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FTA Effects on Agricultural Trade with Matching Approaches

GaSeul Lee and Song Soo Lim

Abstract
While the trade effect of free trade agreements (FTAs) is a global issue, little research has examined the economic effects of trade liberalization on agricultural products with robust empirical methods. In this study, propensity score matching for controlling selection bias is used to examine and analyze the effect of FTAs on the trade of South Korea's agricultural products. To enhance the robustness of estimated results, differences between the FTA treatment effects in 2010 and 2012 are analyzed. The results reveal that the effect of FTAs on agricultural trade varies slightly, depending on the matching approach used; however, the signs of all estimated average treatment effects on the treated (ATT) values are positive, and more values are positive in 2012 than in 2010. Analysis of the difference between selection bias controlled through matching and uncontrolled selection bias shows the value of the average treatment effect (ATE) with uncontrolled bias is greater than the ATT estimate calculated through matching. This implies that controlled versus uncontrolled selection bias can result in different ATE and ATT estimates, and that prior studies on FTA trade effects have overestimated the effect, as selection bias was not addressed therein.

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Keywords Free trade agreements; agricultural trades; propensity score matching; selection bias

Authors
GaSeul Lee, Korea University, Seoul, Korea, gaseul2@korea.ac.kr
Song Soo Lim, ✉ Korea University, Seoul, Korea, songsoo@korea.ac.kr

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I. Introduction

Since the Uruguay Round in 1994, multilateral negotiations have been led by the World Trade Organization (WTO). However, as multilateral negotiations led by the WTO have progressed slowly, different types of preferential trade agreements that lower tariffs and nontariff barriers for goods, services, investments, intellectual properties, and government procurement between signatories are proliferating globally and helping to facilitate mutual trade. According to the WTO Regional Trade Agreements Information System (RTA-IS, rtais.wto.org), 268 FTAs are in force worldwide.

Since the conclusion of a free trade agreement (FTA) with Chile in April 2004 to "catch up" with global trends, South Korea has ratified nine additional FTAs, with Singapore, the European Free Trade Association (EFTA), the Association of Southeast Asian Nations (ASEAN), India, the European Union (EU), Peru, the United States, Turkey, and Australia. The country also signed five FTAs with Colombia, Canada, China, New Zealand, and Vietnam.[1)]

A rapid expansion of FTAs is partly explained by pursuing strategies associated with export led growth models (Palley 2012). Especially, FTA-driven trade creation is regarded as a powerful engine of economic growth for Asian economies, including South Korea (Frankel et al. 1996; Kawai and Wignaraja 2014). However, active pursuit of the so-called mega-FTAs and multiple trade deals en masse by South Korea have created a sense of anxiety in which political leaders and farm organizations are constantly fearful of a surge in imports that may lead to the collapse of the whole farm sectors. Relying on foreign sources for more than 70% of its domestic food needs, and struggling with relatively higher production costs, the country has stuck to the negotiation rule of "exclusion from the concession or partial opening up" for major agricultural products in every trade liberalization talks.

The "opening up" of the South Korean agricultural markets through the channels of FTAs was not until 2011 when each of the EU and the United States became members of the economic blocs. As Kwon et al. (2005) and Kwock et al. (2010) implied, the country began to import a large amount of agricultural products, which resulted in greater trade deficits.

Figure 1 illustrates the volumes of agricultural products exported from and imported into South Korea with FTA and non-FTA member countries between 2004 and 2012. Following the WTO's classification, this paper defines agricultural products as goods bearing harmonized system (HS) codes of 01–24 at the two digit level. Agricultural imports and exports alike increased with both FTA and non-FTA partners. Agricultural imports from FTA blocs are found to be rapidly increasing, and in 2012 exceeded the amount from non-FTA countries. Agricultural exports have also increased with FTA members, to gradually reduce the gap of exports with non-FTA economies. This sheds light on a significant trade effect of successive FTAs.

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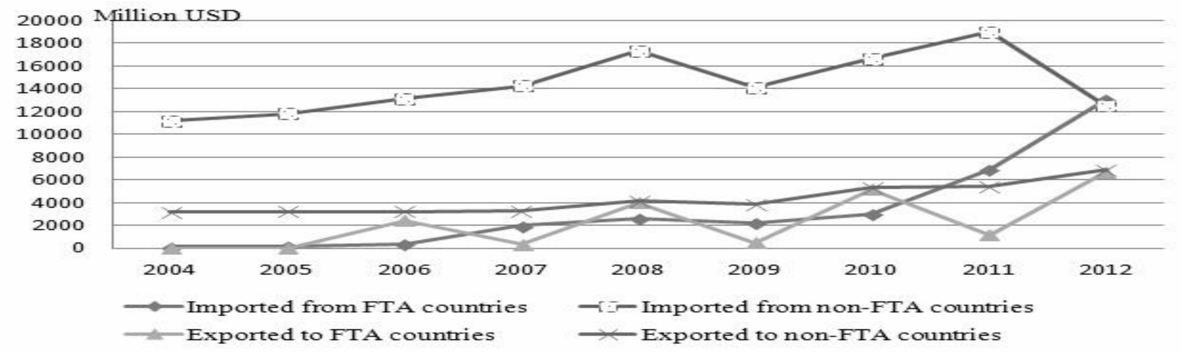
1) An up-to-data status of South Korea's FTAs is posted at the governmental portal website (fta.go.kr).

Figure 1. Agricultural Trade with FTA and Non-FTA Countries



Source: Global Trade Atlas

Table 1 illustrates the agricultural trade within or outside of FTAs. It shows the volumes of trade with those countries each year from the year in which the respective FTA took effect. As of 2014, 15 FTAs had either been signed or taken effect of which South Korea was a party, but only the FTAs that had been effective for at least two years are presented, in order to count for the full-launch FTAs.

