Heterogeneity in Production Technologies and the Effects of FTAs

Jaehan Cho[1] & Jisoo Kim[2]

Korea Institute for Industrial Economics & Trade

This version: March 2017

Preliminary and incomplete
Do not circulate
Welcome any comments

Abstract

This paper provides the empirical evidence for the importance of heterogeneity to examine the effects of Free Trade Agreements (FTAs) on the exports. Using the case of FTAs of Korea, we find that the FTAs are associated with the increased volume of exports in product-level but not in aggregate-level. The increase, furthermore, is attributed to the products embodied with a lower-level of technology. This result suggests that the elasticity of export on trade costs varies across products depending on heterogeneity in production technologies. The finding implies that an FTA related to trade cost reduction to is expected to effectively increase the volume of exports in mainly the product with a lower-level technology.

Keywords: Free Trade Agreements (FTAs), Heterogeneity, Prody Index

---

[1] Center for Global Industrial Strategies, Korea Institute for Industrial Economics & Trade, 370 Sicheongdaero, Sejong 30147, Korea; Tel: 82-44-287-3158, Email: jhcho@kiet.re.kr

[2] Center for Regional Development, Korea Institute for Industrial Economics & Trade, 370 Sicheongdaero, Sejong 30147, Korea; Tel: 82-44-287-3184, Email: jkim@kiet.re.kr

I. Introduction

A bilateral or multilateral free trade agreements (FTAs) is one of the most important and practical policies to increase trade volume between two countries by reducing trade costs. Since the 1990s, a significant number of FTAs have been concluded to reduce trade costs worldwide.[3] A large group of literature provides empirical analysis for evaluating the effect of FTAs on trade volume, but the results seem inconclusive. Especially, the consequences of the analyses are sensitive and fragile depending on the selection of sample periods or countries.[4]

In this paper, we provide empirical evidence of the importance of heterogeneity in production technologies across exporting goods for examining the effects of FTAs. Especially, we apply *prody index* introduced by Hausmann, Hwang and Rodrik (2007) to capture the heterogeneity for each product. Considering the heterogeneity, we revisit the question about the effects of an FTA in the context of Korea. Korea is a useful laboratory to answer the question because it is one of the countries which have signed an FTA with the most number of countries as seen in Table A1. Furthermore, it has various bilateral agreements with both less and more developed countries fairly. [5]

The main result from the empirical analyses is that after the FTAs, export volume to the partner countries has been increasing at product-level while there is weak evidence at the aggregate level. However, the analysis shows strong evidence that this increase happened from products with relatively lower *prody index*. Instead of using dummy before and after FTAs, the paper also provides a consistent result with an additional robustness check which captures the actual reduction in trade cost for a subset of the FTAs. This result suggests that the elasticity of export with respect to trade costs varies across exporting products depending on heterogeneity in production technologies. The finding implies that an FTA is expected to effectively increase the volume of exports in mainly the product with a lower-level technology.

A large group of literature using gravity equations provides analyses of the effects of FTAs

---

[3] Following the WTO, 612 notifications of RTAs had been received by GATT and WTO and 406 of them were in force as of April 2015. See https://www.wto.org

[4] Ghosh and Yamarik (2004) argue that the trade creation effect of most regional trade agreements (RTAs) is fragile. Baier and Bergstrand (2009) also point out that the estimated effects of FTAs often display extreme instability across years and cases.

[5] Since Korea effectuated the first FTA agreement with Chile in April 2004, Korea has actively effectuated 10 FTA agreements including multilateral agreements by end of 2014.

on the change of trade flows.[6] Many previous works, especially Baldwin (1994), Frankel (1997), Sapir (2001) and Schott (2005) estimate the average treatment effect of an FTA with a dummy variable representing the presence or absence of an FTA. However, some recent literature such as Ghosh & Yamarik (2004) and Baier & Bergstrand (2009) point out that the coefficients estimated in this strand of literatures are unstable and inconclusive across years and cases of FTAs. In the case of Korea, Bae et al. (2012) also demonstrate that the FTAs have the positive impact on the export in Korea, but the magnitude of the effects differs across the cases of FTAs[7].

From this controversy, we get second thoughts that the increase in trade volume by an FTA would depend on a certain condition or case. Therefore, we follow the previous literature to estimate a partial effect between pre-FTAs and post-FTAs by using a dummy variable but additionally consider heterogeneity across the exporting goods. The idea of heterogeneity in the effects of FTAs across the goods comes up with the fact that the change in the export at the aggregate level after the FTA is not significant as much as the change in the export at the product level. In the case of US-Korea FTA.[8], for example, the export of Korea to the U.S. has only increased by 0.57 percent point on 3-year average at the aggregate level. At the product level, on the other hand, the change in export varies from -28.1 percent point to 23.5 percent point with the standard deviation of 14.1. The fact gives the idea that the heterogeneity, ignored at the aggregate level, across the exporting goods should be considered to capture the effects of the FTAs.

