The Journal of International Logistics and Trade is an official journal published by Jungseok Research Institute of International Logistics and Trade, Inha University, Korea. JILT welcomes manuscripts that advance the practice and science of logistics, trade, and other related fields.
Frequency: Quarterly (March, June, September, December)

Stable URL: https://www.ejilt.org

The Jungseok Research Institute of International Logistics and Trade is a specialized academic research institute representing Inha University and the Inha Foundation in Korea. The institute aims to become a representative institute in Northeast Asia in the research of logistics and trade.

Stable URL: https://jrieng.inha.ac.kr

ARTICLE

A Study on the Characteristics of Intra-Industry Trade for Korea's E-Commerce Trade

Inkyo Cheong[1], Jeongho Yoo[2,*]

[1]Department of International Trade, Inha University, Incheon, Korea
[2]Department of FTA Policy and Business Consulting, Graduate School, Inha University, Incheon, Korea

Abstract Comprehensive studies examining how Korean e-commerce trade works are currently limited. This study seeks to explore whether Korea's e-commerce trade is more applicable to traditional trade theory or to modern theories. According to our analysis, the share of intra-industry trade (IIT) in modern trade theory is less than that of general trade for Korean e-commerce. Therefore, trade based on comparative advantage can be more valid in explaining e-commerce trade. From results in analyzing the gravity model, it was found that Korea's e-commerce exports are higher as IIT with its FTA partners. In contrast, it is found that the lower the proportion of e-commerce trade, the higher chance for the import growth. Lastly, this study looked at what kind of comparative advantage is realized through imports. While Korea has been mostly exporting goods of high quality, its major trading partners import products based on price and selection of goods. In order for Korea's e-commerce to grow, a more strategic approach is necessary. A strategy of high price based on superior quality is not effective, and as e-commerce has radically reduced sales and marketing costs, so a price reduction needs to be reflected in the price of goods for consumers.

Keywords E-commerce, Intra-industry trade, Vertical intra-industry trade, Gravity model, Modern trade theory

1. Introduction

Through the development of the Internet, digital trade has experienced rapid growth, and the sales and marketing costs of corporations have been radically reduced. Further, due to trade liberalization, the global value chain (GVC) has expanded and intensified, making participation in international trade easier for small and medium-sized enterprises. Although the use of e-commerce is being discussed as one way for domestic corporations to increase exports, studies on the status of Korean e-commerce trade are currently limited. Thus, the objective of this study is to identify the characteristics of e-commerce trade based on both traditional trade theory and new trade theory. Classical trade theory is based on comparative advantage resulting from differences in factor endowments. However, new trade theory has proposed intra-industry trade (IIT), which causes international trade within like-industries based on product differentiation. In this context, called the digital economy, studies on the e-commerce trade of commodities have not explored whether or not it is a successor of classical trade theory. This study, therefore, is expected to show an initial approach to define the characteristics of e-commerce trade. The methods used in the analysis include IIT theory, the gravity model, and the link between vertical IIT and the trade balance. In addition, a definition of e-commerce is necessary because, currently, there is no common definition. Therefore, the study defines it as an ordering of commodities using electronic methods. In parallel with the definition, the source of data used in this study is from the Korea Trade Statistics Promotion Institution (KTSPI), which systematically classifies e-commerce trade as a purchase of goods by electronic means in Korea.

Without applying those concepts relevant to trade structure, such as IIT and vertical specialization, it is difficult to explain today's trend of increasing trade. In order to explain the development of international trade due to the relaxation of trade barriers, such as tariffs and costs of logistics, it should be assumed that the consumption of domestic and imported goods or the elasticity

of substitution in production is very high[1]. The elasticity of substitution may be high depending on items, but the assumption of the high elasticity of substitution for all items is unrealistic. If one assumes that the elasticity of substitution is high, policymakers worry about a sudden increase in income. This causes a timid stance toward the relaxation of tariff barriers. However, vertical specialization enhances the benefits of relaxing trade barriers due to increased trade from the intensification of the division of labor across borders. Thus, it could explain the high growth rates of trade, even if substitutability between domestic and imported products is not assumed.

For the further activation of e-commerce, this paper analyzes the characteristics of Korea's e-commerce trade in terms of trade theories and seeks strategies that can promote e-commerce. In Section 2, the paper explores applicable theories and details the literature review of trade structure. In Section 3, this study introduces methods of analysis and data collection. In Section 4, this paper discusses the outcomes of analysis using various techniques. In Section 5, we will suggest conclusions and implications.

2. Theoretical background of analysis of trade structure and literature review

Before the Kennedy Round, mostly low-priced raw materials were traded internationally, and raw materials could only be produced by those countries with natural resources. Thus, even if their distribution costs were expensive, countries had no choice but to import these resources. However, after the Kennedy Round, tariffs on industrial products, including intermediate goods, were rapidly reduced, and vertical specialization in trade widely expanded. Despite the tariff reduction, trade in intermediate goods did not significantly increase. There was a tendency that the trade of intermediate goods, which focuses on raw materials, depended on natural resources. According to Hummels et al. (2001), trade based on the IO (Input-Output) chart of the 10 OECD member nations in 1990 and statistics of exports of Korea, Taiwan, Ireland, and Mexico, found that exports of vertical specialization trade accounted for 21% of the total exports. This result increased to 30% by the 1970s. Bridgman (2012) found that for the United States, vertical integration of total trade increased from 6% in 1972 to 14% in 1997, while the number of intermediate goods hardly changed. Furthermore, the development of trade according to vertical specialization, did not result in increasing intermediate goods.