Table 1. Agricultural Trade with FTA Countries (millions of US dollars)

Country (Year in effect)	Trade	Year in effect	1st	2nd	3rd	4th	5th	6th	7th	8th
Chile (2004)	Import	126	183	233	299	280	308	329	459	484
	Export	1.2	1.0	0.8	2.4	3.5	3.3	4.5	7.5	5.2
Singapore (2006)	Import	37	42	47	52	83	102	94		
	Export	26	30	40	47	89	85	95		
EFTA (2006)	Import	74	103	93	108	144	209	187		
	Export	5.2	3.6	5.7	5.2	7.0	7.2	14		
ASEAN (2007)	Import	1539	2226	1789	2113	3189	3345			
	Export	314	399	454	607	853	983			
India (2010)	Import	346	417	641						
	Export	12	13	11						

Source: Global Trade Atlas

In comparison to 2004—the year in which an FTA with Chile, the first country with which South Korea signed an FTA, was signed and took effect—exports increased 4.3-fold in 2012, the eighth year of the FTA. Imports have also increased 3.8-fold. With Singapore, exports and imports have increased 3.6 and 2.5-fold, respectively, in the sixth year of the FTA, in comparison to the year in effect. Exports to and imports from the EFTA have increased 2.7 and 2.5-fold, respectively. In the fifth year of the FTA implementation with the ASEAN exports and imports have increased 3.1 and 2.2-fold, respectively. Exports to India have slightly decreased, but imports have increased 1.7-fold.

However, increases in bilateral trade under each FTA framework may not be considered as net trade effects on the grounds that multiple FTAs are inextricably interwoven with one another and simultaneously effective. Besides, a variety of factors, including exchange rate fluctuations, tariffs, non-tariff measures, and natural disasters can affect trade to a large extent. This means that it is not appropriate to estimate the effect solely of institutions, given the unexpected issue of selection bias. Therefore, selection bias should be controlled to identify the pure effect of policies that FTAs have on the trade of South Korea's agricultural products.

To this end, this study uses propensity score matching (PSM) —a non-empirical approach to mitigating selection bias while focusing on a country's observable heterogeneity—rather than empirical estimations that are used to control for a country's observable heterogeneity. PSM is an approach used to address selection bias by applying two strong conditions as restrictions in estimating propensity scores (Blundell and Costa-Dias 2009). Because agricultural trade data, not probabilistic data, are used to classify FTA and non-FTA countries, selection bias can occur. Therefore, PSM is used in this study to analyze the trade effect of FTAs, and to suggest implications. To ensure robust estimation results, data from 2010 and 2012 are compared and explained.

This study is organized as follows. Section 2 describes previous studies that investigated the effects of FTAs with respect to South Korea. Section 3 explains both the characteristics of PSM and the methodology, and defines the variables used in this study. Section 4 applies PSM and identifies the characteristics of each set of matching-approach results; it also explains the trade effect by comparing differences between 2010 and 2012. Section 5 offers conclusions and implications.

II. Literature Review

While a priori studies analyze the feasibility of an FTA prior to negotiations, ex post FTA studies explore the economic effects associated with trade policy reforms, including tariff cuts or elimination. Both prior and post-FTA studies focus on the impact of FTAs on trade volume following the reduction or elimination of tariffs in the domestic market.

Widely adopted analytical methods include those that make use of the computable general equilibrium (CGE) model, the partial equilibrium model, and the gravity model. The CGE model quantitatively measures the effect of bilateral FTAs, through the use of virtual simulation; it generates easily understood macro-indexes. However, the CGE model is not ideal for analyzing subdivided markets, and its results are considered unreliable due to the unrealistic assumptions therein. The partial equilibrium model considers agricultural products produced and imported as homogeneous goods, to define the difference between domestic demand and supply as an import-demand index. It is estimated changes in import demand after price changes have occurred among imported goods, to measure impact. However, it is not ideal either, because domestic and imported agricultural products are considered homogenous goods, and hence quality differences are ignored. The criticism has arisen that using this method contributes to an overestimation of price drops or reduced production. The gravity model adds geographical factors—including economic scale and distance, *inter alia*—to analyze both the factors that determine trade volume between bloc economies and the welfare effect of FTAs. However, it is only weakly based on economic theory, and it is criticized for its lack of consideration of substitution effects among countries (Bikker 1987).

Table 2 lists the studies that have examined the welfare effects of FTAs with respect to South Korea's agricultural trade.

Table 2. A Selective List of FTA Studies

Country	Empirical studies			Non-empirical studies
	Computable general equilibrium	Partial equilibrium	Gravity model	
Chile		Eor et al. (2000) Moon and Hong (2004) Kim and Choi (2007) Moon et al. (2012)		Park (2013)
Singapore		Choi and Choi (2004)		
EFTA		Eor et al. (2004)		
India		Lee and Kim (2008)		
EU			Kwock et al. (2010)	
United States	Kim (2001) Lee et al. (2005) Kim (2008) Ahn et al. (2009)	Kwon et al. (2005) Kim (2006) Kim and Jang (2008) Moon et al. (2013)		Cooper and Manyin (2011)

Source: Authors' compilation

Most prior studies have estimated the expected effects of FTAs, in advance of their conclusion. The number of post-FTA studies—which analyze the effect of FTAs on an economy, following their conclusion—is relatively small. All of these studies focus on bilateral free trade—for example, with Chile, the EU, and the United States—while explaining some of the particulars of certain trade items like beef, red pepper, and fruit.