<Table 1> Average change in export before/after the FTA with the U.S.

(% point)

	3-year average change before/after the FTA
Aggregate level	0.57
Product level	
the highest 10% goods	23.5
the lowest 10% goods	-28.1

[6] See Anderson (1979), Bergstrand (1985), Baier and Begstrand (2001), Anderson and van Wincoop (2003, 2004), Baier and Begstrand (2007)

[7] They demonstrate that the FTA with Singapore has the largest effect on Korea's exports while there is little effect on exports in the case of the FTA with EFTA.

[8] Considering the trade volume and the number of the traded goods with the U.S., we regard the FTA with the U.S. as the representative case of the FTA in Korea. We also calculate the average change in export after the FTA with Chile which is one of the major FTAs in Korea. The results are not much different with the case of the U.S.; 0.15percent point at the aggregate level and -2.1~2.3 percent point at the product level.

The empirical analysis in the paper is theoretically based on Fieler (2011). Fieler (2011) proposes an analytically tractable Ricardian model with heterogeneity in technology across product based on Eaton and Kortum (2002) and confirms the heterogeneity can improve the model to match the real data. A gravity equation from Fieler (2011) considering the heterogeneity implies that the variable in the elasticity on trade can be different across each product. To construct a measure to capture this property, we use the *prody index* from Hausmann, Hwang and Rodrik (2007). Lall et al. (2006) point out the difficulty to measue of technology for tradable goods due to the lack of comprehensive data and suggest that the alternative idea that a higher income country exports a good requiring more technology. The *prody index* can capture the property well.

The heterogeneity in the effect of FTAs of Korea across the goods are also considered in Min et al (2011). For each good, they calculate the competitiveness of the individual good in the domestic market, and show that the effect of the FTA with Chile on Korea's import is larger for the goods which have exerted higher competitiveness in Korea before the FTA[9]. Our approach is in line with them in that we presume that the FTAs may differ across the products depending on the characteristics of the products.

Our findings are also related to a large group of the recent literature emphasizing cost uncertainty and heterogeneity at the level of firms, such as Bernard et al. (2003), Melitz and Ottaviano (2005). This strand of the literature emphasizes the heterogeneity to predict trade volume between countries. More recently, Ossa (2015) shows that there is cross-industry variation in trade elasticities and that considering it is critical to measure the gain of trade. Furthermore, there is pervasive evidence that the income elasticity of demand varies across products and the variation is economically meaningful.[10] So we examine how the heterogeneity across products responds to FTAs.

The rest of the paper proceeds as follows. Section II introduce the gravity equation from Fieler (2011) which includes heterogeneity in the elasticity of trade cost across products and how to construct a proxy for it using trade data. Section III conducts the empirical analysis. Section IV provides the alternative robustness check using reduction in actual trade costs instead of the dummy variable before and after FTAs. Section V concludes

---

9 For each good, they calculate the ratio of the import of a good from Chile to the total import of the good from the world and regard this ratio as the competitiveness of the individual good in the domestic market.

10 See Deaton (1975), Hunter (1991), Grigg (1994), Bils and Klenow (1998) and Fieler (2011)

II. Theoretical Backgrounds

In this section, we provide the theoretical backgrounds to derive the gravity equation based on Fieler (2011) which consider the heterogeneity in production technology. Furthermore, we explain how to measure the heterogeneity across tradable products based on Hausmann et al. (2007).

1. The Gravity Equation w/ the Heterogeneity in Production

Fieler (2011) extends the Ricardian model from Eaton-Kortum (2002) to a general equilibrium model for trade with heterogeneity in production technology. Fieler (2011) propose an analytically tractable Ricardian model that relaxed a homogenous good assumption. The paper assumes that there are two types of goods and the distribution of labor efficiency may be more variable for some types of goods than for others. In Eaton-Kortum (2002), a probabilistic representation of technologies to derive the distribution of prices is a key. Fieler (2011) considers two different goods that one has a larger spread of the distribution and the other has a smaller one. Input costs, i.e. wage if labor is the only input, govern relatively less comparative advantage across types in the larger spread but more in the small one. Under the circumstance, a higher income country which has a higher labor cost will produce a good with the larger spread while a lower income country will reverse ex-post.