Founded on the expansion of the EU and the advancement of economic integration, research on the effects of regional IIT was widely conducted (Ferto and Hubbard 2001a, 2001b; Jing 2009; Leitão et al. 2006, 2008, 2010; Melitz and Trefler 2012; Mora 2002; Oliveras and Terra 1997; Perobelli 2006). Oliveras and Terra (1997) improved the former Grubel-Lloyd (GL) index into a dynamic index that explained the change in the trade structure of major European countries. Faustino et al. (2000) analyzed the trade structure of Portugal's horticulture industry with EU members and predicted that the Portuguese industry would be under substantial pressure of restructuring. According to Mora (2002), the GL index of all the EU members increased, especially that of the relatively deprived members of Portugal, Greece, and Spain. Cristóbal (2001) suggested that Spain's GL gradually increased during the early days of the establishment of the EU, but most of the increase resulted from inter-industry trade rather than IIT. For those industries featuring highly advanced degrees of vertical specialization, the dynamic index was shown to be relatively high.

Some research suggests that the increase in IIT due to economic integration improved consumer welfare. From 1972 to 2001, the choice of imports in the US consumers increased by more than three times, and in this sense, consumer welfare reached 2.6% of the total US GDP (Broda and Weinstein, 2006). Feenstra (2010) found that consumer benefits resulting from global trade liberalization represented 9%–15% of the world's total GDP. Melitz and Trefler (2012) proposed that IIT brings benefits to consumers, producers, and the national economy in 3 broad areas. First, as Krugman and others have explained, economies of scale can be realized in terms of consumers' preferences of variety and production. Second, production factors between different corporations with distinct competitive advantages are reallocated for profit maximization. Thus, various products within the industry are invented as Melitz and others have suggested, and IIT increases. In this sense, industry-wide and national economic efficiency improves as well. Third, IIT would increase due to the invention of new technology and innovation when trade agreements are implemented. In other words, the implementation of trade agreements as FTAs would expand markets, and subsequently, corporations would increase investment for the invention of new products. Then, the effects of economies of scale would intensify as fixed costs are high, and the benefits of IIT are enhanced.

What comes next is the emergence of vertical IIT. Vertical IIT comes from the concept that differentiation exists between

---

[1]During the time of analysis, tariffs and costs of logistics were reduced to less than 0.5%, and the weight of trade compared to international GDP was increased by 2.5%. To explain this, the elasticity of substitution higher than 5 has to be premised.

items in IIT and is conceptualized as the horizontal differentiation and the vertical differentiation of goods. Horizontal differentiation is explained by consumers' preferences for a variety of goods under the structure of monopolistic competition markets, and vertical differentiation is mainly explained by factor endowments, technology, income distribution, and the life cycle of products. Falvey (1981), Falvey and Kierzhowski (1987) and others have suggested that differences in prices appear in the production function, which ultimately leads to differences in quality. Using the method of relative value units (RVUs), Greenaway et al. (1994) extended the analysis of the GL index by separating it into HIIT (Horizontal) and VIIT (Vertical) indices. RVUs analyze by linking horizontal and vertical IIT to the concept of value units of products, and Abd-el-Rahman (1991) first scrutinized trade structures by applying the 15% difference of import prices in order to distinguish horizontal and vertical intra industry trade.

As income levels are similar, the horizontal HIIT increases, and the HIIT has a correlation with monopolistic competition, economies of scale, and the level of product differentiation. Vertical VIIT of imports and exports have qualitative differences and can be explained by traditional trade theory based on resource endowments under perfect competition and by R&D investment and technology-based production factors under oligopolistic markets (Aturupane et al. 1999). For vertical specialization, Abd-el Rahman (1991) received attention in academia with his research on the trade of France, Fontagné and Freudenberg (1997) on Germany, and Greenaway et al. (1994) on the quantitative research on the United Kingdom. For Western European countries, Fontagné and Freudenberg (1997, 2002) suggested that although the GL index gradually increased from 33% to 37% between 1980–1998, the horizontal intra-industry index remained between 18% and 20%. Vertical IIT expanded from 35% to 45%. Furthermore, one-way trade was reduced from 46% to 36%. Thus, the possibility that one-way trade transformed into IIT was also raised.

Technological advancement, the strengthening of international competitiveness, the relaxation of trade barriers, and the reduction of deliberation costs affect the production process by comparative advantage. Consequently, vertical IIT occurs. Nevertheless, generally in developing countries, an increase in the GL index can be viewed as a signal of industrial development but does not necessarily mean that this is advantageous. One must look at this in conjunction with the trade balance. If an item has a trade deficit (surplus), it can be seen that an increase in the GL index means that item develops in a positive (negative) direction, and a decrease in the index can be evaluated that negative (positive) development is occurring.

