland	723	994	73
23	Uruguay	62	86	72
24	Argentina	495	726	68
25	Canada	3830	5616	68
26	Japan	46896	70059	67
27	Thailand	3342	5231	64
28	Venezuela	190	307	62
29	Morocco	57	117	49
30	Mexico	1164	4004	29

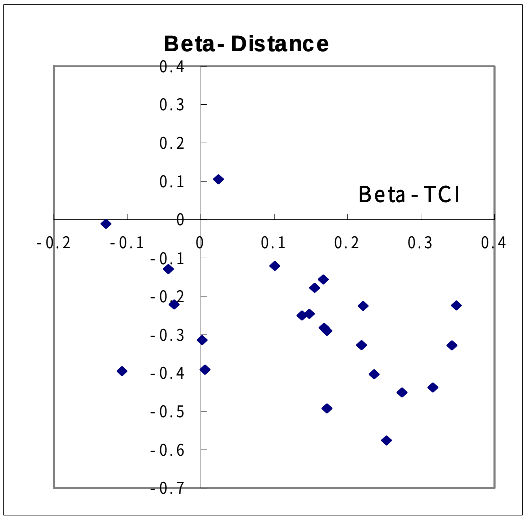
Source: GTAP Statistics (1995)

<Table 5> Predicted Trade Volumes between South and North Korea

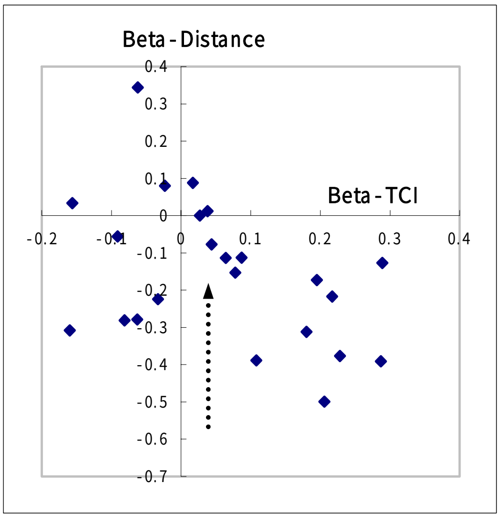
(unit: US$ million)

	North Korea's APEC Membership	TCI=0.2	TCI=0.4	TCI=0.6	TCI=0.8
Predicted Trade Flows	No	661.3	973.3	**1,432.6**	2,108.8
	Yes	1,986.4	2,923.9	**4,303.9**	6,335.1
Actual Trade Flows		290			

<Figure 1> Changes in β-coefficients of Distance and TCI Variable



(a) Without APEC variable



(b) With APEC variable

Appendix

< Table A1 > Data for the Gravity Model

	Country	T ij	GDP j	Per capita GDP j	Distance ij	TCI j
1	Australia	5,039	363	20,090	5,160	0.542
2	New Zealand	989	60	16,959	6,205	0.460
3	Japan	46,896	5,137	41,033	716	0.444
4	Korea	-	489	10,853	-	-
5	Indonesia	6,118	201	1,038	3,278	0.320
6	Malaysia	5,011	87	4,342	2,864	0.859
7	Philippines	2,003	74	1,055	1,624	0.530
8	Singapore	7,617	85	23,590	2,900	0.821
9	Thailand	3,342	168	2,834	2,311	0.686
10	China	19,165	711	582	542	0.536
11	Sri Lanka	291	13	719	3,627	0.377
12	Canada	3,830	574	19,386	6,546	0.522
13	U.S.	50,184	7,625	27,621	6,544	0.642
14	Mexico	1,164	287	3,168	7,494	0.647
15	Colombia	262	81	2,294	9,226	0.418
16	Chile	1,583	65	4,593	11,495	0.382
17	Uruguay	62	18	5,657	12,175	0.382
18	England	4,087	1,112	18,965	5,519	0.608
19	Germany	10,897	2,414	29,562	5,348	0.564
20	Denmark	668	181	34,596	4,950	0.482
21	Sweden	1,116	231	26,194	4,631	0.515
22	Finland	723	126	24,642	4,400	0.659
23	Turkey	662	172	2,792	4,821	0.298
24	France	5,620	1,535	26,403	5,587	0.541
25	Italy	4,400	1,088	18,988	5,584	0.536
26	Taiwan	6,166	260	12,264	922	0.365
27	Argentina	495	280	8,042	12,055	0.459
28	Brazil	2,439	704	4,517	11,396	0.510
29	Hong Kong	6,401	139	22,456	1,307	0.729
30	Morocco	57	33	1,250	6,741	0.173
31	Venezuela	190	77	3,657	9,001	0.425