Fieler (2011) derives a modified gravity equation as the following from the assumption.

$$X_{ij}(l) = \frac{T_i(c_i\tau_{ij})^{-\theta(l)}}{\sum_k T_k(c_k\tau_{kj})^{-\theta(l)}} X_j(l)$$

$X_{ij}(l)$ is the total export from country i to country j for product l. T_i is the parameter determining the level of the distribution for country i. c_i is the input cost for country i. τ_{ij} is the iceberg cost between country i and j. $\theta(l)$ is the spread of the distribution of technologies in production for product l. $X_j(l)$ is the total consumption of country j for product l. The equation is a gravity equation including multilateral resistance in the denominator and bilateral resistance in the numerator. The key difference from Eaton-Kortum is that θ varies across products. Fieler (2011) confirms that the variable θ across the types of goods make the model match to the trade pattern compared to one from Eaton-Kortum (2002).[11]

From the gravity equation, we find out that the relationship between the share of total export and the change of the trade cost may not be homogenous but should depend on *θ(l)* determining the spread of the distribution in production technologies.

2. Measure to Capture the Heterogeneity in Production Technologies

To capture the heterogeneity in the production technologies for each product, we follow the *prody index* introduced by Hausmann et al. (2007). We construct the proxy to measure the level of technology for each good using an index introduced by Hausmann et al. (2007), called the *prody index*. Hausmann et al. (2007) show that some trade goods are associated with higher productivity or technology levels than others. Furthermore, they show that a country with higher productivity or technology performs better for those goods so that the country exports more of them to the world market.

The index is a weighted average of the per capita GDPs of all countries exporting a given product, with the weight corresponding to the revealed comparative advantage of each country in good k. Let Y_j denote the per-capita GDP of country *j*. The *prody index* for product *k* equals,

$$prody_k = \sum_j \frac{(x_{jk}/X_j)}{\sum_j (x_{jk}/X_j)} Y_j$$

The numerator of the weight, X_{jk}/X_j is the value-share of the commodity in the country's overall export basket. The denominator of the weight, $\sum_j X_{jk}/X_j$, aggregates the value-shares across all countries exporting the good. So the weight reveals the comparative advantage of each country in each product. By definition of the index, a product which a higher income country considered having higher productivity and technology exports would have a higher value for it. This property is consistent with the prediction from the gravity equation from Fieler (2011) well.

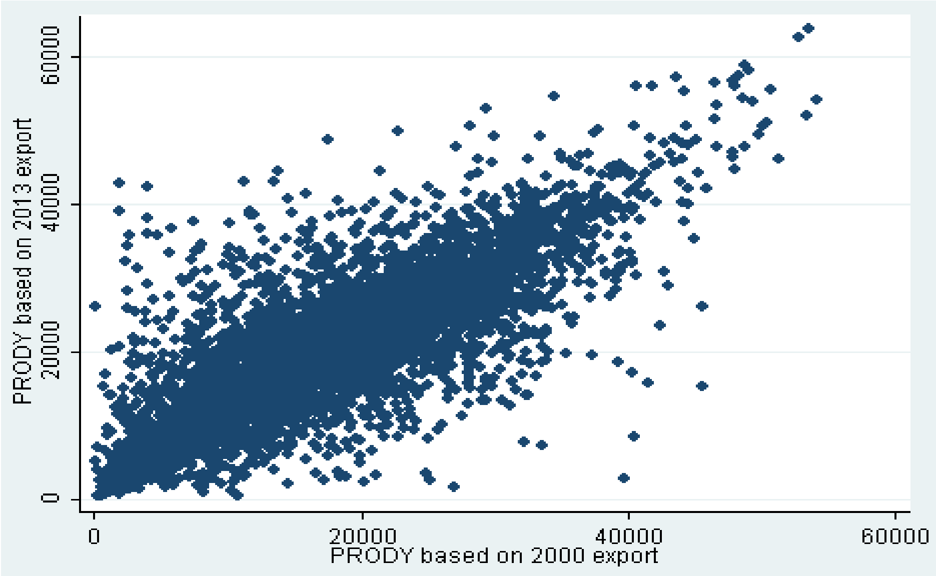
Prody index can also be interpreted as the level of the technology for the tradable good

[11] Fieler (2011) also consider nonhomothetic preference as well as the heterogeneity. The paper emphasizes that nonhomothetic preference alone is not enough to make the model to predict trade patterns.

