Does tariff reduction have a positive effect on the world's grain self-sufficiency?

May, 2016

Byeong-il Ahn
Department of Food and Resource Economics
Korea University
Anam-dong, Seongbuk-gu, Seoul, 136-701
South Korea
Tel: +82-2-3290-3031

Younghyeon Jeon
Korea Rural Economic Institute
Bitgaram-ro 601, Naju-si, Jeollanam-do, 58217
South Korea

Selected Paper prepared for presentation for the 2016 Agricultural & Applied Economics Association, Boston, MA, July 31-August 2

Corresponding author: Byeong-il Ahn, Ahn08@korea.ac.kr

Does Tariff Reduction Have a Positive Effect on the World's Grain Self-Sufficiency?

Abstract

This paper investigates the effect of a tariff reduction on the world's grain self-sufficiency which is a main component in defining the food security. We develop a theoretical model in which trade, tariff and supply-demand equations are explicitly included, with the classification of food-importing and exporting countries. Empirical equations are estimated using the system generalized method-of-moments (GMM) approach to control endogeneity problem. Estimation results based on panel data for 150 countries over 17 years show that world grain price and world's self-sufficiency rate(SSR) are positively correlated, but the country level GDP per capita, population, agricultural input price, and prices of substitutes for grain have negative effects on world's SSR. The effects of domestic tariff of food-importing countries on the world's grain SSR are estimated to be positive. Using the estimated coefficients on the empirical equations, we derived the elasticities of grain SSR with respect to the tariff level of food-importing countries. Those are in the ranges of 0.221-0.387. These results support the argument that tariff reduction has a negative effect on the importer's food SSR.

Keywords: *trade liberalization, tariff reduction, self-sufficiency, system generalized method of moments*

1. Introduction

The international trade of agricultural products significantly influences not only on the livelihoods of millions of farmers across the world, but also on the food security strategies of most countries (Burnett and Murphy, 2014). World Bank, International Monetary Fund, and pro-liberalization trade advocates argue that trade liberalization leads to an increase in imports and a decrease in the price of imported products, thereby enhancing food security (Bezuneh and Yiheyis, 2014; Clapp, 2014; Hailu, 2010).

However, on the other side, it has been also pointed out that the benefit from the improvements in food security through agricultural trade liberalization is highly limited (Nguema and Ella, 2014; Pinckney, 1993; Pyakuryal et al., 2010). Trade liberalization through the reduction or removal of the import tariff has increased the demand for low-cost, imported agricultural products. At the same time, it increased the dependency on food imports by drastically decreasing domestic production. The typical example is the wheat market in Korea. After the trade liberalization of wheat in 1983, as the demand for imported wheat has increased, the domestic production of wheat has decreased; the country has become entirely dependent on imported goods (self-sufficiency rate is less than 1% as of 2014). Similar example is found for rice in Philippines. Further, many African countries that were traditionally food exporters have become food importers over the past 20 years (Hailu, 2010). Many previous studies argue that tariff reduction is the main reason for the decrease in food self-sufficiency (For example, Tanaka and Hosoe, 2011; Siddig and Mubarak , 2013: Kako, 2009; Hwang, 2009: Im et al., 2010; Park and Seung, 2013).

The world food crisis, which was caused by a spike in food prices in 2008, led to doubts regarding trade liberalization’s role as a strategy for improving food security, and reminded most food importers, once again, of the importance of maintaining food security through self-sufficiency. This crisis emphasized the importance of a globally stable food security level (Amid, 2007; Ito and Ni, 2013; Tanaka and Hosoe, 2011).

With growing efforts to expand the market for agricultural products through trade, it is time to verify how trade liberalization though the tariff reduction will affect the world's food self-sufficiency. Furthermore, based on the theoretical discussion and empirical estimation, impacts of the various factors that affect the food self-sufficiency need to be investigated.

Most recent previous studies on the trade liberalization and its impacts focused on the specific products. (For example, wheat (Elsheikh et al., 2015)), corn (Jayasinghe et al., 2010) and mushroom (Kim et al., 2014)). While, prior studies on food self-sufficiency have focused on its conceptualization (Leung and Loke, 2008; Choi et al. 2010), improvement plan (Bah, 2013), calculation method (Hwang, 2009), and world distribution pattern(Han et al., 2012). However, there have been no empirical studies on how tariff reduction affects the world's food self-sufficiency.

The objective of this paper is to analyze whether tariff reduction has a positive effect on the world's food self-sufficiency. For this analysis, first, we build a theoretical model using the supply-demand model for importing and exporting countries, and then investigate how changes in the tariff and other factors affect the grain self-sufficiency rate (SSR). We construct the panel data for 150 countries from 1995-2011, and empirically analyze the various factors using the system GMM model.

The Food and Agriculture Association's (FAO's) broad range of food commodities includes whole edible food items, like grains (rice, wheat, and barley), as well as food items in other categories, like vegetables, fruit, meat, fish, milk, and milk products. However, grain is regarded as more important than other food items, like meat or seafood, thus food self-sufficiency is usually defined in terms of the staple food crops, such as basic cereals and root crops (Choi et al., 2010; Kim et al., 2010; Minot and Pelijor, 2010; Park et al., 2011). Following this tradition, in this study, we only include grains in our food range, and then calculate the SSR with that limitation.

The rest of this paper is structured as follows. In the next section, the various factors that could affect the grain SSR is identified using previous studies, and the theoretical model is used to assess the effects of each factor on SSR is established, using the supply-demand model. In Section 3, the data and estimation method are explained, while, in Section 4, based on the theoretical model, empirical estimation is conducted and the influences of tariff on world's grain SSR are discussed. Finally, in Section 5, summary as well as implications of the analytical results are presented.