To verify empirically the effects of FTAs on agricultural trade, it is essential to select and use a method capable of analyzing cause and effect among variables. A key component of this process is the isolation of the effect on agricultural trade. Given various extraneous demand-and-supply fluctuation factors, it is difficult to quantify the net effects imposed solely by an FTA. Although linear regression, or other techniques which use it, can analyze many matters and an effective control method can be added, all are subject to selection bias.

Selection bias refers to the bias that arises when a sample selected for investigation is not sufficiently representative. A quasi-experimental or nonexperimental design is generally used to measure the effect of government policy or projects. Because such designs do not allow for the random allocation of items to be processed in pertinent study groups, the issue of selection bias control often arises.

Estimation methods frequently used to address problems subject to selection bias include instrumental variable estimation, Heckman's two-stage estimation, the fixed-effects model, and the matching approach (Damondar and Dawn 2008). However, even these methods pose challenges. It is difficult to pinpoint ideal instrumental variables within an instrumental variable estimation. It is essential to use lagged variables as an independent variable in the fixed-effects model. In Heckman's two-stage estimation, it is difficult to determine ideal explanatory variables that classify the selection equation and the outcome equation (Lee et al. 2008; Kim 2010). The basic logic of the matching approach is to identify what will happen if the object for treatment and observation is not treated through matching. The matching approach is used to analyze the effect solely of FTAs among non-FTA countries that have characteristics similar to those of the FTA countries, within a comparison group. Although it is widely used to analyze the effect of institutions, the matching approach is relatively new to trade analysis.

Baier and Bergstrand (2009) used the gravity model and Mahalanobis matching to undertake analysis while focusing on the distance factor. They controlled selection bias through matching, and used the gravity model to efficiently estimate the effect of FTAs in considering the distance factor. They drew the conclusion that the long-term effect of FTAs is a stable and significant trade volume increase between signatories. This finding is very similar to the result obtained through experiments.

Chang and Lee (2011) used pair matching to analyze the effect of trade among General Agreement on Tariffs and Trade (GATT)/WTO members after signing an FTA. Although they used the same data as Rose (2004), they reached a different conclusion of a facilitating trade effect following the signing and enforcement of FTAs.

Iacus et al. (2012) used coarsened exact matching (CEM): an effective approach for reducing imbalance between a treatment group and a comparison group in order to control selection bias. This method, however, leads to sample loss in the process of coarsening each section of the treatment group and the comparison group. Therefore, CEM is an approach ideal for a case involving a large sample.

Although they are efficient approaches to estimating the effect of FTAs, Mahalanobis matching, pair matching, and CEM are not ideal for use in the study of countries with a small number of FTA signatories, like South Korea. If the number of variables that represent any characteristics is not the same among comparison groups, problems will occur in selecting sections between groups. In fact, matching based on these variables will be impossible (Dehejia and Wahba 2002). An alternative used to address this problem is the matching approach based on propensity scores (i.e., PSM), which has been widely used to analyze the effect of policies. This is a method used to minimize selection bias, the greatest weakness inherent in a quasi-experimental design. It makes use of bootstrapping, which allows the treatment group and the comparison group to have as many similar or identical propensities as possible (Rosenbaum and Rubin 1983).

Hayakawa (2012) used 1:1 nearest-neighbor matching, among other PSM approaches, to determine that FTAs do not have a great impact on unemployment. Nayga et al. (2011) wanted to identify the effect of school lunch programs in elementary schools on obesity among school children. This study aimed to control selection bias and used the nearest-neighbor, kernel, and radius-matching approaches. In particular, the radius-matching approach was used to widen the scope of radius by 0.5 units on the basis of the treatment group, to compare changes in the effect of treatment. Kim and Kim (2011) used data matching to analyze wage gaps among temporary workers. That study identified differences in the wage effect before and after data matching, and robustly explained the effect of wage gaps by controlling the ratio of the treatment group to the comparison group.

However, only a few studies have used matching approaches to estimate the effects solely of FTAs and no previous empirical study has examined the effect of FTAs on South Korea's agricultural trade.

III. Empirical Methods and Data

3.1 Selection Bias

It is necessary to compare the conclusion of FTAs in their absence, in order to measure the effect of FTAs on a country's agricultural trade. However, in reality, it is impossible to compare cases in which South Korea has concluded an FTA with one country, to the cases in which has and *not* concluded that FTA. Therefore, in this study, PSM analysis is used to identify countries with propensities similar to those of countries who have concluded FTAs with South Korea as a comparison group. The end point is to analyze outcome differences between the treatment and comparison groups. This method can have some issues. Selection bias can occur due to unexpected factors, i.e., effects caused by factors other than FTAs, such as tariffs, natural disasters, social issues, and political issues. Therefore, in using general linear regression (or methods that apply it), there is a need to use an effective method to control for these factors.

The effect of an FTA is defined as the difference between the result observed with an FTA for a given country, and the result seen in a non-FTA country at the same temporal point as the treatment country (Heckman and Todd 1997). More specifically, the FTA effect is calculated as a treatment effect through the following equation, in which Y_{1i} is the result that occurs when a specific country i signs an FTA with South Korea at time t; Y_{0i} is the result that occurs when the country does not sign an FTA with South Korea in t; and (α_i) is the difference between the results, given that the dummy variable of FTA participation is D_i (signing, $D_i = 1$; nonsigning, $D_i = 0$).

$$\alpha_i = Y_{1i} - Y_{0i},\ Y_i = D_i Y_{1i} + (1 - D_i) Y_{0i} \tag{1}$$

$$ATE = E(\alpha_i) = E(Y_{1i}) - E(\ Y_{0i}) \tag{2}$$

Equation (2)—which uses the expected values from equation (1)—defines the average treatment effect (ATE). However, it is impossible to measure the "real effect obtained for the case in which an FTA with the same country is simultaneously *not* signed," to measure the real effect of its institution. That is, the value observable in one country i can be only one of Y_{0i} or Y_{1i}, for what is referred to as a "counterfactual situation." This is an effectiveness analysis method, but it cannot efficiently control selection bias. Heckman and Todd (1997) point out that selection bias can occur on account of differences in various values observed as being different. They suggest the use of the average treatment effect on the treated (ATT) of the actual treatment effect α_i.