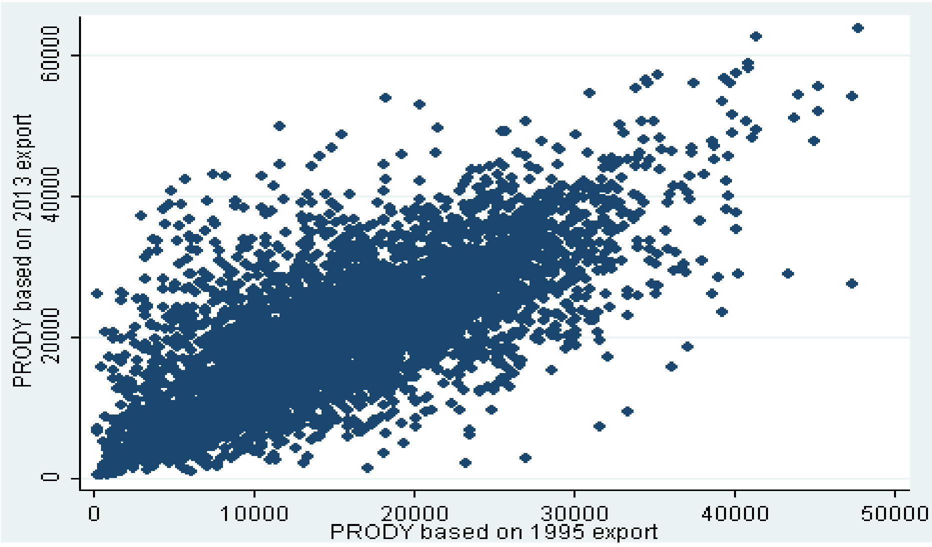
based on Lall et al. (2006). Lall et al. (2006) point out the difficulty in measuring the level due to the lack of data.[12] The paper suggests that per capita GDP of the exporting country can provide meaningful information for it. The good exported by a high-income country needs more technology or other then it overcomes the price competition from a lower income country. Higher share of higher-income countries which gives higher *prody index*, therefore, means a higher technology good.

It might be a concern that the *prody index* fluctuates over time. In this case, it is hard to interpret the index as time-invariant characteristics to capture embedded technology for each product because of volatility over time. It is hard, furthermore to interpret the impact on the change of trade volume with trade reduction in the next chapter. It is necessary, therefore, to check if the *prody index* is a time-invariant characteristic for each product, We calculate the index using export data in both 2000 and 2013 using HS92 from the United Nations Commodity Trade Statistics Data Base (COMTRADE). Since trade structure and income level across countries have been changing over time, it might be possible that the index also changed significantly. As shown in Figure 1, however, the indexes are highly correlated with each other and the correlation is 0.8. Even though we compare a longer period, from 1990 to 2013, the correlation is slightly smaller 0.74 but highly correlated as seen in Figure 2. Therefore, we presume that the *prody index* is a time invariant characteristic for each product.

[12] Factor intensity and technological intensity are practically popular way to measure the technology level in the product. Lall et al. (2006) point out that a basic problem from data with the method stems from the relatively high level of aggregation. Factor input data is normally from input-output tables or industrial data at 2-digit level as well as R&d expenditure by the manufacturing. Trade data, hoever, are available at highly disaggregated levels, i.e. 6-digit level.



<Figure 1> Correlation of Prody Index between 2000 and 2013



<Figure 2> Correlation of Prody Index between 1995 and 2013

III. Effect of FTAs on Export

In this section, we analyze how the heterogeneity in production technology in each product affects changes of export volume by FTAs. First, we test how the FTAs change Korean export volume to the partner countries at the aggregate level. We use the following gravity equation to examine how the export volume changes after the FTA compared to before.

Regression1: At aggregate level

$$Export_{ct} = \beta_0 + \beta_1 X_t + \beta_2 X_c + \beta_3 X_{ct} + \beta_4 FTA_{ct} + \varepsilon_{ct}$$

The dependent variable, $Export_{ct}$ is the share of exports from Korea to a partner country *c* over the world. During the sample period, 1988-2013, exports of Korea to the whole world increased quickly. Since we want to control unobservable factors in Korea which increase exports to most countries, we use the share of exports from Korea to partner countries over the world instead of the actual total value. We construct the percentage of exports from Korea to a partner country using export data from COMTRADE(HS92).

Our most important variable is FTA_{ct}, a dummy variable which has 0 and 1 for years before and after the FTAs with a country *c* respectively. We also control any time trend of the share of exports to country *c* so we include a time trend and any unobservable factor at time t as each year dummy in X_t. We also control time-fixed variable X_c such as distance and common language from the dataset constructed by Rose Dataset.[13] Distance is measured as miles between the main cities of two countries. Common language is a dummy variable which is unity if two countries have a common language. We also include time-varying variables X_{ct} such as GDP of Korea and a partner country for gravity variables. To measure the economic size between the two nations engaged in trade, we consider the interaction of real GDP of the two nations. We use GDP at 2005 US $ from the World Development Indicator (WDI) for this measure. In last, ε_{ct} is an error term.