2. Theoretical Discussion

We define a country's grain SSR as the ratio of domestic grain production to overall domestic grain consumption, which is presented as $\frac{Production\ (Q_P)}{Consumption\ (Q_C)}$. Thus, we can say that the factors which affect grain production or consumption ultimately have an impact on the grain SSR. As a representative example, if tariff reduction occurs in an importing country, the amount of imported grain will increase, domestic production decreases and domestic consumption increases, therefore it causes a decrease in the grain SSR in that county. However, this discussion is valid only under the controlled supply and demand. In other words, a country's grain SSR can be affected by other factors such as world grain price and population growth etc.

The Overseas Development Institute (ODI) (2008), Organization for Economic Co-operation and Development (OECD) (2008), FAO (2011), and Brooks (2014) discuss the influence of the increase in the world grain price on the food consumption and production. According to them, in the long term, this increase will negatively affect the overall consumption and production of a poor country. In addition, Lee (2014) asserts that the volatility of the world food price is correlated with domestic production. Sung et al. (2008) insist that the increase in the world grain price can be a serious influencing factor on the grain production and consumption in the importing country Korea. These researches clearly suggest that world grain price must be included as a main variable.

In order to make the discussion relatively simple, we start with the assumption that there is no trade cost between importing and exporting countries other than tariff. Second assumption for the theoretical discussion is that the importer and exporter both are small countries, thus the world grain price is given as an exogenous variable. With these assumptions, we can examine how the change in tariff, world grain price, the shifters of supply and demand affect the grain SSR.

The components of SSR, such as consumption (Q_C) and production (Q_P), are determined by a supply and demand curve, which means the SSR can be defined using the framework of a supply-demand model. The supply of domestic production and demand in the importing country are presented as:

(1) $Q_{IP} = S_I(P_I, S_{SI}),$

(2) $Q_{IC} = D_I(P_I, S_{DI})$,

where Q_{IP} is the importing country's domestic supply, P_I is the imported grain price which is the same as world price (P_W) multiplied by 1 plus tariff rate(i.e, $P_W(1+t)$), S_{SI} is the supply shifter, Q_{IC} is the importing country's domestic demand, and S_{DI} is the demand shifter.

Supply and demand in exporting country can be defined as:

(3) $Q_{EP} = S_E(P_W, S_{SE})$,

(4) $Q_{EC} = D_E(P_W, S_{DE})$,

where Q_{EP} is the production, S_{SE} is the supply shifter, Q_{EC} is the domestic demand, and S_{DE} is the demand shifter.

Figure 1. Effects of each variable on grain SSR.

<Small importer> <Small exporter>

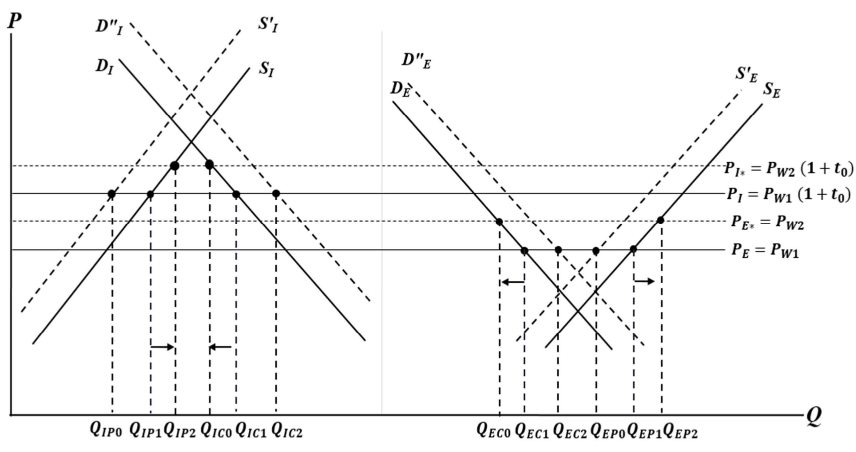


Figure 1 depicts the influences of changes in international price, supply and demand shifters in the framework discussed using equation (1) to (4). If the world grain price is P_{W1}, the importer's production and consumption will be decided at the crossing point of the demand curve, D_I, the supply curve, S_I, and the domestic price of imported grain $P_{W1}(1+t_0)$. The crossing points are $Q_{IC\,1}$ and $Q_{IP\,1}$, therefore the importer's grain SSR will be $\frac{Q_{IP\,1}}{Q_{IC\,1}}$. In the exporter's case, the crossing points of the demand curve, D_E, and the supply curve, S_E, with the world grain price, P_{W1}, are the deciding points of the consumption and production. These points are Q_{EC1} and Q_{EP1}, and we can present the exporter's grain SSR as $\frac{Q_{EP1}}{Q_{EC1}}$.

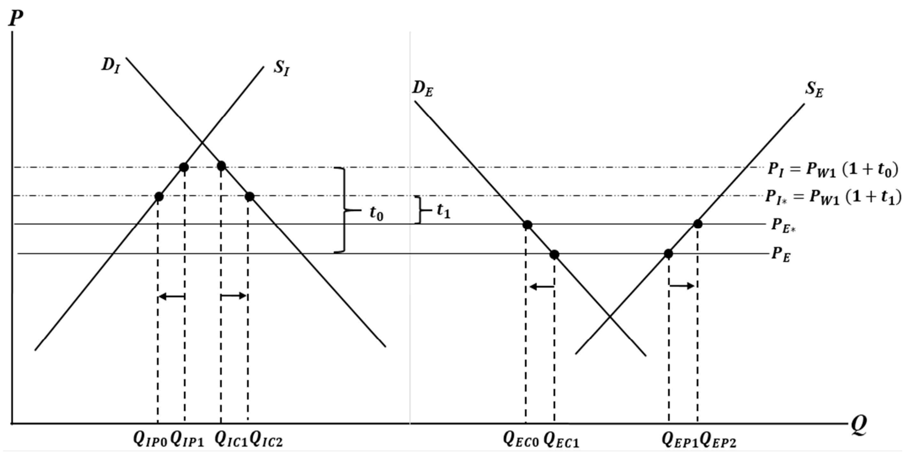
If the world grain price increases from P_{W1} to P_{W2}, the importer's production will increase to $Q_{IP\,2}$ and consumption will decrease to $Q_{IC\,0}$; thus, the importer's grain SSR will increase to $\frac{Q_{IP\,2}}{Q_{IC\,0}}$. Likewise, an increase in the world grain price will cause an increase in the exported price, which means that the exporter's production increases to Q_{EP2} and consumption decreases to Q_{EC0}. This will increase the exporter's SSR to $\frac{Q_{EP2}}{Q_{EC0}}$. Consequently, an increase in the world grain price causes an increase in grain SSR of both the importer and exporter.