Note: 1) Trade value (Tij) is the sum of total exports and imports between Korea(i) and its trading partner. 1 billion dollars
2) The unit for GDP is 1 billion U.S. dollars
3) The unit for Per capita GDP is 1 U.S. dollar
4) Distance means great circle distance between Seoul and the capital city of its trading partner. The unit is in miles.
5) TCI represents the degree of trade complementarity between Korean and its trading partner, 0<TCI<1
6) TCIj of Sri Lanka is based on 1994 data.
7) TCIj of Taiwan is an estimated value.

Source: Bank of Korea [National Account], 1988
IMF [International Financial Statistics] 1999. 6
Taiwan [Financial Statistics] 1999. 4

<Table A2> TCI for Korean Exports

Importing Country	TCI(1995)	Importing Country	TCI(1995)
Algeria	0.219	Kenya	-
Argentina	0.459	Korea	0.598
Australia	0.542	Latvia	0.261
Austria	0.490	Lithuania	-
Bangladesh	-	Madagascar	0.187
Denmark-Luxembourg	0.347	Malawi	0.209
Bolivia	0.343	Malaysia	0.859
Brazil	0.510	Mexico	0.647
Bulgaria	-	Morocco	0.173
Cameroon	0.241	Mozambique	-
Canada	0.522	Netherlands	0.487
Central African Rep.	0.194	New Zealand	0.460
Chile	0.382	Nicaragua	0.184
China	0.536	Norway	0.493
Colombia	0.418	Pakistan	0.202
Congo	-	Panama	0.353
Costa Rica	0.326	Paraguay	0.351
Croatia	0.277	Peru	0.388
Czech Republic	0.444	Philippines	0.530
Denmark	0.482	Poland	0.394
Ecuador	0.353	Portugal	0.513
Egypt	0.198	Rumania	0.294
El Salvador	0.322	Saudi Arabia	-
Estonia	-	Singapore	0.821
Finland	0.659	Slovakia	0.326
France	0.541	Slovenia	0.442
Gabon	-	South Africa Rep.	0.360
Germany	0.564	Spain	0.394
Ghana	-	Sri Lanka	-
Greece	0.396	Sweden	0.515
Guatemala	0.328	Switzerland	0.463
Honduras	0.213	Thailand	0.686
Hong Kong	0.729	Tunisia	0.370
Hungary	0.406	Turkey	0.298
Indonesia	0.320	Unite Kingdom	0.608
Ireland	0.567	Uruguay	0.382
Israel	0.295	United States	0.642
Italy	0.536	Venezuela	0.425
Jamaica	0.327	Yugoslavia	-
Japan	0.444	Zimbabwe	0.317
Jordan	0.215		

Source: Patrick J. Gormely and John M. Morrill (1998), *Korea's International Trade in Goods: The Potential for Increased Exports to and Imports from Trade partners.*

<Table A3> Data for North Korea

Population	23,261 thousand
Distance	125 miles
Nominal GNP	US$22.3 billion
Per capita Nominal GNP	US$957
Trade volume with Korea (1995)	US$287 million

Source: Internal KIEP (1996) data.