We estimate the above equation using Ordinary Least Square (OLS) first. However, we are also concerned about some unobservable characteristics potentially affecting the dependent

---

[13] Rose Dataset is available at http://faculty.haas.berkeley.edu/arose/RecRes.htm#Trade

variable, so we estimate it with panel fixed effect. Our benchmark estimation focuses on panel analysis with controlling unobservable fixed effect. Since a country without an FTA with Korea would not have any variation in variable FTA_{ct} which is our main interest, we only include countries which signed an FTA with Korea as reported in <Table 2> in our sample. <Table 2> shows the results. The first low in <Table 2> indicates that the share of exports to a country is positively associated with the FTA dummy. It means that the share of export volume to each country is higher in the presence of the FTAs compared to the absence of them. However, the second low in <Table 2> shows that the coefficient between the share of exports and the FTA dummy is insignificant after controlling unobservable time-country fixed effect. Therefore, it was difficult to conclude that the volumes of exports from Korea to partner countries increased after FTAs.

<Table 2> The effects of FTAs on Export in Korea at Aggregate Level

	[1]	[2]
	Pooled OLS	FE
ln (Distance)	-0.387**	
	[0.136]	
Common language	2.296**	
	[0.345]	
ln (GDPR*GDPP)	0.822**	1.549**
	[0.096]	[0.548]
FTA dummy	0.544*	0.387
	[0.229]	[0.393]
Observations	1,040	1,040
R-squared	0.329	0.067

Note: Dependent variable (EXP_{ct}) is the share of exports from Korea to a partner country *c* at the aggregate level. ln(Distance) is the logarithm of miles between the main cities of two countries. Common language is dummy variable which is unity if two countries have a common language. Ln(GDPR*GDPP) is the interaction of real GDP of two countries engaged in trade. We use GDP at 2005 US $ from WDI. FTAs is time-varying dummy variable which is unity if FTAs is started at t between Korea and a partner country and zero otherwise. Year dummy and the constant term are included in the regression but not report here. ** and * indicates 1% and 5% significant level, respectively. Numbers in brackets are robust standard errors.

Now, we estimate the above equation considering the heterogeneity of each product. We use the Harmonized System (HS) 6-digit level, so the export data includes export value to individual countries signing an FTA with Korea worldwide with about 4,700 products. Especially, our main interest is how FTAs affect the export volume of goods from Korea depending on the different levels of technology. We estimate the following equation similar to the previous one but at the product level. Additionally, we include an interaction term of the FTAs dummy and *prody index* ($PRODY_i$) for each product to check how the different level of technology matters corresponding to the FTAs. We construct the *prody index* using each export data from COMTRADE and GDP at 2005 US$ in 2013 using the equation in Section II. As we already showed it is invariant depending on trade data from different years. The other variables are the same as those at the aggregate level analysis.

Regression2: By product

$$EXP_{cit} = c + \beta_1 X_t + \beta_2 X_c + \beta_3 X_{ct} + \beta_4 FTA_{ct} + \beta_5 FTA_{ct} \cdot PRODY_i + \varepsilon_{cit}$$

Since there is the additional interaction term, we can interpret the effect of the FTAs based on not only coefficient β_4 but also β_5. The effect of FTAs would be $\beta_4 + \beta_5 \cdot PRODY_{cit}$. Therefore, if $\beta_5 > 0$, then the FTAs increased export volume of a product comparing to the world more especially to the higher level of technology while if $\beta_5 < 0$, then FTAs increase export of a product more in the lower level of technology as predicted of the discussion in section II. <Table 3> shows the results. The results in <Table 3> indicate that FTA dummy is positively associated with the share of exports from all differently specified estimations. We can find evidence at the product level that Korean exports to the partner countries increased after the FTAs comparing to others, so it is significantly important to consider the heterogeneity of products to examine the precise effects of FTAs. The coefficient of the interaction term is negative which is consistent with the prediction of Fieler (2011). Therefore, the FTAs of Korea increased exports to the partner countries relatively, but it mostly happened in lower-technology products.

<Table 3> The Effects of FTAs on Export in Korea at Product Level

	[1]	[2]	[3]	[4]
	Pooled OLS		FE	
ln (Distance)	-3.385**	-3.362**		
	[0.031]	[0.031]		
Common language	3.108**	3.109**		
	[0.033]	[0.033]		
ln (GDPR*GDPP)	2.422**	2.409**	1.866**	1.853**
	[0.012]	[0.012]	[0.138]	[0.137]
FTA dummy	1.894**	1.903**	0.356**	0.411**
	[0.046]	[0.047]	[0.052]	[0.052]
$\ln\widetilde{Prody}$*FTA dummy		-0.362**		-0.549**
		[0.057]		[0.078]
$\ln\widetilde{Prody}$		-0.392**		
		[0.027]		
Observations	921,306	921,306	921,306	921,306
R-squared	0.103	0.104	0.013	0.013