In Gabrisch et al. (2001), significant conclusions of their literature review concerned the HIIT and VIIT indices. First, when the horizontal intra-industry index is dominant, the size and scale of IIT in the total trade were inversely proportional to the income gap. Second, for trade agreements, when the income gap is reduced, the similarity between members increases. Thus, there is a tendency that horizontal IIT increases. Third, since an increase in vertical IIT means an increase in the income gap, when vertical IIT is dominant, the size and scale of IIT out of total trade is proportional to the income gap. On the other hand, some research results have suggested that horizontal and vertical IIT is proportional to the development of the GVC (Kilavuz et al. 2013). The GVC is the most significant factor in an increase in vertical IIT, and exports and imports specialized in vertical IIT predominantly consist of intermediate goods and services (Zhang and Clark 2009). Moreover, vertical IIT occurs due to a variety of factor endowments, and there is a tendency that trade usually takes place between a developing country and a developed country, as is similar to the north-south trade model. Furthermore, recent research on IIT shows a tendency of inducing eco-innovations (Gallucci et al. 2019) and also draws Foreign Direct Investment (FDI) inflow to countries that are more vertically integrated in IIT (Ambroziak 2016). The difference in this study is in the focus of e-commerce data to extract intra-industry characteristics of its trade in Korea, which is active in the global trade of digital goods.

3. Analytic model

Fundamentally, trade can be classified into inter-industry trade and IIT. IIT means trade among countries with a comparative advantage in different industries. One country specializes in an industry with a comparative advantage, produces goods, exports them, and then imports goods with a comparative disadvantage. The IIT index is calculated by the GL index. The GL index, which was invented in 1975, is calculated as follows.

$$GL_i = \frac{(X_i + M_i) - |(X_i - M_i)|}{(X_i + M_i)} = 1 - \frac{|(X_i - M_i)|}{(X_i + M_i)} \tag{1}$$

where, X stands for exports, and M means imports. i is an industry.

Next, the gravity model is used to estimate the effects of IIT on e-commerce exports. The gravity model is a model that

predicts an increase in bilateral trade flows depending on the size of an economy, physical distance, and the extent of trade liberalization. The gravity model is based on the theory of physics and follows from the theory of economics (Bergstrand 1985; Eaton and Kortum 2002). The use of the gravity model in analyzing the spreading influence of trade agreements, such as the FTAs, began in Anderson and van Wincoop (2003). This paper sets the Anderson and van Wincoop (2003) model (Equation 2) in an appropriate research purpose by reflecting the Beckman et al. (2015) model.

$$p_{ij}^k x_{ij}^k = v_{ij}^k = \left[\frac{Y_i^k E_j^k}{Y^W}\right]\left[\frac{t_{ij}^k}{P_i^k \Pi_i^k}\right]^{1-\sigma_k} \tag{2}$$

Here, for p_{ij}^k, x_{ij}^k and v_{ij}^k, p is the price, and x is the weight, which is the sum of the value of production at the origin. v is the trade costs that the exporter passes on to the importer, and i, j, and k represent the exporter, importer, and item, respectively. Further, Y is the production amount, E the consumption which is used as the nominal income of the region to consider a country's budget constraints, and t indicates trade costs, such as delivery and deliberation costs. σ_k is the elasticity of substitution between domestically produced goods and imported goods, and P is the price variability, which is a proxy as multilateral trade resistance depends positively on trade barriers with all trading partners. The paper replaces the equation (2) in order to see fixed-effects following Feenstra (2003), to make the estimation more convenient. Moreover, this paper analyzes the data of Korean trade. In addition, we change the equation into a form of a log equation, add a distance variable, and add whether or not a country signed an FTA. Our analytic model is displayed in Equation (3) below.

$$\ln v_{ij} = \alpha + \beta_1 IIT_{ij} + \beta_2 FTA_{ij} + \beta_3 \ln(GDP_i) + \beta_4 \ln(DST_{ij}) + \varepsilon_{ij} \tag{3}$$

In order to solve the possibility of endogeneity between error terms and explanatory variables in Equation (3), independence between error terms and explanatory variables is assumed, as in Silva and Tenreyro (2006). Using the Poisson Pseudo-Maximum Likelihood (PPML), Equation (4) is set. In detail, the PPML approach is initially derived from the consideration of outward and inward multilateral resistance because of the bias in estimation resulting from heteroscedasticity, model misspecification, and excess zeros. Several approaches were considered to overcome these limitations, such as fixed or random-effects and relevant econometric estimators. However, the PPML estimator for gravity regressions was used in order to account for heteroscedasticity, and to take advantage of the information contained in zero trade flows was used as an appropriate approach to resolve these constraints accordingly. Here v_{ij}^k is exports from region i to region j, IIT_{ij} is the intra-industry index, FTA_{ij} is a dummy variable equal to one for FTA partners, and zero for non-trade agreement partners. DST_{ij} is the distance between country i and country j.

$$v_{ij} = exp[\alpha + \beta_1 IIT_{ij} + \beta_2 FTA_{ij} + \beta_3 \ln(GDP_i) + \beta_4 \ln(DST_{ij})]\varepsilon_{ij} \tag{4}$$

If IIT has a positive effect on exportation, there is a need to understand the causes behind it. To analyze these causes, this paper focuses on vertical IIT. As mentioned previously, traditional trade theory faces difficulties in interpreting IIT. Thus, trade economists concerning international economics classifies IIT into horizontal and vertical IIT. Gabrisch and Segnana (2001) analyzed why IIT of like products occurs. They mentioned differences in technical skills embodied in goods as a reason for such occurrence of trade of like products. Technical skills are drawn by comparing the export and import prices of goods. This means that in spite of trade of like products, the qualitative differences of products are significant. Further, this paper is one of the first to seek ways to understand the causes of IIT by linking the ratio of export and import prices and the trade balance. This research also determines whether trade via e-commerce has qualitative differences through a comparison of the ratio of export and import prices by country.