$$\begin{aligned} ATT &= E(Y_i|D_i = 1) - E(Y_i|D_i = 0) \\ &= E(Y_{1i}|D = 1) - E(Y_{0i}|D = 1) + E(Y_{0i}|D = 1) - E(Y_{0i}|D = 0) \\ &= E(Y_{1i} - Y_{0i}|D = 1) + S_i \end{aligned} \tag{3}$$

where S_i is selection bias $E(Y_{0i}|D = 1) - E(Y_{0i}|D = 0)$, and D is a dummy variable that indicates the signing of an FTA and is assumed to be a parameter that distinguishes between treatment and comparison groups.

With equation (3), the same country will have an average value of Y_{0i} that is identical to that of Y_{1i}, independent of D—that is, if the heterogeneity of each country following the conclusion of the FTA is controlled, and the effect due solely of the FTA can be estimated.

In particular, if an observed value that is a covariate is controlled more specifically, the selection bias can be completely controlled equal 0. Therefore, equation (1) —which relates to the treatment effect—implies that because the treatment is performed while selection bias is 0, the pure trade effect is not obtained if selection bias is not controlled. That is, the average difference between the two groups is equal to the treatment effect of the treatment group, provided that selection bias is controlled. Wherever this logic also applies to the comparison group and the bias of both groups is 0, selection is controlled to be $E(Y_{0i}|D = 1) - E(Y_{0i}|D = 0)$. Through this process, ATT—which is the trade effect solely of FTAs—can be estimated.

3.2 Propensity Score Matching (PSM)

To reduce selection bias, it is important to use a comparison group that bears characteristics similar to those of the treatment group. To this end, PSM is used. The logic of this approach is to compare and analyze groups that are as similar as possible in terms of national characteristics, with the one difference being the presence or absence of an FTA. In the present case, this "filters out" impacts of factors in South Korea's agricultural trade other than the concluded FTA. This is the probability that the analyzed objects derived through regression analysis belong to the treatment group, with the FTA—a variable used to classify the treatment and comparison groups—being a dependent variable. The characteristics variables that have an impact on trade are independent variables. In PSM, each observed value of the treatment group is matched with the observed values of the comparison group that has the nearest propensity score. That is to say, in this way, a treatment group and a comparison group are created by pairing countries with similar characteristics. With this approach, the estimation process comprises two steps.

The first step is to estimate a propensity score, in order to create a comparison group that is similar to the treatment group. Estimation of the propensity score is carried out not just once, but repeatedly, until the distribution of observable characteristics of the treatment group and the comparison group is balanced. Estimation is implemented through discriminant analysis or logit analysis, for which the dependent variable is an FTA with South Korea and the independent variable is various characteristics that can affect the dependent variable. These two methods of analysis allow us to make probability estimates for treatment-group assignment, while observed variables are already given. While the multivariate normal distribution of variables is assumed in discriminant analysis, the logit analysis is freer for the assumption, and can reduce selection bias even further than that seen with discriminant analysis (Rubin 1979). Therefore, logit analysis is used in this study, for ease of analysis.

$$P(X) = Pr(Y_i = 1|X) = E(Y_i|X) \quad (4)$$

In equation (4), X is each feature vector of FTA countries and non-FTA countries, and $P(X)$ is the probability of signing an FTA under the condition of such features. The key assumptions of the propensity scores are described below.

$$(Y_{0i,}Y_{1i}) \perp D_i|X \tag{5}$$

$$0 < Pr(D_i = 1|X) < 1 \tag{6}$$

Equation (5) is about the conditional independent assumption (CIA), which means that, while the observed feature (X) is given in the most important process used to justify matching, the concluded FTA (D) of a country is independent of the potential outcome $(Y_{0i,}Y_{1i})$ of the FTA. This means that any feature not observed by controlling all differences that influence the effect of a concluded FTA does not have an impact on the effect—that is, $E(Y_{1i}|D_i = 1) - E(Y_{0i}|D_i = 0)$. Equation (6), on the other hand, is about the common support assumption. In this equation, $P(X)$ is a continuous variable between 0 and 1, and there is the assumption that the probability distributions of countries who have signed an FTA (i.e., an FTA country) with South Korea and non-FTA countries overlap within the same range (Rosenbaum and Rubin 1983). A strongly ignorable treatment assumption between variables established on the assumptions of equations (5) and (6) contributes to the strongly ignorable assumption vis-à-vis the propensity score, which is a probability function. The issue of dimensions that occur in matching based on variables can be addressed by comparing differences by virtue of propensity scores, which summarize the characteristics of variables as one figure.

The second step is to find a non-FTA country group with propensity scores similar to those of the FTA country group, for ATT values that cannot be estimated merely by estimating propensity scores in the first step; this is done to analyze the effect of FTAs by matching differences. That is to say, the observable characteristics of the two groups will have the same distribution, so that the effect in the absence of selection bias can be estimated.

In this case, we can select various matching approaches, and a selection can be made through stratification matching, kernel matching, and nearest-neighbor matching to determine matching between FTA countries with South Korea and non-FTA countries (Heckman and Todd 1997).