Note: Dependent variable (EXP_{cit}) is the share of exports of commodity *i* from Korea to a partner country *c*. The *Prody* index is measured as a weighted average of the per capita GDPs of all countries exporting a given product, with the weight corresponding to the revealed comparative advantage of each country in good i. $\ln\widetilde{Prody}$ in the regression above indicates the demeaned *Prody* index such that $\ln Prody_i - \overline{\ln Prody}$. For other independent variables such as ln(Distance), Common language, ln(GDPR*GDPP) and FTA dummy, please refer to <Note> in Table 2. Year dummy and constant term is included in the regression but not report here. ** and * indicates 1% and 5% significant level, respectively. Numbers in brackets are robust standard errors.

Our finding is consistent to the recent researches how heterogeneity matters to examine the effects of a bilateral trade. Recent literature such as Bernard et al. (2003), Melitz and Ottaviano (2005) emphasize the role of heterogeneity in predicting trade pattern across countries. This kind of literature asks us to analyze the effect of a change in trade volume not at the aggregate level but a more micro level such as product level. Furthermore, recent research by Ossa (2015) shows that there is a significant variation in the elasticity of trade costs across industries and the variation is economically meaningful to determine the gain of trade. For example, estimated elasticity of trade costs across products varies from 1.5 to 25 in value.[14] In that sense, even the same extent of reduction in trade costs after an FTA, the trade

[14] Ossa (2015) estimate them at 3 digit (SITC code) and the average value of the elasticity is 3.6

would not be expected to increase uniformly. Furthermore, we can easily guess that a product with lower technology would be sensitive to a change of price compared to that with higher technology.

To recap our conclusions from the empirical analyses, we note that it is cautious to interpret the coefficient as we discuss in this section. There is one practical issue we cannot include in the analysis. To identify treatment pre and post FTAs, we presume that the reduction of trade costs exists uniformly across products because we use only a dummy variable to assign 1 for a time after FTAs and 0 before it instead of measuring actual trade cost reduction. However, we can separate the interpretation of the coefficient from the empirical results into two parts.

$$\beta = [e_1 \quad \cdots \quad e_J] \begin{bmatrix} d_1 \\ \vdots \\ d_J \end{bmatrix}$$

The first vector *e* is one by j vector which included elasticity of the trade cost for each product *j*. The second vector *d* is one by j vector which included the extent to capture whether how much the reduction of the trade cost happened or not at all. We interpreted the coefficient of our empirical results based on the assumption where all d_i is one. If the vector *d* is ones, it means that there is the same reduction of trade cost across products due to an FTA and the change of export volume would depend on only the elasticity of trade cost. However, there might be the possibility that there is a variation across d_is and not one which means that extends of reduction costs vary across each product even across each FTA case.

For example, suppose that a country wants to protect domestic firms which produce good *j* so it negotiates with its partner to keep its incumbent tariff rate after the FTA. In that case, we would observe no change of export even if the product has a high elasticity of trade cost. Most developing countries might try to protect their industry with lower competitiveness from opening the market. We presume that a developed country has a comparative advantage for a product with relatively high technology as we constructed our index to capture the characteristic for each product. So, it might be possible there would be no trade cost reduction in an industry with high technology products even after an FTA in a developing country because they exclude the reduction of the tariff in provisions of the FTA. This point is critical for our empirical analysis because we only identify times at effectuating FTAs but not the actual extent of the cost reduction for each product from it. However, to determine the coefficient separately as the above, we need to examine all provisions for each product of each FTAs. We will discuss this issue further in the next section.

IV. Robustness Check Using Tariff Rates

This section provides additional robustness analysis about the issue related to the interpretation of the empirical analysis in Section III. We try using a measure for the extent of reduction in trade cost according to the FTAs to avoid the problem discussed before. The analysis in this section uses tariff rates applied to Korea according to the FTAs versus MFN (Most Favoured Nationa) tariff rates instead of the simple dummy in the last section. We implement the tariff rated under FTAs as one after the FTAs and MFN tariff rates as one before them. This makes our analysis distinguish actual reduction in trade cost and the elasticity of trade cost. The information comes from KIET DataBase Management System (DBMS) constructed based on WTO Integrated Data Base, FedEx World Tariff and Korea Customs Service. We have the tariff information for 12 countries and about 5,200 products for each country. <Table 3> shows the basic descriptions of tariff information.[15] It is observable that the partner countries levy lower tariff rate to Korea under the FTAs related to one to MFN.