As in Fontagné and Freudenberg (1997, 2002), it is viewed that vertical IIT occurs when the price gap is more than 15%. We use a more conservative approach in our analysis, assuming vertical IIT occurs with a 25% price difference. The reason for a more conservative approach is to increase the credibility of research results. The wider the price gap is, the bigger the difference of technology included within the industry. For instance, if an export price is higher than an import price by 1.25 times, that particular product or industry could have superior quality in exports when compared to a country subject to comparison. Likewise, if an export price is lower by 0.75 times, that product or industry may have a price advantage compared to the other.

Table 1. Link between price gap and trade balance

Classification	Price gap	Trade balance	Elements of advantage	Interpretation
Horizontal	$0.75 < RUV < 1.25$ (like products)	-	-	Pure intra-industry trade depending on preferences of diversity
Vertical	$RUV > 1.25$ (quality advantage)	Surplus	Exporter quality advantage	Difference of level of technology
		Deficit	Importer price advantage	Low unit cost from factor endowments
	$RUV < 0.75$ (price advantage)	Surplus	Exporter price advantage	Low unit cost from factor endowments
		Deficit	Importer quality advantage	Difference of level of technology

Relative Unit Values (RUV) is the ratio of export prices/import prices; the source of data used in this research is the Korea Trade Statistics Promotion Institution (KTSPI) and used data from 2017; Trade included in the KTSPI is classified in various forms, but this research mainly analyzes exports and imports via number 15, e-commerce, rather than number 11, representing general trade.
Modifications based on Fontagné and Freudenberg (1997, 2002).

When price differences of 1.25 and 0.75 times exist, that particular product or industry could be classified as pure IIT, which is the trade of like products.

When linking vertical and horizontal IIT to the trade balance, one can identify factors of comparative advantage of products or industries. From this, it is expected that a new angle of a trend in IIT flows between countries is identified. The linkage between IIT and the trade balance is important in the sense that it suggests a cause of trade occurring from quality and price advantages, moving one step forward in international trade theory, which emphasizes the superiority of labor productivity (Ricardo) or factor endowments (Heckscher-Olin).

To be more exact, in a situation in which an export price is 1.25 times higher than an import price when the trade balance is in surplus, it can be viewed that the exporter has a quality advantage in products or industries. Only when the trade balance records a deficit under the same situation, it can be thought that the other country has a price advantage. In contrast, when an export price is 0.75 times lower than an import price, and there are trade surpluses, it can be seen that the exporter has a price advantage in the particular product or industry. Nevertheless, when there are trade deficits, the importer has a quality advantage. When the RUVs are between 0.75 and 1.25 times, it can be considered that trade of like products is occurring, and this emerges depending on consumer preferences, which the former theory of IIT suggests.

4. Analysis results

4.1 Intra-industry trade index of e-commerce and general trade

Analysis results of the IIT index found that there is a considerable difference between the indices of e-commerce and general trade. The IIT of e-commerce accounts for approximately 16.8% of the total. In contrast, IIT represents 63.7% of the total trade. The gap between these two percentages is about 47%, which is very large. Unlike general trade, e-commerce carries less importance within IIT. Now trade can be explained with traditional trade theory. This can be viewed that trade depended on differences in productivity or factor endowments. When looking at the difference of IIT indices by industry, the following points are discovered. The industry with possibly the most significant gap is the manufacturing industry of machinery and equipment. For the manufacturing industries of machinery and equipment, the IIT index for general trade was 81.6%, and the index for e-commerce was 4.9%. Thus, their difference was 76.7%. Further, manufacturing industries are representative industries that include the trade of intermediate goods. Characteristics of e-commerce include a greater amount of trade involving final goods and consumer goods rather than intermediate goods. In this sense, the IIT index for e-commerce seems to be low in the manufacturing industries of machinery and equipment.