Meanwhile, if the importer's demand curve shift from D_I and D_I'' and, likewise, the exporter's demand curve will shift from D_E to D_E'' due to the change in the demand shifter. The shifting of the demand curve causes the importer's consumption to increase to $Q_{IC\,2}$, but production remains constant; thus, the importer's SSR decreases from $\frac{Q_{IP1}}{Q_{IC1}}$ to $\frac{Q_{IP1}}{Q_{IC2}}$. Similarly, the exporter's consumption increases to Q_{EC2}, but production remains constant; thus, the exporter's SSR decreases from $\frac{Q_{EP1}}{Q_{EC1}}$ to $\frac{Q_{EP1}}{Q_{EC2}}$. As a result, the right shifting of the demand curve causes a decrease in the grain SSR to both the importer and exporter.

If the supply curves of both the exporter and importer shift to the left due to the change in the supply shifter such as an increase in input price, the importer's production decreases from Q_{IP1} to Q_{IP0}, and the exporter's production decreases from Q_{EP1} to Q_{EP0}. Thus, the left shifting of the supply curve causes a decrease in the SSR from $\frac{Q_{IP1}}{Q_{IC1}}$ to $\frac{Q_{IP0}}{Q_{IC1}}$ and $\frac{Q_{EP1}}{Q_{EC1}}$ to $\frac{Q_{EP0}}{Q_{EC1}}$, for the importer and exporter, respectively.

Figure 2. Effects of tariff reduction on grain SSR.

<Small importer> <Small exporter>



The effects of tariff reduction on the grain SSR are presented in Figure 2. If the importer reduces its tariff from t_0 to t_1, the imported grain price will decrease from P_I to P_{I*}, and importer's production and consumption will be decided at the crossing point with P_{I*}. Because the importer's production decreases to $Q_{P\,0}$ and consumption increases to $Q_{C\,2}$, the importer's SSR will decrease. However, in the exporter's case, if its trading partner's tariff decreases from t_o to t_1, the exported grain price will increase from P_E to P_{E*}. Then, production and consumption will shift from Q_{EP1} to Q_{EP2} and Q_{EC1} to Q_{EC0}, respectively. Thus, the exporter's SSR will increase from $\frac{Q_{EP1}}{Q_{EC1}}$ to $\frac{Q_{EP2}}{Q_{EC0}}$.

In the empirical estimations for testing the theoretical expectations discussed using Figure 1 and 2, we select the control variables of demand and supply shifters, based on the previous studies. Gerbens-Leenes et al. (2010) and Tilman et al. (2011) discuss the effect of economic growth on food consumption and production, by examining the change in the food supply and consumption pattern caused by economic growth (or increase in income). Ahn and Han (2012) and Park et al. (2011) insist that increasing income can be a threat to food security on the consumption side. Furthermore, van Oort et al. (2015), Park et al. (2011), Schneider et al. (2011), Kim et al. (2010), and Faisal and Parveen (2004) predict that a consistent increase in the population will cause an increase in consumption and a supply-demand problem. Considering these studies, we added income and population growth as representative demand shifters. Kim et al. (2011) discuss that an increase in the production cost, caused by an increase in the fertilizer price, will lead to a decrease in food production. Trostle (2008) asserts that increasing world input costs, like that of fertilizer, causes a decrease in production. Reflecting these studies we select fertilizer price as a representative supply shifter. We also include meat price in the empirical equations in order to capture the substitution effect between grain and meat.

Table 1 shows the overall anticipated relationship between the SSR and control variables. An increase in the world grain price will cause an increase in the grain SSR for both the importer and exporter. An increase in income, population, input and substitute prices will generate a decrease in the grain SSR. On the other hand, the importer's tariff reduction will bring different effects to the importer and exporter. There will be a positive relationship between the tariff and importer's grain SSR, but, with the exporter, there will be a negative relationship.

Table 1. Anticipated relationship between grain SSR and explanatory variables

	Importer's SSR	Exporter's SSR
World grain price	+	+
Income	-	-
Population	-	-
Input price	-	-
Importer's tariff	+	-
Meat price	-	-

3. Data and Methodology

3.1 Data

The estimation method of SSR is divided into four categories with data types:

quantity-based food SSR, staple-grain-based SSR, calorie-based SSR, and value-amount-based SSR (Choi et al, 2010).[1] This study uses the quantity-based SSR because it is appropriate method for defining grain SSR, considering the data availability. FAO's statistics data is used for calculating the grain SSR for each country. This grain data includes production, stock from last year, import and consumption of rice, wheat, maize, barley, and mixed grains. We use the annual data for 150 countries from 1995 to 2011, for which we could obtain data for the entire countries. The calculated SSRs from this data are presented in Table 2.