<Table 4> Description of Tariff Data from KIET DBMS

Description	# Products	Tariff Rate to Korea	Tariff Rate to MFN
China	5208	7.2%	9.3%
Vietnam	5292	2.2%	9.6%
Singapore	5208	0.0%	0.0%
India	5205	5.9%	13.3%
Austrailia	5204	0.2%	2.5%
Indonesia	5212	1.3%	7.9%
Myanmmar	5197	0.5%	5.0%
UK	5299	0.1%	4.0%
Turkey	5205	6.8%	10.8%
Canada	5318	1.9%	3.4%
Norway	5205	1.5%	2.2%
US	5369	2.6%	5.8%

Note: Column 3 and 4 shows the average tariff rate applied to Korea under FTAs and one applied to MFN.

<Table 5> shows the estimation result from the similar analysis in the last section but we use the tariff rates instead of the dummy. The result indicates that the tariff rate is negatively

[15] Some products provide different tariff rates at lower 6-digit level. In this case, we calculate the simple average upto the 6-digit level.

associated with the trade volume across products, so a decrease in tariff from the FTAs evidently increases trade export of Korea to the partner countries. However, the coefficient of the interaction term shows positive and statistically significant. The result conclude that the decrease in trade cost would increase the export, but the effect is mainly associated with a product with a lower technology. So the discussion in the previous section is consistent to the robustness analysis in this section.

<Table 5> The Effects of FTAs on Export in Korea at Product Level (Using Tariffs Data)

	[1]	[2]	[3]	[4]
	Pooled OLS		FE	
ln (Distance)	-23.578**	-23.537**		
	[0.155]	[0.157]		
Common language	-0.866**	-0.933**		
	[0.060]	[0.062]		
ln (GDPR*GDPP)	7.303**	7.296**	8.566**	8.603**
	[0.043]	[0.043]	[0.390]	[0.390]
Tariff rate bef/aft FTA	-2.202**	-3.611**	-6.390**	-5.469**
	[0.675]	[0.763]	[1.254]	[1.271]
ln$\widetilde{\text{Prod}}$y* Tariff rate bef/aft FTA		-0.569		5.008*
		[0.906]		[2.145]
ln$\widetilde{\text{Prod}}$y		-1.031**		
		[0.066]		
Observations	294,230	294,230	294,230	294,230
R-squared	0.132	0.133	0.028	0.028

Note: Dependent variable (EXP_{cit}) is the share of exports of commodity *i* from Korea to a partner country *c*. To capture the change in tariff rate after FTA, we include the variable of Tariff rate bef/aft FTA. The variable indicates a tariff rate imposed on a commodity i which is imported from Korea after FTA with Korea become effective. Due to the data limitation, we use a general tariff rate imposed on commodity i if FTA between Korea and country *c* is not concluded yet. For other independent variables such as ln(Distance), Common language, ln(GDPR*GDPP), FTA dummy and p*rody index,* please refer to <Note> in Table 2. Year dummy and the constant term are included in the regression but not report here. ** and * indicates 1% and 5% significant level, respectively. Numbers in brackets are robust standard errors.

V. Conclusion

In this paper, we examine the importance of heterogeneity of each product on the effects of FTAs. Recent literature emphasizes the elasticity of trade cost may vary depending on technology level embodied on each product. Following Hausmann et al (2007), we construct a measure of technology for each product and provide evidence that the index is quite time-invariant. Then using product level export data and cases of FTAs in Korea, we empirically test how this technology difference for each product affects a change of export volume after the FTAs.

Our empirical results show that Korean exports to the partner country increased at the product level after FTAs while it is ambiguous at the aggregate level depending on the specification. However, we find strong evidence that the increase happened in products with relatively lower technology. Furthermore, we provide an additional robustness test using the changes of tariff rates before/after FTAs. From the robustness, we provide empirical evidence of the elasticity of trade cost vary across products.

The empirical finding contributes to both theoretical and policy aspects. In the theoretical aspect, we provide the evidence that heterogeneity in the product is critical to examine trade patterns after the reduction in trade cost. Especially, the product embodied a lower technology is more elastic as previous theoretical works predict. In the policy implication, an FTA related to the reduction of trade cost, i.e. tariff reductions, may increase export or import in products mainly embodied a lower technology.

This paper, of course, did not include various aspects which may be critical, for example, non-tariff barriers in FTAs. Some important aspects such non-homothetic or dynamics from FTAs in theoretical aspect were not discussed much. We leave these aspects for future works.