Industries with wide gap of indices include primary metal goods, other manufacturing industries, and wood and paper/printing industries. These industries also differ in productivity by regions and in technology, and produce intermediate goods. The industry with the smallest gap is the mining industry. However, the mining industry has enormous differences in production by region. Thus, IIT of general trade rarely occurs. Such results can be seen as reflecting industrial characteristics. The industry with the second smallest gap is agriculture, forestry, and fishery. The difference between the IIT indices of the general trade and e-commerce of the industry of agriculture, forestry, and fishery was 20.2%. However, for the industry of

Table 2. Intra-industry trade ratio in E-commerce and general trade by sector

Industry	E-commerce (%)	General trade (%)	Difference (%)
Primary metal goods	29.8	96.6	66.80
Mining	1.5	0.7	–0.80
Metal goods	26.3	67.0	40.70
Machinery and equipment	4.9	81.6	76.70
Others	11.4	76.6	65.20
Agriculture, forestry and fishery	1.6	21.8	20.20
Wood and paper	7.8	72.9	65.10
Nonmetallic mineral	24.8	68.9	44.10
Coal and oil	22.6	70.3	47.70
Textiles and leather goods	29.9	77.6	47.70
Transportation equipment	3.1	33.8	30.70
Food and beverage	0.8	50.1	49.30
Electricity and electronics	14.8	68.4	53.60
Precision equipment	33.5	90.7	57.20
Chemical products	39.2	78.0	38.80
Total average	16.8	63.7	46.90

agriculture, forestry, and fishery, the IIT index of general trade was not as high as other industries.

Like the mining industry, agriculture, forestry, and fishery is a representative industry that has a large difference in production by region. Furthermore, this industry produces consumer goods rather than intermediate goods. Therefore, the difference in the indices of general trade and e-commerce did not appear substantial. Yet, the IIT index of e-commerce was also low at 1.6%. This is because the foundation of exports of agriculture, forestry, and fishery in Korea was not as high as that of imports. The food and beverage industry featured the IIT index of 50.1% for general trade, but for e-commerce, the index displayed a very low percentage of 0.8%. Similar to agriculture, forestry, and fishery, the food and beverage industry also has a relatively weak level of exports.

The industries with a high IIT index for e-commerce include manufacturing industries of precision instruments, chemical products, textiles, and leather goods(Table 2). For the industry of precision instruments, its IIT index for e-commerce was 33.5%. For chemical products, its IIT index was for e-commerce 39.2%, and for textiles and leather goods, it was 29.9%. Such industries are Korea's representative export industries. Among domestic industries, there certainly exist exports of intermediate goods through general trade, but there also exist exports of final goods through e-commerce. Therefore, the indices of IIT for general trade and e-commerce are relatively higher than in other industries.

4.2 Analysis of intra-industry trade index by countries subject to FTAs

Next, this paper looks at IIT indices focused on countries that have signed an FTA with Korea and with countries around them (Table 3). The IIT indices for general trade and e-commerce of these countries average 71.8% and 26.5%, respectively. Although a gap of IIT indices by country exists, the index for e-commerce was shown to be relatively low. In this sense, e-commerce trade can be evaluated as following traditional trade theory, which advocates that trade occurs according to labor productivity and factor endowments. The trade involving an industry with relatively abundant factor endowments emerges in the e-commerce trade. Looking at the countries that Korea has signed an FTA with can lead to more precise results.

Considering the overall trends, the IIT index for e-commerce trade with Korea was lower for larger economies. For EU countries, IIT of general trade ranged from a minimum of 60% and a maximum of 88%. Thus, more than half of the trade occurred as IIT. Yet, for e-commerce, these values decreased to 0.1% to 2.7%, respectively, for European countries. The reasons for this include that the EU nations have large economies, and differences in labor productivity or production factors exist. Thus, final products and consumer goods that are not produced in domestic industries are exchanged via e-commerce, ultimately displaying a very low IIT index for e-commerce.

In contrast, for ASEAN countries, their economies are relatively smaller than in Korea. In terms of their consumer goods, ASEAN countries also have more labor-intensive goods based on low wages. Regarding goods exchanged with Korea, the IIT

Table 3. Overall intra-industry trade ratio in E-commerce and general trade with FTA partners

Country	E-commerce (%)	General trade (%)	Difference (%)	GDP (10 billion)
Chile	15.5	57.4	41.9	28
ASEAN				
Singapore	42.2	86.6	44.4	32
Thailand	21.7	82.1	60.4	46
Vietnam	17.2	50.6	33.4	22
Indonesia	33.3	93.5	60.2	102
Malaysia	60.9	96.0	35.1	31
Philippines	48.2	51.8	3.6	31
EU				
Germany	0.7	60.1	59.4	368
UK	2.7	87.5	84.8	262
Italy	0.1	79.5	79.4	193
France	2.4	68.5	66.1	258
Spain	4.9	82.3	77.4	131
Peru	51.6	60.0	8.4	21
USA	4.4	85.0	80.6	1,939
Australia	31.9	98.2	66.3	132
Canada	35.2	96.7	61.5	165
China	95.8	81.6	−14.2	1,224
New Zealand	2.5	96.4	93.9	21
Japan	14.7	65.5	50.8	487
Hong Kong	25.4	9.2	−16.2	34
Total average	26.5	71.8	45.3	-

index for e-commerce was found to be very high, ranging from 17.2% to 60.9%. When these percentages are compared to developed countries, the differences are significant. Table 3 shows exports and imports by industry. Trade shows that an inversely proportional relationship between the IIT index for e-commerce and the size of an economy does not apply to China. Even though the size of the Chinese economy is massive, the IIT index for e-commerce was 95.8%, which is higher than the general trade index of 81.6%. In the case of China, goods produced by Korean corporations that are operating businesses in China are being imported back to Korea via e-commerce.