Table 2. Summary statistics of grain SSR

Year	Avg.	Std. Dev.	Median	Min.	Max.
1995	0.67213	0.47520	0.69139	0.00014	2.65091
2000	0.66054	0.49575	0.67710	0.00012	3.00068
2005	0.67991	0.50262	0.68799	0.00001	2.79927
2006	0.68297	0.50395	0.68361	0.00001	2.71749
2007	0.65801	0.50377	0.66338	0.00008	2.90895
2008	0.70339	0.56301	0.67666	0.00008	2.99009
2009	0.72107	0.55698	0.70759	0.00006	2.61092
2010	0.71422	0.56777	0.72086	0.00009	3.45691
2011	0.72272	0.60208	0.69657	0.00009	3.30655

Source: Calculated from the Food and Agriculture Organization's raw data

[1] Quantity-based SSR is calculated as domestic production divided by domestic consumption. The staple-grain-based SSR is divided into two different SSRs; one includes rice, wheat, and barley, but excludes feed, and the other includes feed. A calorie-based SSR is the ratio of caloric supply by domestic production to the caloric value by domestically consumed food. The monetary-value-based SSR is the ratio of the total monetary value of domestic food production to that of domestic food consumption.

Table 3. Summary statistics of variables

Variables	Avg.	Std. Dev.
World rice price ($/mt)	365.9099	117.336
World wheat price ($/mt)	205.3848	50.2224
World maize price ($/mt)	151.5075	42.8934
GDP per capita ($)	8,805.785	13,233.3
Population	40,800,000	141,000,000
World DAP price ($/mt)	330.6931	192.305
Importer's domestic tariff (%)	9.790144	16.8982
Exporter's trade partner's tariff (%)	9.347681	1.11087
World beef price ($/kg)	2.681765	0.47335

Notes: mt denotes million tons.

The summary statistics for the variables used in our estimation are shown in Table 3. We use data from the World Bank for the world grain price, GDP per capita, population, world fertilizer price, and world beef price. All price data is real price, which applies inflation rate. Especially, in the world grain price data, we use Thai rice, U.S. hard red winter wheat, and maize prices, which are the typical grain products traded at international market. We use price of diammonium phosphate (DAP) fertilizer for representing the input price.

We separate 150 countries into exporters and importers; the former refers to a country with over 100% grain self-sufficiency during the period in the analysis, and the latter refers to a country with under 100% grain self-sufficiency. We use the "effectively applied tariff" data of the World Bank's World Integrated Trade Solution (WITS) database. As shown in Table 3, the importer's domestic tariff refers to the tariff on imported grains in the importing country. On the contrary, the exporter's trade partner's tariff refers to the applied tariff by the exporter's trade partner (i.e., importers). In exporting, the exporter should consider the tariff on exporting products; thus, the exporter's domestic tariff is unimportant in this study. However, the WITS's data only includes the importer's domestic tariff. Therefore, to find the tariff of the exporter's trade partner, we use the average value of the importer's domestic tariff $t_E = \frac{\sum_{i=1}^{n} t_i}{n}$, where t_E is the tariff of the exporter's trading partner, t_i is the importer i's domestic tariff, and n is the number of importers.

3.2 Empirical estimation

For estimating the effect of tariff reduction on the grain SSR, we construct a balanced panel of 150 countries over the 17 years. The discussion using Figure 1 and 2 based on the strong assumption of exogenous world grain price. However, international price is likely to be influenced by large exporting or importing countries, which may cause a problem of endogeneity between the grain SSR as a world grain price. In other words, the world grain price causes a change in the grain SSR, but also that there is a possibility of reverse causality which means the grain SSR can cause a change in the world grain price. This endogeneity problem causes a biased estimator and prevents consistent estimation.

The endogeneity problem can be solved efficiently by including the lagged level of the dependent variable, without another instrument variable in the panel data estimation (Kumar and Woo, 2015; Kyriacou at al., 2015). However, if we include the lagged level of the dependent variables as the explanatory variables, we cannot use the fixed and random effect models. Therefore, we need a dynamic panel model that applies the GMM approach (Arellano and Bond, 1991; Blundell and Bond 1998; Choi, 2013; Schwarz and Kripfganz, 2015). Dynamic panel models are useful under the condition that the dependent variable depends on its own past realizations.[2] This study uses the system GMM estimator, proposed by Arellano and Bover (1995) as well as Blundell and Bond (1998). This estimator, which makes up the difference of the GMM's defects, is a combination equation of the original level variable and differenced equation. The system GMM estimation approach which is applied for importing countries is set as equation (5),

$$(5)\ \ln SSR_{NT} = \alpha + \beta_1 \ln SSR_{NT-1} + \beta_2 \ln P_{W,T} + \beta_3 \ln P_{W,T-1} + \beta_4 \ln GDP_{NT} + \beta_5 \ln Pop_{NT} + \beta_6 \ln P_{F,T} + \beta_7 (1 + Tariff_{NT}) + \beta_8 \ln P_{S,T} + \beta_9\, Food\ crisis + u_N + \epsilon_{NT},$$

where SSR_{NT-1} and SSR_{NT-1} are the grain SSR at T and its lagged level at $T - 1$; $P_{W,T}$ and $P_{W,T-1}$ are the current and lagged world grain prices (we include both because they may have different effects on the grain SSR; the former reflects the immediate effects, whereas the latter reflects the accumulated effects of the grain price (Ha et al., 2015)); GDP is the GDP per capita as a proxy variable of the income level; Pop is the population; P_F is the world fertilizer price; $Tariff$ is

---

[2] If the lagged level of the dependent variable as the explanatory variable is significant, the dynamic model is more appropriate; otherwise, the static model is preferred (Brañas-Garza et al., 2011).

the importer's domestic tariff rate; P_S is the world beef price as a substitute price; u is a country fixed effect, and ε is an error term. For capturing the influence of the food crisis in 2008, we add a dummy variable of $Food\ crisis$.

For all the countries including exporting and importing countries, empirical equation (6) is applied.

(6) $$\ln SSR_{NT} = \alpha + \beta_1 \ln SSR_{NT-1} + \beta_2 \ln P_{W,T} + \beta_3 \ln P_{W,T-1} + \beta_4 \ln GDP_{NT} + \beta_5 \ln Pop_{NT} + \beta_6 \ln P_{F,T} + Import \cdot \beta_7 \ln(1 + Tariff_{NT}) + Export \cdot \beta_8 Trade\ Partner's\ Tariff_{NT} + \beta_9 \ln P_{S,T} + \beta_{10} Food\ crisis + u_N + \epsilon_{NT},$$

where $Trade\ Partner's\ Tariff$ is the tariff for exporter's trade partner.