References

Anderson, James E., "A theoretical foundation for the gravity equation," *American Economic Review* Vol. 69 (1), 1979

Anderson, James E., van Wincoop, Eric, "Gravity with gravitas: a solution to the border puzzle," *American Economic Review* Vol. 93 (1), 2003

________________________________ , "Trade costs," *Journal of Economic Literature* 62 (3), 2004

Bils, M., and P. Klenow, "Using Consumer Theory to Test Competing Business Cycle Models," *Journal of Political Economy* Vol. 106, 1998

Baier, Scott L. and Jeffrey H. Bergstrand, "The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity," *Journal of International Economics* Vol.53 (1), 2001

___________________________________, "Do free trade agreements actually increase members' international trade?" *Journal of International Economics* Vol. 71 (1), 2007a

___________________________________, "Estimating the Effects of Free Trade Agreements on International Trade Flows using Matching Econometrics," *Journal of International Economics* Vol.77, 2009

Baldwin, Richard E., *Towards an Integrated Europe*. London: CEPR, 1994

Bernard A. B.,J. Eaton, J. B. Jensen, and S. Kortum, "Plants and Productivity in International Trade," *American Economic Review* Vol. 93(4), 2003

Bergstrand, Jeffrey H., "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence," *Review of Economics and Statistics* Vol. 67 (3), 1985

Deaton, A., "The Measurement of Income and Price Elasticities," *European Economic Review*, Vol.6, 1975

Frankel, Jeffrey A., *Regional Trading Blocs in the World Economic System*. Washington, DC: Peterson

Institute for International Economics, 1997

Fieler A.C., “Nonhomotheticity and Bilateral Trade: Evidence and a Quantitative Explanation,” *Econometrica*, Vol. 79 (4), 2011

Grigg, D., “Food Expenditure and Economic Development,” *GeoJournal* Vol.33, 1994

Ghosh, S. and Y. Steven, “Are regional trading arrangements trade creating?: an application of extreme bounds analysis,” *Journal of International Economics,* Vol.63 (2), 2004

Hausmann R., J. Hwang, and D. Rodrik**.** “What You Export Matters,” *Journal of Economic Growth* 2007

Hunter, L., “The Contribution of Nonhomothetic Preferences to Trade,” *Journal of International Economics*, Vol.30, 1991

Melitz Marc J. and Gianmarco I. P. Ottaviano, “Market Size, Trade, and Productivity,” *Review of Economic Studies* Vol. 75, 2008

Ossa R., “Why Trade Matters After All,” forthcoming in *Journal of International Economics*

Sapir, A., “Domino effects in Western European regional trade,” *European Journal of Political Economy* Vol.17, 2001

Schott, J., *Free Trade Agreements: U.S. Strategies and Priorities*. Washington, DC: Peterson Institute for International Economics, 2005

<Table A1> Effective date of FTAs of Korea

Partner Country	Effective date
Chile	Jan. 2004
Singapore	Mar. 2006
EFTA (Switzerland, Norway, Iceland, Liechtenstein)	Sep. 2006
ASEAN	Jun. 2007
Brunei	Jul. 2008
Cambodia	Nov. 2008
Indonesia	Jun. 2007
Laos	Oct. 2008
Malaysia	Jun. 2007
Philippine	Jan. 2008
Myanmar	Jun. 2007
Singapore	Jun. 2007
Thailand	Jan. 2010
Vietnam	Jun. 2007
India	Jan. 2010
EU	Jul. 2011
Peru	Aug. 2011
U.S.	Mar. 2012
Turkey	May. 2013
Australia	Dec. 2012

Note: The table shows that the effective dates of each FTA of Korea from www.fta.go.kr

Data Description

Data for constructing PRDDY

Trade data used in this paper come from the United Nations Commodity Trade Statistics Database (COMTRADE). At the Harmonized System (HS) 6-digit level, we use the data on individual countries' export to the world for over 4,700 products in 2013. The value of exports is in current US $. We obtain the GDP per capita at 2005 US $ from World Development Indicator (WDI) which covers over 150 countries.

Gravity Variable

For the time-fixed gravity variables such as distance and common language, are from dataset constructed by Rose[16]. Distance is measured as miles between the main cities of two countries. Common language is dummy variable which is unity if two countries have a common language. To measure the economic size between the two nations engaged in trade, we consider the interaction of real GDP of two countries. We use GDP at 2005 US $ from WDI for this measure. Basic statistics are described in <Table A1>

Other set of variables

To construct the dependent variables, the share of export from Korea to a partner country *c* over the world, we also use the COMTRADE data for the value of export reported by Korea to a partner country and world, respectively, for years 1988-2013. Time trend is measured by linearly approximating the increasing trend over time. FTAs is time-varying dummy variable which is unity if FTAs is started at t between Korea and a partner country and zero otherwise.

<Table A1>

Variable	Obs.	Mean	Std. Dev.
Commodity export share	921,306	4.39	12.54
log (Distance)	921,306	8.34	0.46
Common Language	921,306	0.31	0.46
log (size)	921,306	53.84	1.77

[16] Rose Dataset is available at http://faculty.haas.berkeley.edu/arose/RecRes.htm#Trade