Stratification matching uses a process of dividing the scope of changing propensity scores into subgroups, and classifying each subgroup with both treatment and the FTA group as units with similar propensities. This is done to obtain weighted averages of the effect calculated for each group. The kernel-matching approach uses a process that leverages the kernel function to give higher weights to all members of the non-FTA group nearer to the propensity score of the FTA group, and smaller weights to the members farther from the propensity score. The nearest-neighbor-matching approach sorts two groups of FTA countries and non-FTA countries in random order to find and match members of the non-FTA country group with a propensity score nearest to that of the members of the FTA country group, in a 1:1 manner. This approach repeats the aforementioned matching process for all countries to calculate the difference between FTA countries and non-FTA countries, to reduce selection bias and thus obtain robust results. However, because with the nearest-neighbor-matching approach the scope of the common area in estimating the propensity score is narrow, the size of the matching sample is relatively small.

In conclusion, the PSM approach holds the same basic framework regarding differences between the treatment and comparison groups, but its results can differ from those of stratification matching, nearest-neighbor matching, kernel matching, depending on the given weights, the definition of the number of sections, the standards of the treatment group and the comparison group, and the definition of "function values." The aforementioned matching approaches can be seen to offset each other in terms of bias and variance, if they are evaluated on those bases. This means there is no absolutely superior matching approach, which makes it necessary to compare estimation results from a variety of matching approaches (Becker and Ichino 2002; Caliendo and Kopeining 2008; Kim 2010).

3.3 Data

Table 3 lists variable definitions and data sources.

Table 3. Data Sources

Variable	Unit	Source
FTAs	Dummy	WTO
Trade value	USD	Global Trade Atlas
GDP per capita	USD	World Bank Development Indicators
Total population	Person	World Bank Development Indicators
Distance weighed	Km	Centre d'Études Prospectives et d'Informations Internationales.
Trade balance	USD	Global Trade Atlas

With PSM, there is a cause-and-effect relationship between the FTA country group that contains South Korea and the non-FTA country group. Accurate ATT values can be estimated by using variables that satisfy the assumption of conditional independence and are balanced in the common area. Therefore, in this study, we pinpoint a variable that is balanced between the conclusion of an FTA or non-FTA, and which satisfies the assumption of conditional independence and is within the common area (Baier and Bergstrand 2009). The variables are the volume of agricultural trade between the two countries, GDP per capita, population, distance, and balance of trade.

The volume of agricultural trade and the balance of trade between two countries is sourced from the *Global Trade Atlas*. The agricultural products to be analyzed are based on the HS codes 01–24. GDP per capita and population data are sourced from World Bank Development Indicators (WDI). The latest WDI data are from 2012, and the information within the data analyzed in this study is also from 2012. Data regarding the distance variable are sourced from the indicators of the Centre d'Études Prospectives et d'Informations Internationales (CEPII), a French research institute.

As of 2012, South Korea had signed 15 FTAs. The relatively small number of FTAs that South Korea had signed between 2004 and 2006 is not sufficiently large to create a treatment group. Therefore, cross-sectional data from 2012 are used in the analysis in this study.

Table 4 provides summary statistics of data.

Table 4. Summary Statistics of Data

	Variable	Obs.	Mean	Std. Err.	Min	Max
Import	FTAs	204	0.215686	0.412309	0	1
	Trade value	204	1.25E+08	5.37E+08	0	5.87E+09
	GDP per capita	184	14479.47	20444.74	251.0145	103858.9
	Total population	204	3.57E+07	1.34E+08	9860	1.35E+09
	GDP per capita of South Korea	204	24453.97	0	24453.97	24453.97
	Total population of South Korea	204	5.00E+07	0	5.00E+07	5.00E+07
	Distance weighed	204	9484.03	3744.478	354.549	19563.9
	Trade balance	204	–4.60E+08	5.28E+09	–7.52E+10	1.89E+09
Export	FTAs	195	0.2205128	0.41566	0	1
	Trade value	195	3.54E+07	1.90E+08	0	2.30E+09
	GDP per capita	179	14467.2	20483.53	266.589	103858.9
	Total population	195	3.55E+07	1.35E+08	9860	1.35E+09
	Distance weighed	195	9541.234	3734.13	951.737	19563.9
	Trade balance	193	–4.86E+08	5.43E+09	–7.52E+10	1.89E+09

Because there are cases of no imports or small import volumes within the analysis period of 2012, the use of ordinary least squares is very likely to cause bias. The PSM approach is used to control this selection bias. The statistics program used to undertake empirical analysis is Stata 12.

South Korea imports agricultural products from 204 countries, and it exports to 195 countries. As of 2010, South Korea had signed FTAs with about 7% of these countries. The country signed FTAs with the EU and the United States, two large economic entities, as of 2012, when those numbers became 21% and 22%, respectively.[2)]

IV. Estimation Results and Discussion

4.1 Propensity Scores

Logit analysis is used to estimate the propensity score, depending on the effect of FTAs. The estimated parameters of logit analysis are used to calculate the propensity score, and to investigate the satisfaction of both the CIA—the major premise of PSM estimation—and the common support assumption. Tables 6 illustrates the results of logit analysis for each country of export or import of South Korea's agricultural products, to identify those factors that have had an impact on the signing of FTAs. These results were obtained by using 2012 data.[3)]

[2)] The summary statistics of the 2010 data are provided in the Appendix.

[3)] The 2010 data by logit analysis are not any different from the results from the 2012 data; these are provided in the Appendix.

In Table 5, one can see similar aspects of coefficient signs that illustrate the cases of the importation and exportation of South Korea's agricultural products. The estimation results illustrate that a country is more likely to conclude an FTA with South Korea if its GDP is greater, its population is larger, it is located geographically near to South Korea, and has a comparatively larger trade balance. The larger estimates of coefficient values among significant variables were of GDP, for both imports and exports. This implies that national competitiveness is an important factor in signing an FTA.