We need to test the validity of the instrument variables when applying the system GMM estimation. The required test is checking the exogeneity of instrument variables. In other words, the dependent variable's lagged value, which we use as an instrument variable, should have a first autocorrelation, but not a second, for the residuals. We use the Arellano-Bond AR(1) and AR(2) tests for this checking. We additionally conduct Hansen test for verifying the over-identification problem (Arellano and Bond, 1991; Min and Choi, 2013; Schuster and Maertens, 2015; Yoon et al., 2013).

4. Empirical Results

4.1 Estimation results for the importing countries

Table 6 reports the estimation results for the variables that affect the importing countries' grain SSR. Once getting a system GMM estimator, we should check our validity for applying the model. First, we check the significance of the coefficients of the lagged dependent variable. This variable is significant at 1% level, so it is proper to use a dynamic panel model. According to Models (1) ~ (3), if last year's grain SSR is high, the present value of the grain SSR is also high. This implies that there is a large degree of persistence of the grain SSR. .One country's SSR is decided by economic, cultural, environmental, and climatic conditions. Thus, the SSR cannot change suddenly in the short term, so we can say the grain SSR is strongly time-persisting from the strong correlation between the past and present grain SSRs. System GMM is an estimator that uses the instrument variables; therefore, we need to know the validity of the instrument variables in the model. The null hypotheses of "no second-order autocorrelation" (AR (2) test) and "over-identification of all instruments" (Hansen test) cannot be rejected. These test results confirm the validity of the instruments used.

In Table 6, we use the world rice, wheat, and maize prices as the representative grain prices in Models (1), (2), and (3), respectively. In Model (1), when the world rice price increases, the grain SSR also increases, but it is not statistically significant. However, other grains in other models show significant results; thus, it seems that the world rice price cannot be the representative price of world grain. If the GDP per capita increases by 1%, the importer's grain SSR will decrease by 1.2%. The world food crisis in 2008 caused a 0.2% decrease in the importer's grain

SSR.

In Model (2), we use the world wheat price as the representative grain price, and we obtain a statistically and positively significant result for this variable. This corresponds with our theoretical discussions as well as the findings of previous studies. An increase in the world wheat price by 1% causes a 0.3% increase in the grain SSR. Other variables, such as the GDP per capita and world beef price, show statistically significant results. When these variables increase by 1%, the importer's grain SSR will decrease, which also corresponds with our theoretical expectation.

Table 4. Estimation results for importers

Variables	Model (1) Rice price is used for representing world grain price	Model (2) Wheat price is used for representing world grain price	Model (3) Maze price is used for representing world grain price
Lagged SSR	0.470***(0.056)	0.479***(0.056)	0.475***(0.059)
World rice price	0.0728(0.160)		
Lagged world rice price	-0.0369(0.095)		
World wheat price		0.310***(0.104)	
Lagged world wheat price		-0.169(0.141)	
World maize price			0.262***(0.074)
Lagged world maize price			-0.0620(0.068)
GDP per capita	-1.196**(0.546)	-0.977**(0.448)	-0.989*(0.514)
Population	1.875**(0.926)	2.224**(1.002)	2.075**(0.833)
DAP fertilizer price	0.239(0.171)	0.176(0.139)	0.130(0.164)
Importer's domestic tariff (α)	2.766**(1.130)	2.643**(1.235)	3.097**(1.330)
World beef price	-0.551(0.435)	-0.861*(0.520)	-0.719*(0.405)

World food crisis	-0.220**(0.101)	-0.295***(0.110)	-0.228*(0.124)
AR (1) test	0.000	0.000	0.000
AR (2) test	0.090	0.109	0.122
Sargan test	0.000	0.000	0.000
Hansen test	0.341	0.433	0.401
Observations	1,949	1,949	1,949
Number of groups	132	132	132

Notes: Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

In Model (3), we use the world maize price; when it increases by 1%, the importer's grain SSR increases by 0.26%. Similar to the results of Model (2), the GDP per capita and world beef price are also significant.

From the estimation results in Table 6, we can confirm that the external shock, the world food crisis in 2008, which was caused by a spike in grain prices, led to a decrease in the importer's grain SSR. This crisis caused serious food deficiency in not only poor countries, but throughout the whole world as well. Our results empirically prove that the grain SSR of importing countries was weakened by the world food crisis.

Meanwhile, this study uses log values on the dependent variables and explanatory variables, so that all coefficient estimates are treated as elasticity. However, a 1% increase in the importer's domestic tariff means $\frac{\%\Delta \text{SSR}}{\%\Delta(1+\text{t})}$; thus, we can interpret this with the influence of the proportional value of $1+t$ on that of the grain SSR. However, our interest is not the $1+t$; rather, we want to find the elasticity of the grain SSR with respect to t ($\frac{\%\Delta \text{SSR}}{\%\Delta \text{t}}$). For deriving this, we apply simple calculation procedure as follows:

(7) $\alpha = \frac{\partial SST}{\partial(1+t)}\frac{1+t}{SSR},$

(8) $\alpha\,\frac{\partial(1+t)}{\partial t}\frac{t}{1+t} = \frac{\partial SSR}{\partial(1+t)}\frac{1+t}{SSR}\frac{\partial(1+t)}{\partial t}\frac{t}{1+t},$

(9) $\alpha\,\frac{t}{1+t} = \frac{\partial SSR}{\partial t}\frac{t}{SSR},$ therefore $\varepsilon_t = \alpha\,\frac{t}{1+t},$

where α is the estimated coefficient on the variable "*Importer's domestic tariff*" and ε_t is the elasticity of the grain SSR with respect to tariff rate. Table 5 presents the derived ε_t. As indicated, if the importer's domestic tariff increases by 1%, the grain SSR will increase by 0.26% in Model (1), 0.24% in Model (2), and 0.29% in Model (3) on average for the entire data period.