The paper seeks to analyze whether or not the e-commerce exports of Korea can be explained with trade theory through the gravity model. Our analysis uses the ordinary least squares (OLS) and the PPML, which supplements the OLS and weaknesses of the gravity model. An industry dummy is used for the two models, having 4 cases for this paper. As a result of the analysis, the gravity model was valid in both the OLS and the PPML. From the OLS analysis, the parameter of ln (GDP) was expected to be between 0.767 and 0.96, and the PPML model resulted in parameters of 0.101 and 0.122. Since the estimation of the PPML model with dummy variable seems to be more stable, the paper would try to discuss empirical results based on the model (iv) of Table 4. When the GDP increases by 1%, exports via e-commerce were shown to increase by 0.122%. Even for the distance variable, both the OLS and PPML presented a negative causality and a matching result with the gravity model.

The OLS model had values of −0.969 and −1.159, and the PPML had results of −0.102 and −0.123. Viewing the model of (iv), it is interpreted that Korea's exports increase by 1.2% as the distance becomes closer by 10%. In terms of the variable of IIT, which this research focuses on, it has a positive effect on the e-commerce exports of Korea. Although the OLS model displayed relatively higher parameters of 2.004 and 1.324 and was shown to have low stability, the PPML model had parameters of 0.262 and 0.169 that feature relatively more stable results. When IIT increases by 10%, it can be seen that exports increase by 1.69%. This implies that as the trade of differentiated products grows, Korea will be more active in exports of goods through e-commerce.

In addition, according to the analysis on variables of the FTAs, which helps to understand how signing an FTA positively affects the e-commerce exports, it was found that FTAs have a positive impact on exports. The FTA variable is a dummy variable,

Table 4. Gravity model analysis results on exports of e-commerce

	OLS		PPML	
	(i)	(ii)	(iii)	(iv)
IIT	2.004***	1.324***	0.262***	0.169***
	(0.312)	(0.245)	(0.041)	(0.033)
FTA	0.329*	0.357**	0.052*	0.052**
	(0.198)	(0.15)	(0.027)	(0.021)
Ln (gdp)	0.767***	0.96***	0.101***	0.122***
	(0.056)	(0.044)	(0.008)	(0.006)
Ln (dst)	−0.969***	−1.159***	−0.102***	−0.123***
	(0.154)	(0.116)	(0.018)	(0.015)
Constant	−5.134**	−6.138***	0.103	−0.002
	(2.225)	(1.708)	(0.294)	(0.234)
Industry dummy	N	Y	N	Y
Adjusted R^2	0.32	0.62	-	-
F-statistics	76.65***	58.67***	-	-
Obs.	839	839	839	839

Standard error is in parenthesis; *, **, *** indicate rejection at 10%, 5%, 1% respectively original hypothesis.
OLS, ordinary least squares; PPML, poisson pseudo-maximum likelihood.

and the estimated value exp (0.052) corresponds to about 1.05. In other words, for countries that have signed an FTA, their e-commerce exports would be higher than those who have not signed an FTAs by 1.05%. Such a result has been drawn due to the benefit in which the FTAs apply zero tariffs under certain costs.

Looking at the effects of IIT on Korea's imports via e-commerce, results can be summarized as follows. The IIT index is what displays the most significant differences in e-commerce exports. It has been found that as the IIT index escalates, the amount of exports increase. On the other hand, as the IIT index for e-commerce becomes smaller, the amount of imports increases. For imports, it was revealed that they increase further when the trade in the same industries does not occur. Under the OLS model, the coefficients of IIT on imports are –2.654 and –2.115 in Table 5, while those under the PPML analysis –0.301 and –0.254, implying that the latter model predicts smaller reductions. As the IIT index lowers by 10%, the number of imports via e-commerce was found to increase by 2.54%. Then, for the FTA variable, it was also found that if a country has signed an FTA, it was more likely to have higher imports. The value of the parameter, 0.175, corresponds to 1.19, and this means that imports from the countries that have signed FTAs are higher than those countries that have not signed these

Table 5. Gravity model analysis results on imports of e-commerce

	OLS		PPML	
	(i)	(ii)	(iii)	(iv)
IIT	−2.654***	−2.115***	−0.301***	−0.254***
	(0.346)	(0.313)	(0.039)	(0.036)
FTA	1.305***	1.462***	0.158***	0.175***
	(0.219)	(0.192)	(0.025)	(0.022)
Ln (gdp)	1.053***	1.252***	0.112***	0.131***
	(0.063)	(0.057)	(0.007)	(0.006)
Ln (dst)	−0.724***	−0.84***	−0.067***	−0.075***
	(0.17)	(0.149)	(0.017)	(0.015)
Constant	−12.461***	−15.971***	−0.22	−0.576*
	(2.468)	(2.188)	(0.263)	(0.238)
Industry dummy	N	Y	N	Y
Adjusted R^2	0.47	0.60	-	-
F-statistics	142.2***	54.65***	-	-
Obs.	839	839	839	839

Standard error is in parenthesis; *, **, *** indicate rejection at 10%, 5%, 1% respectively original hypothesis.
OLS, ordinary least squares; PPML, poisson pseudo-maximum likelihood.

agreements by 1.19%.