Table 5. Logit Estimation Results

Explanatory variable	Dependent variable	
	Import	Export
GDP per capita of importers	0.0000375*** (0.00000917)	0.0000388*** (9.46E-06)
Total population	0.000000000837** (1.13E-09)	0.00000000105** (1.17E-09)
Distance weighed	–0.0001457* (0.0000605)	–0.0001434* (0.000061)
Trade balance	0.00000000000723* (5.79E-11)	0.00000000000953* (6.13E-11)
Constant	–0.6095753 (0.5960046)	–0.6133886 (0.6052889)
Log-likelihood value	–82.490227	–80.840728
Prob > X^2	0.0000	0.0000
Pseudo R^2	0.1654	0.1711

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively

Table 6 shows the common area result in the process of estimating propensity scores. The sample size was reduced when considering the characteristics of the covariates in calculating the propensity scores. Between 1% and 99%, in 2010, the common area was between 0.002 and 0.362 (where South Korea imports agricultural products) and between 0.002 and 0.366 (where South Korea exports them). In 2012, those ranges were 0.061–0.923 and 0.064–0.932, respectively.

Figure 2 shows the propensity scores in the common area. The satisfaction of the common area is greater between the treatment group and the comparison group, as the two bars are similar in height.

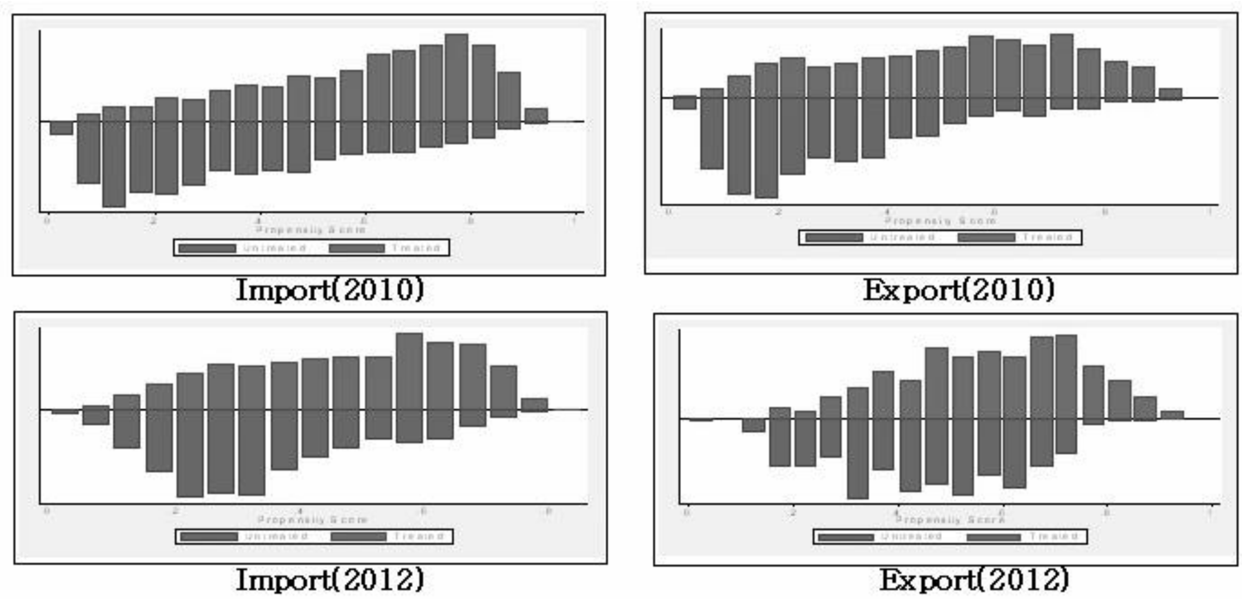
The comparison group with a propensity score similar to that of the treatment group is subdivided into several blocks in terms of percentiles, to determine the satisfaction of conditional independence. The subdivided blocks include four countries for each of imports and exports in 2010, and five countries for each of imports and exports in 2012. This grouping allows one to see differences in average propensity score between the two groups. As a result of analysis, no difference is found between FTA and non-FTA countries, and this implies the satisfaction of the assumption of conditional independence (Kim et al. 2013).[4)]

[4)] With PSM undertaken through Stata, the program calculates conditional independence. If this assumption is violated, matching is not implemented. We omit from this study the Stata-based process of examining conditional independence.

Table 6. Common Support

Year	Sample	Propensity score		Common support	
		Before	After	Minimum	Maximum
2010	Import	15	14	0.002	0.362
	Export	15	14	0.002	0.366
2012	Import	44	42	0.061	0.923
	Export	43	42	0.064	0.932

Figure 2. Propensity Scores (Frequencies of Probability Intervals by Treatments and Models)



4.2 Stratification, Kernel, and Nearest-Neighbor Matching

The stratification-matching, kernel-matching, and nearest-neighbor-matching approaches are used to investigate the effect of FTAs on South Korea's agricultural trade. The nearest-neighbor-matching approach, which leverages 1:1 matching, is generally used. The one divided group has four countries for each of imports and exports in 2010; the other divided group contains five countries for each of imports and exports in 2012. Here, the number of countries in each group is the same as those in the groups calculated through the common area and used in tandem with the stratification-matching approach. Kernel matching[5] uses the Epanechnikov kernel

[5] In kernel matching, matching is implemented with a plurality of treatment groups per comparison group sample. In this case, greater weight is given to a treatment group sample for which the propensity score is nearer to that of the comparison group. The Gaussian kernel, Epanechnikov kernel, or Unimodal kernel is used, depending on the assumption that the weight follows a certain distribution function. The Epanechnikov kernel is used in this study to analyze matching.

function, and for the purpose of analysis, each bandwidth is 0.05. The trust region of the FTA effect is estimated through bootstrapping. Resampling through bootstrapping is repeated 1,000 times. This applies to all matching analyses. It is possible to identify reductions in selection bias by comparing the figures before and after each matching for which bootstrapping was carried out. Table 7 illustrates changes in selection bias for each matching type.