We compare the elasticity for the OECD member and non-member countries. If the importer is a OECD member, the elasticity is slightly higher than that of a non-member importer. We also use the importer's annual average tariff for measuring the grain SSR's elasticity in 2000, 2002, 2004, 2006, 2008, and 2010. There are no large gaps; however, among these years, that with the lowest elasticity of grain SSR is in 2008. This phenomenon can be interpreted as a side effect of 2008's world food crisis.

According to the value of the average tariff, the changing degree of the grain SSR shows different results. However, in models (1) ~ (3), a 1% tariff increase causes an improvement of the importer's grain SSR in common. Therefore, the decrease in the importer's tariff negatively affects the importer's grain SSR.

Table 5. Importer's elasticity of SSR with respect to tariff rate

		Average tariff (t)	Average of the elasticity of SSR to the tariff(ε_t)		
			Model (1)	Model (2)	Model (3)
Importer		0.102	0.257	0.245	0.287
OECD	Member	0.143	0.346	0.330	0.387
	Non-member	0.104	0.261	0.250	0.292
Year	2000	0.114	0.282	0.270	0.316
	2002	0.106	0.266	0.254	0.298
	2004	0.108	0.269	0.257	0.302
	2006	0.098	0.247	0.236	0.277
	2008	0.091	0.232	0.221	0.259
	2010	0.094	0.237	0.227	0.266

Meanwhile, this paper hypothesizes that the importer is small country, and that the world grain price is given as an exogenous variable. If importers are small countries, such as Antigua and Barbuda (90 tons in 2011), Dominica (140 tons in 2011), and Sao Tome and Principe (3,900 tons in 2011), production variability cannot effect the world grain price. Therefore, it is desirable to regard these countries as a small country group. However, countries like China (453,142,026 tons in 2011) and India (235,279,299 tons in 2011) can affect the world grain price, because their level of grain production is high. Further, the trade volume and import policies of major grain importers, like Japan (26,009,376 tons in 2011) and Mexico (17,876,033 tons in 2011), can also affect the world grain price more than those of smaller importers can. In other words, they are not small country but large country. Although small country assumption is convenient for estimating, there is a possibility that it does not reflect reality. As such, this study considers another case, which allows an importer as a large country.

We classify 137 importing countries as large or small, according to their import and production-quantity levels. We divide import countries into quintiles, 1^{st} (under 20%), 2^{nd} (20~40%), 3^{rd} (40~60%), 4^{th} (60~80%), and 5^{th} (80~90%), by the amount of import and production of grain. Thus, for example, importers in the 1^{st}~4^{th} quintiles have lower import or production levels than those in the 5^{th}. Therefore, we define them as small countries. Meanwhile, importers in the 5^{th} quintile are treated as large countries. We set the 5^{th} quintile as a base for creating dummy variables that represent the countries in each quantile. We add interaction terms, which multiply the main variable (Importer's domestic tariff; t) by the dummy variables in the regression models. The interaction term estimates how big of a gap can be made between tariff and grain SSR by import and production size. Therefore, through this, we can compare the impact on the grain SSR when the tariffs of both the large and small countries increase by 1%.

Table 6 presents the regression results, including the tariff interaction term. The estimation results are consistent with the ones reported in Table 4. Importer's tariff is estimated to have positive effect on grain SSR. World grain price and population are also estimated to be positively correlated with grain SSR as in Table 4. Per capita GDP is estimated to be positively correlated with grain SSR.

Table 6. Estimation results for importers with tariff interaction terms.

Variables	Model (1) Rice price is used for representing world grain price	Model (2) Wheat price is used for representing world grain price	Model (3) Maze price is used for representing world grain price
Lagged SSR	0.497***(0.050)	0.494***(0.0509)	0.491***(0.0523)
World rice price	0.0400(0.157)		
Lagged world rice price	-0.0402(0.097)		
World wheat price		0.290**(0.134)	
Lagged world wheat price		-0.213(0.164)	
World maize price			0.220***(0.0814)
Lagged world maize price			-0.0903(0.0736)
GDP per capita	-1.215*(0.655)	-1.040*(0.533)	-1.088*(0.636)
Population	1.690*(0.946)	2.124*(1.126)	1.939**(0.947)
DAP fertilizer price	0.203(0.213)	0.153(0.165)	0.117(0.184)
Importer's domestic tariff (α)	4.828**(2.126)	4.644**(2.100)	4.873**(2.072)
Import 1^{st} quintile * t (α)	-0.169(3.945)	-1.014(4.012)	-1.267(4.059)
Import 2^{nd} quintile * t (α)	-1.301(2.372)	-1.082(2.289)	-0.492(2.323)
Import 3^{rd} quintile * t (α)	-2.467(3.624)	-2.791(3.456)	-2.498(3.344)
Import 4^{th} quintile * t (α)	1.055(1.319)	1.397(1.393)	1.247(1.255)
Production 1^{st} quintile * t (α)	-8.139**(3.563)	-6.566*(3.640)	-7.099**(3.497)
Production 2^{nd} quintile * t (α)	-3.764(3.014)	-3.220(2.938)	-3.108(2.925)
Production 3^{rd} quintile * t (α)	-3.314*(1.764)	-3.212**(1.623)	-2.960*(1.623)
Production 4^{th} quintile * t (α)	-1.706*(1.005)	-1.551*(0.863)	-1.500*(0.872)
World beef price	0.531(0.481)	-0.865(0.603)	-0.687(0.453)
World food crisis	-0.191*(0.114)	-0.243*(0.130)	-0.195(0.145)
AR (1) test	0.000	0.000	0.000
AR (2) test	0.375	0.631	0.470
Sargan test	0.000	0.000	0.000
Hansen test	0.294	0.301	0.308
Observations	1,949	1,949	1,949
Number of groups	132	132	132

Notes: Standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p<0.1.