This also coincides with the gravity model, and the parameters of the variables of GDP and distance were 0.131 and –0.075, respectively. This implies that if GDP increases by 10%, imports increase by 1.3%, and if countries are relatively closer by 10%, imports increase by 0.7%. When compared to exports, the effect of distance on imports seems relatively limited.

In terms of e-commerce trade, Korea's exports were found to be more significant when the IIT index is higher, and its imports were greater when the IIT index is lower. This can be viewed as similar to trade in e-commerce. Korea tends to export like products and import those goods that are not produced domestically. This is also a characteristic of the trade in consumer goods.

4.3 Analysis of vertical intra-industry trade

Exports and imports of e-commerce had different results based on IIT. In order to understand the causes behind this, this paper analyzed vertical IIT with the approach presented in the Table 1 and linked to the trade balance. Vertical IIT reflects technical skills inherent in an industry as a ratio of export and import unit prices. As technical skills increase, the unit price also increases. When compared to the unit price of the other countries and its unit price is higher by at least 25%, it is viewed as a quality advantage. In contrast, if the unit price is lower than 75%, it can be interpreted as a price advantage, instead of the superiority of technology.

As Table 6 suggests, Korea has quality advantages in all industries, except textiles and leather goods. This means that Korea's export unit prices by industry are higher by more than 25% compared to other countries. When this is compared to the trade balance, Korea exports with a quality advantage or imports in terms of the other country's price advantage. As a result of linking this finding with the trade balance, Korea had trade deficits in all industries, except textile industries. This signifies a structure where Korea is able to import goods with lower prices, rather than importing goods with a quality advantage. For the textile industries, the prices of exports and imports are similar. Thus, it can be viewed that trade occurs based on consumer preferences.

When tying in this structure with the gravity model analysis, Korea has been exporting goods featuring a quality advantage and has been importing goods of lower prices than are produced domestically. It is essential to look at the overall structure of trade by calculating the vertical IIT index by industry. Nevertheless, it would also be significant to look at the structure of trade by considering the national characteristics of other countries.

Table 6. Advantage of intra-industry trade and trade balance

Industry	RUV	IIT	Trade balance ($1,000)	Elements of advantage
Primary metal goods	2.42		–65	
Mining	44.25		–371	
Metal goods	2.11		–8,373	
Machinery and equipment	1.34		–75,000	
Others	2.86	Quality advantage	–49,160	Price advantage of an importer
Agriculture, forestry and fishery	9.84		–9,870	
Wood and paper	3.49		–18,029	
Nonmetallic mineral	3.68		–3,038	
Coal and oil	8.67		–28	
Textiles and leather goods	0.92	Horizontal	–220,063	Preference of diversity
Transportation equipment	2.62		–19,026	
Food and beverage	6.57	Quality advantage	–476,645	Price advantage of an importer
Electricity and electronics	2.53		–131,903	
Precision equipment	1.77		–27,458	
Chemical products	1.42		–85,783	

RUV, ratio of export prices/import prices; IIT, intra-industry trade.

5. Conclusion and implications

The paper analyzed e-commerce trade that corresponds to traditional trade theory and modern trade theory. Further, this paper has shown that Korea's e-commerce trade involves a smaller amount of IIT, which is applicable to modern trade theory, than general trade. This implies that trade based on the law of comparative advantage can explain e-commerce trade. According to our research results involving the gravity model, Korea's e-commerce trade increases as IIT involving a country with an FTA in places also increased. On the other hand, as the scale of e-commerce trade lowers, the imports of the other country increases. Lastly, this paper examined how trade via e-commerce occurs and what type of comparative advantage is involved. Korea mostly exports goods featuring a quality advantage. Yet, it was found that the major trading partners of Korea export products based on price advantages or diversity of goods.

Summing up the results of the analysis, Korea certainly features differences with its major trading partners in terms of e-commerce trade. Thus, this calls for a change in order to enhance e-commerce trade. The scale of Korea's e-commerce exports is very low compared to that of imports. Thus, it can be perceived that the possibility of future exportation is also high. Yet, there may be problems with high prices since exports have been based on quality advantages until now. Further, in terms of imports of countries with relatively more advanced technology and higher wages, such as the United States, Japan, Germany, and Italy, they are mostly based on price advantages. In order for Korea's e-commerce to develop, a more strategic approach is needed. Instead of setting high prices based on quality advantages, a strategy of price advantage must also be utilized. As e-commerce has radically lowered the costs of sales and marketing of corporations, there is a need to reflect such price reduction on goods and to increase corporations' net profits through increased sales.

Acknowledgements

References

Abd-el-Rahman, K., 1991. Firms' competitive and national comparative advantages as joint determinants of trade composition. Review of World Economics 127, 83-97.

Ambroziak, Ł., 2016. FDI and intra-industry trade in the automotive industry in the new EU member states. International Journal of Management and Economics 52, 23-42.

Anderson, J. E., Van Wincoop, E., 2003. Gravity with gravitas: A solution to the border puzzle. American Economic Review 93, 170-192.

Aturupane, C., Djankov, S., Hoekman, B., 1999. Horizontal and vertical intra-industry trade between Eastern Europe and the European Union. Weltwirtschaftliches Archiv 135, 62-81.