Table 7. Bias Reduction after Matching

Year	Sample	Matching method	Bias reduction (%, after matching)
2010	Importers	Stratification matching	–31.7(%)
		Kernel matching	–29.6(%)
		Nearest-neighbor matching	–38.9(%)
	Exporters	Stratification matching	–32.5(%)
		Kernel matching	–30.3(%)
		Nearest-neighbor matching	–40.1(%)
2012	Importers	Stratification matching	–31.3(%)
		Kernel matching	–28.9(%)
		Nearest-neighbor matching	–39.6(%)
	Exporters	Stratification matching	–33.7(%)
		Kernel matching	–31.6(%)
		Nearest-neighbor matching	–41.1(%)

Matching can lead to effective or ineffective estimations, depending on how much heterogeneity is controlled between the variables of the two comparison groups—that is, the degree to which bias reduction contributes to measurements of the true effect of FTAs. The estimation results reveal that each group is balanced with respect to the average of each variable after matching, compared to the average of each variable prior to matching. Bias is reduced with each matching approach, and each instance of bias reduction is different, depending on the matching type. Nearest-neighbor matching reduced bias the most, followed by stratification matching and kernel matching. Therefore, it is concluded that nearest-neighbor matching is the best approach for controlling heterogeneity between the treatment and comparison groups.

Table 8 illustrates South Korea's net agricultural trade after signing FTAs in 2010. South Korea concluded FTAs with five trade countries (i.e., Chile, Singapore, EFTA, ASEAN, and India) in 2010, and with 16 countries in total. However, from these samples for matching, 14 FTA countries for both imports and exports, as well as 9–152 and 9–157 non-FTA countries for imports and exports, respectively, were used to study matching. South Korea is a net importer of agricultural products. Its agricultural product exports account for a relatively small proportion of overall trade, in comparison to its imports. Nonetheless, all were found to have positive signs (+) in all matching approaches. Therefore, we can conclude that FTAs signed in 2010 contributed to increases in both imports and exports.

Table 8. Agricultural Trade Effects of FTAs in 2010

Matching method		Treatment group (FTA countries)	Control group (non-FTA countries)	ATT
Import	Stratification matching	14	165	198** (7.67e+07)
	Kernel matching	14	165	176** (5.35e+07)
	Nearest-neighbor matching	14	11	113*** (1.86e+08)
Export	Stratification matching	14	158	40.3* (2.02e+07)
	Kernel matching	14	158	40.4* (2.10e+07)
	Nearest-neighbor matching	14	9	40.0** (1.70e+07)

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 9 shows agricultural trade effects of FTAs in 2012. South Korea signed FTAs with the EU and Peru in 2011, and the United States in 2012, to bring the total number of FTA countries to 44. This implies an increase of 28 FTA countries compared to 2010. Forty-two countries were used in the estimations, and the treatment group was reduced by two when calculating the common area prior to matching. It is thought that the reduction occurred in the process of calculating the countries whose propensity scores were similar to those of the countries in the comparison group. In particular, nearest-neighbor matching shows an obvious reduction in the sample within the comparison group. This result derives from the narrower scope of the common area in estimating the propensity score. As such, the reduced sample in the comparison group is advantageous, in that the heterogeneity with the treatment group is controlled best, and is therefore most effective in controlling selection bias and calculating relatively robust estimation results.

In comparison to estimations that derive from each matching approach for differences between 2010 and 2012, stratification matching reveals an increase from USD198 million to USD206 million. Kernel matching and nearest-neighbor matching, meanwhile, reveals an increase from USD176 million to USD185 million, and from USD113 million to USD156 million, respectively. With respect to exports, all matching approaches reveal increases in 2012, relative to 2010. Stratification matching reveals an increase from USD40.3 million to USD57.2 million; kernel matching, from USD40.4 million to USD67.4 million; and nearest-neighbor matching, from USD40 million to USD47.7 million. The FTA trade effect illustrated in Tables 8 and 9 shows slight differences, depending on the matching approach used. However, all result figures carry a positive sign (+), and this implies that FTAs have had the effect of increasing South Korea's net agricultural trade.

Table 9. Agricultural Trade Effects of FTAs in 2012

Matching method		Treatment group (FTA countries)	Control group (non-FTA countries)	ATT
Import	Stratification matching	42	137	206** (1.50e+08)
	Kernel matching	42	137	185** (1.44e+08)
	Nearest-neighbor matching	42	23	156*** (1.14e+08)
Export	Stratification matching	42	132	57.2** (4.05e+07)
	Kernel matching	42	132	67.4* (5.31e+07)
	Nearest-neighbor matching	42	20	47.7** (5.93e+07)

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

A comparison of ATT values in terms of matching approaches shows that with respect to imports in 2010 and 2012, stratification matching is superior to kernel matching, which is in turn superior to nearest-neighbor matching. For exports, kernel matching is superior to stratification matching, which is in turn superior to nearest-neighbor matching. This is because while bias can increase, kernel matching can reduce the standard deviation by using all the variables within a controlled group. Nearest-neighbor matching has an ATT difference, because events likely to occur by virtue of the connected variables nearest to the propensity score are omitted, or because of the large standard deviation that occurs and is attributable to the PSM of other variables (Kim et al. 2013)

Table 10 compares ATE and ATT values generated through matching. This allows us to investigate differences between the selection bias effect controlled through various matching approaches and the uncontrolled effect. In 2010, the ATE for agricultural products between FTA countries and non-FTA countries was USD852 million for imports and USD184 million for exports. In 2012, on the other hand, the ATE for agricultural products was USD314 million for imports and USD78 million for exports. The ATE values in 2012 were smaller than those in 2010, and this implies an increased trade volume with FTA countries that in turn reduces exports to non-FTA countries. However, with respect to analysis of the results obtained through the ATE, the results estimated by excluding selection bias do not constitute a pure FTA effect.