By calculating $\frac{\%\Delta SSR}{\%\Delta t}$ using the equation (9), we can distinguish the different effects of a tariff reduction, according to each country's import and production levels. Table 7 reports the average elasticity of the 1^{st}-5^{th} quintiles. As reported, the elasticity tends to be higher when the country is a bigger importer. This means that if a country has a higher dependence on grain imports, its grain SSR will be more affected by tariff reduction.

In the case of classification according to production, the estimated coefficients in the 2^{nd}-5^{th} quintiles are positive, and higher production quintiles have higher elasticity. If the importer is a large country in terms of production, this country can have an effect on world grain price. Therefore, if the tariff is reduced, its grain SSR will decrease more than it will in the small countries. Interesting results are found on the 1^{st} quintile. For these countries, the tariff has a negative effect on the grain SSR, which means that if the tariff is reduced, the grain SSR will increase, rather than decrease. Most of the countries in the 1^{st} quintile, like Belize, Fiji, Botswana, Dominica, Djibouti, Congo, Liberia, Lesotho, and Solomon Islands, are under-developed or low-income countries, and receive official development assistance (ODA) because they have acute food insecurity problems. Thus, we can consider that the reason for their grain SSR increase under tariff reduction is the agricultural development support, such as ODA.

Table 7. Importer's average tariff elasticity according to quintile.

		Average tariff (t)	Average tariff elasticity of SSR (ε_t)		
			Model (1)	Model (2)	Model (3)
According to Importing volume	1st quintile	0.104	(0.439)	(0.342)	(0.339)
	2nd quintile	0.073	(0.238)	(0.241)	(0.296)
	3rd quintile	0.077	(0.169)	(0.133)	(0.170)
	4th quintile	0.084	(0.454)	(0.466)	(0.472)
	5th quintile	0.173	0.714	0.687	0.720
According to Production volume	1st quintile	0.083	-0.251	-0.145	-0.167
	2nd quintile	0.076	(0.078)	(0.103)	(0.128)
	3rd quintile	0.087	0.124	0.117	0.156
	4th quintile	0.144	0.398	0.394	0.430
	5th quintile	0.123	0.527	0.507	0.532

Notes: The elasticity in parentheses is statistically insignificant.

4.1 Estimation results for the overall countries

Table 8 shows the estimation results for all 150 countries. Through the p-values for the AR (1) and (2) tests, we can confirm the presence of first-order autocorrelation, but no second-order autocorrelation. We find that there is no over-identifying problem from the result of Hansen test.

Model (1) uses the world rice price as a representative grain price, and the result is the same as the one in Table 4: the world rice price does not affect the world grain SSR. Model (2) presents that a 1% increase in the world wheat price will generate a 0.29% rise in the level of the world's grain SSR, which is significant at the 1% level. In Model (3), a 1% increase in the world maize price will cause a 0.26% rise in the level of the world's grain SSR. Estimated results suggest that the world grain prices seem to have the largest effect on the world grain SSR than other variables have. In this regard, this study includes the past (T-1) grain prices in the empirical regressions; however, the rice, wheat, and maize prices in the past years have no significant effect on the world's grain SSR.

The importer's tariff and grain SSR show a positive correlation, and the exporter's grain SSR and trade partner's tariff SSR show a negative correlation. These estimation results correspond to our theoretical discussion, but in the case of the exporter, the estimated coefficients are not statistically significant. The GDP per capita, world beef price, and food crisis in 2008 are estimated to cause the decrease in the world's grain SSR.

We expect that there will be a negative relationship between the population and grain SSR, but the estimated coefficients on population are consistently positive and statistically significant. This is the result of the cross-sectional effect that offsets the time-series effect. In terms of time-series data, population growth will cause a decrease in the grain SSR as time passes. However, according to the cross-sectional effect, the most populous countries have higher grain SSR because they have higher levels of consumption and production. In the panel data analysis, the cross-sectional effect is large enough to offset the time-series effect. Thus, all estimation results present that the coefficients in the population have a consistently positive effect on the grain SSR.

Table 8. Estimation results for all countries

Variables	Model (1) Rice price is used for representing world grain price	Model (2) Wheat price is used for representing world grain price	Model (3) Maze price is used for representing world grain price
Lagged SSR	0.458***(0.062)	0.472***(0.0606)	0.468***(0.0622)
World rice price	0.0866(0.150)		
Lagged world rice price	-0.0343(0.0970)		
World wheat price		0.286***(0.106)	
Lagged world wheat price		-0.157(0.125)	
World maize price			0.260***(0.0760)
Lagged world maize price			-0.0461(0.0601)
GDP per capita	-1.225**(0.548)	-1.008**(0.449)	-1.000**(0.509)
Population	1.810**(0.873)	2.118**(0.952)	1.968**(0.816)
DAP fertilizer price	0.223(0.155)	0.190(0.142)	0.128(0.164)
Importer's domestic tariff	2.774***(1.037)	2.688**(1.177)	3.004**(1.235)
Exporter's partner's tariff	-0.0463(1.478)	-0.681(1.371)	0.159(1.512)
World beef price	-0.489(0.371)	-0.823*(0.471)	-0.666*(0.373)
World food crisis	-0.204**(0.101)	-0.289***(0.110)	-0.217*(0.124)
AR (1) test	0.000	0.000	0.000
AR (2) test	0.070	0.115	0.085
Sargan test	0.000	0.000	0.000
Hansen test	0.264	0.345	0.251
Observations	2139	2139	2139
Number of groups	145	145	145

Notes: L. = lagged. Standard errors are in parentheses, *** p < 0.01, ** p < 0.05, and * p < 0.1.