Beckman, J., Arita, S., Mitchell, L., Burfisher, M., 2015. Agriculture in the transatlantic trade and investment partnership: Tariffs, tariff-rate quotas, and non-tariff measures. Economic Research Report Number 198.

Bergstrand, J. H., 1985. The gravity equation in international trade: Some microeconomic foundations and empirical evidence. The Review of Economics and Statistics 67, 474-481.

Bridgman, B., 2012. The rise of vertical specialization trade. Journal of International Economics 86, 133-140.

Broda, C., Weinstein, D. E., 2006. Globalization and the gains from variety. The Quarterly Journal of Economics 121, 541-585.

Cristóbal, J. V. B., 2001. Dynamics and nature of intra-industry trade and labour-market adjustment: evidence for Spain. In Workshop on Recent Developments in Research on Intra-industry Trade and Labour Market Adjustment, Leverhulme Research Centre School of Economics, University of Nottingham.

Eaton, J., Kortum, S., 2002. Technology, geography, and trade. Econometrica 70, 1741-1779.

Falvey, R. E., 1981. Commercial policy and intra-industry trade. Journal of International Economics 11, 495-511.

Falvey, R. E., Kierzkowski, H., 1987. Product quality, intra-industry trade and (im) perfect competition. In: Kierzkowski, H., Corden, W. M. (Eds), Protection and Competition in International Trade. Basil Blackwell, Oxford, UK.

Faustino, H. C., Silva, J. R., Carvalho, R. V., 2000. Testing intra-industry trade between Portugal and Spain 1990−1996. Universidade de Lisboa Working Papers Department of Economics No. 2000/06.

Feenstra, R. C., 2003. A homothetic utility function for monopolistic competition models, without constant price elasticity. Economics Letters 78, 79-86.

Feenstra, R. C., 2010. Product Variety and the Gains from International Trade. MIT Press, Cambridge, MA.

Ferto, I., Hubbard, L. J., 2001a. Intra-industry trade in agri-food products between Hungary and the EU. 2001 Annual meeting, Chicago, IL.

Ferto, I., Hubbard, L. J. 2001b. Competitiveness and comparative advantage in Hungarian agriculture. IEHAS Discussion Papers No. 2001/2.

Fontagné, L., Freudenberg, M., 1997. Intra-industry trade: Methodological issues reconsidered. CEPII Working Paper No. 1997-01.

Fontagné, L., Freudenberg, M. 2002. Long-term trends in intra-industry trade. In Lloyd, P. G. (Ed), Frontiers of Research in Intra-Industry Trade. Palgrave Macmillan, London, UK.

Gabrisch, H., Segnana, M. L., 2001. Trade structure and trade liberalization: The emerging pattern between the EU and transition economies. MOST: Economic Policy in Transitional Economies 11, 27-46.

Gallucci, T., Dimitrova, V., Marinov, G., 2019. Interrelation between eco-innovation and intra-industry trade: A proposal for a proxy indicator of sustainability in the EU countries. Sustainability 11, 6641.

Greenaway, D., Hine, R., Milner, C., 1994. Country-specific factors and the pattern of horizontal and vertical intra-industry trade in the UK. Weltwirtschaftliches Archiv 130, 77-100.

Hummels, D., Ishii, J., Yi, K. M., 2001. The nature and growth of vertical specialization in world trade. Journal of International Economics 54, 75-96.

Jing, W., 2009. The analysis of intra-industry trade on agricultural products of China. Frontiers of Economics in China 4, 62-75.

Kılavuz, E., Erkekoglu, H., Topcu, B. A., 2013. Globalizing production structure and intra-industry trade: The case of Turkey. International Journal of Economics and Financial Issues 3, 799-812.

Leitão, N. C., Faustino, H. C., 2006. Country-Specific Determinants of Horizontal and Vertical Intra-Industry Trade in Portugal. Fifth GEP Postgraduate Conference, Nottingham, UK.

Leitão, N. C., Faustino, H. C., 2008. Intra-industry trade in the food processing sector: The portuguese case. Journal of Global Business and Technology, 4.

Leitão, N. C., Faustino, H. C., Yoshida, Y., 2010. Fragmentation, vertical intra-industry trade and automobile components. Economics Bulletin 30, 1006-1015.

Melitz, M. J., Trefler, D., 2012. Gains from trade when firms matter. Journal of Economic Perspectives 26, 91-118.

Mora, C. D., 2002. The role of comparative advantage in trade within industries: A panel data approach for the European Union. Weltwirtschaftliches Archiv 138, 291-316.

Oliveras, J., Terra, I., 1997. Marginal intra-industry trade index: The period and aggregation choice. Weltwirtschaftliches Archiv 133, 170-178.

Perobelli, F., Haddad, E., Domingues, E., 2006. Interdependence among the Brazilian states: An input-output approach. ERSA Conference Papers No. ersa06p414.

Silva, J. M. C. S., Tenreyro, S., 2006. The log of gravity. The Review of Economics and Statistics 88, 641-658.

Zhang, Y., Clark, D. P., 2009. Pattern and determinants of United States' intra-industry trade. The International Trade Journal 23, 325-356.