Table 10. Comparisons of ATE and ATT (millions of US dollars)

Sample		Import		Export	
		2010	2012	2010	2012
ATE		852	314	184	78
ATT	Stratification matching	198	206	40.3	57.2
	Kernel matching	176	185	40.4	67.4
	Nearest-neighbor matching	113	156	40.0	47.7

On the other hand, the ATT—for which selection bias is controlled through PSM—reveals a difference of USD156–206 million for when selection bias was controlled. This implies a relatively accurate FTA effect in comparison to that derived with the ATE. All ATT figures are smaller than the ATE figures; therefore, bias control was a clearly factor that led to the difference between the estimated ATE and ATT figures. More significantly, this means that previous studies on the trade effect of signed FTAs have overestimated the effect, as they do not address selection bias.

In summary, FTAs have contributed to increases in both imports and exports agricultural products in South Korea. Because their effect on imports is greater than that on exports, there are concerns about their impact on the overall domestic agricultural industry. However, analysis of ATE prior to matching, as well as of ATT—which involves the result of each matching approach—reveals that the effect solely of FTAs is smaller than all ATE figures. This implies that the impact of FTAs on South Korea's agricultural trade is not overly significant.

V. Conclusions

This study used PSM to control selection bias, to investigate the effect solely of FTAs on South Korea's agricultural trade. It also sought to analyze the effect of FTAs on international trade. Differences in treatment effects with regard to 2010 and 2012 data were compared and analyzed to obtain robust results.

Analysis of the effect of FTAs on South Korea's agricultural trade revealed increased imports of USD8 million when using stratification matching, USD9 million when using kernel matching, and USD43 million when using nearest-neighbor matching. With respect to exports, the increases were USD16.9 million with stratification matching, USD27 million with kernel matching, and USD7.7 million with nearest-neighbor matching. Clearly, the FTA trade effect varied slightly, depending on the matching approach used. However, all results bore a positive effect (+), and this implies that FTAs contribute to an increased net trade in South Korea's agricultural products.

ATT was compared to ATE to exam differences between selection bias controlled through the use of various matching approaches and selection bias left uncontrolled. The result is that the ATE figures—which constitute the average treatment effect for which bias was not controlled—are greater than the ATT estimates calculated through matching. This suggests that differences between ATE and ATT estimates depend on whether or not selection bias was controlled. Most prior studies on the effect of FTAs on trade have not addressed the issue of selection bias and thus have overestimates their effect.

This study identifies the smaller impact of controlled selection bias on South Korea's agricultural product market, relative to uncontrolled selection bias. However, it seems that South Korea, a net importer of agricultural products, will import more agricultural products than it will export, after signing FTAs. In this way, FTAs will continue to make South Korea's domestic agricultural industry be vulnerable to import competition, which sheds light on policy reactions, including income safety net measures and trade adjustment assistance.

The data used in this study are not complete and should be supplemented with future research. An FTA does not cover all items subject to FTA tariffs. Although a certain imported item can be included in a concession list, not all items on that list are subject to lowered tariffs the moment an FTA is signed. Rather, products are subject to various tariff exemption rates and a schedule, depending on the items traded by the counterpart FTA countries. Therefore, future panel analysis that combines cross-sectional analysis to examine the long-term trade structure—especially that featuring vertical analysis, by extending the observation period—will help derive more significant results.

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Appendix 1. Descriptive Statistics of Dependent Variable (2010)

	Variance	Obs.	Mean	Standard error	Minimum	Maximum
Imports	FTAs	204	0.078431	0.269511	0	1
	Trade value	204	9.63E+07	4.64E+08	0	5.33E+09
	GDP per capita	184	13801.99	20764.8	219.5298	145229.8
	Total population	204	3.49E+07	1.32E+08	9827	1.34E+09
	GDP per capita of South Korea	204	22151.21	0	22151.21	22151.21
	Total population of South Korea	204	4.94E+07	0	4.94E+07	4.94E+07
	Distance weighed	204	9484.03	3744.478	354.549	19563.9
	Trade balance	204	–6.94E+08	8.91E+09	–1.27E+10	1.30E+09
Exports	FTAs	195	0.076923	0.267155	0	1
	Trade value	195	2.72E+07	1.49E+08	0	1.85E+09
	GDP per capita	179	13069.49	18448.66	326.6043	102678.8
	Total population	195	3.47E+07	1.33E+08	9827	1.34E+09
	Distance weighed	195	9541.234	3734.13	951.737	19563.9
	Trade balance	193	–7.33E+08	9.16E+09	–1.27E+10	1.30E+09

Appendix 2. Logit Analysis with Matching (2010)

	Import	Export
GDP per capita of importers	0.0000142* (0.0000107)	0.0000184** (0.0000123)
Total population	1.05E-09* (1.27E-09)	1.13 e-09* (1.30e-90)
Distance weighed	–0.0003338*** (0.000104)	–0.0003273*** 0.000105
Trade balance	8.38E-12* (1.48E-10)	1.15e-11* (1.73e-10)
Constant	–0.2244228 (0.7861946)	–0.299569 (0.8181058)
Log-likelihood value	–40.519918	–39.781692
Prob > X^2	0.0010	0.0008
Pseudo R^2	0.1855	0.1927

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.