5. Summary and Conclusions

After the world food crisis in 2008, concerns about food security have expanded to most of the countries that import food. Moreover, the problem of food insecurity is not only a concern for importers, but also for the entire world. Therefore, importers and exporters began to set forth policies for securing the food SSR, since it has been regarded as one of the most effective tools for achieving food security. However, trade liberalization through a tariff reduction has conflicting effects on food accessibility and availability[3]. This paper investigates the effect of a tariff reduction on the world's grain self-sufficiency which is a main component in defining the food security, especially from the perspective of food-importing countries.

We define grain self-sufficiency as domestic production divided by domestic consumption. Prior to the empirical estimation, we develop a theoretical model using a supply-demand framework, with importer and exporter classifications. Then, we theoretically discuss each variable's effect on the grain SSR. According to the results, the world grain price and SSR are positively correlated, but the GDP per capita, population, input price, and substitute price show negative results. The notable result is that a change in the importer's domestic tariff has a different influence on the importer than it does on the exporter. The importer's domestic tariff reduction will cause a decrease in the importer's grain SSR, but under the equal conditions, an increase in the exporter's grain SSR.

Empirical estimation shows that the world wheat and maize prices affect the world's grain SSR. However, the world rice price shows no relationship with the world's grain SSR. In many countries, since rice is mainly produced and consumed domestically, its international trade is thin. As such, only a small fraction of the rice production is exported and imported internationally, unlike is the case with wheat

[3] FAO defines food security using the concepts of "accessibility", "availability" and "use".

and maize (Tanaka and Hosoe, 2011). Therefore, the world rice price cannot be a representative price of world grains, and cannot affect the world's grain SSR. As mentioned in our theoretical discussion, the GDP per capita and world beef price negatively influences the world's grain SSR. We include a food crisis dummy to examine the sensitivity toward external shocks, and find that the food crisis of 2008 negatively affects the world's grain SSR.

In this study, we especially focus on the tariff variable. The domestic tariff for the importer and importer's grain SSR are positive, while the exporter's tariff and grain SSR are negative; however, the result of the exporter's case is statistically insignificant. This means that the tariff reduction has a negative effect only on the importer's grain SSR. From the results, we are able to answer our original question, regarding whether tariff reduction has a positive effect on the world's grain SSR; our findings show that such a reduction has a negative effect on the importer's grain SSR. We consider the case of large countries adding tariff- interaction term. As the country is bigger importer, the effect on tariff reduction on the degree of the grain SSR's decrease becomes larger.

The results based on our theoretical and empirical models support the perspective that market expansion through tariff reduction will have a negative effect on the importer's food SSR. Moreover, the findings from this study will serve as useful reference for most food-importing countries that want to implement policies for improving food SSR.

This paper, however, also presents some limitations and future challenges to overcome. First, we need to expand the "food" category to include not only grains, in order to analyze all food items like meat, seafood, and vegetables. Second, we should have a precise and distinguishable standard in the process of classifying 150 countries into importers and exporters. Finally, the inequality and polarization of the world's food SSR, which Jeon and Ahn (2015) discussed, seem to be closely related to the determinants that are used in this study. Therefore, further research is required to analyze the factors affecting the inequality and polarization of the food SSR in the world.

References

Ahn, B. I. (2002), "The Market Structure and Import Demand of Milling Wheats," *Journal of Rural Development* 25(2): 1-15.

Ahn, B. I. (2007), "Effects of Tariff Reductions on the Korean Cheese Market," *Journal of Rural Development* 30(1): 45-60.

Ahn, B. I. and D. B. Han (2012), "Review of Various Viewpoints on Food Security and Policy Implications," *Korea Journal of Agricultural Management and Policy* 39(4): 815-840.

Ahn, B. I., S. Y. Kim and M. H. Park (2008), "Effects of Tariff Reductions on the Green Tea Industry in Korea," *Journal of Rural Development* 31(4): 123-150.

Amid, J. (2007), "The Dilemma of Cheap Food and Self-Sufficiency: The Case of Wheat in Iran," *Food Policy* 32(4): 537-552.

Arellano, M. and Bond, S. (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *The review of economic studies* 58(2): 277-297.

Arellano, M. and Bover, O. (1995), "Another Look at the Instrumental Variable Estimation of Error-components Models," *Journal of econometrics* 68(1): 29-

51.

Bah, A. A. (2013), "Strategies for Promoting Rice Self-sufficiency in Sierra Leone," *Journal of Northeast Agricultural University (English Edition)* 20(4): 78-86.

Bezuneh, M., and Yiheyis, Z. (2014), "Has Liberalization Improved Food Availability In Developing Countries? An Empirical Analysis," *Journal of Economic Development 39*(1): 63-78.

Blundell, R. and Bond, S. (1998), "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics* 87(1): 115-143.

Brañas-Garza, P., Bucheli, M. and García-Muñoz, T. (2011), "Dynamic Panel Data: A Useful Technique in Experiments," Universidad de Granada. Departamento de Teoría e Historia Económica.

Brooks, J. (2014), "Policy Coherence and Food Security: The Effects of OECD Countries' Agricultural Policies," *Food Policy* 44: 88-94.

Burnett, K. and Murphy, S. (2014), "What Place for International Trade in Food Sovereignty?" *Journal of Peasant Studies* 41(6): 1065-1084.

Choi, J. H., B. J. Woo and Y. J. Hwang (2010), *A Study on Conceptualization of Food Self-Sufficiency Rate and Reestablishing its Target in Korea*, Korea Rural Economic Institute, Research Report C2010-36.

Choi, Y. H. (2013), "The Governance Effect on Economic Growth depending on Form of Government – An Empirical Analysis employing 'system GMM' Dynamic Panel Model," Department of Public Administration, Korea University Graduate School.

Clapp, J. (2014), *Trade Liberalization and Food Security: Examining the Linkages*, Quaker United Nations Office.

Elsheikh, O. E., Elbushra, A. A. and Salih, A. A. (2015), "Economic Impacts of Changes in Wheat's Import Tariff on the Sudanese Economy," *Journal of the Saudi Society of Agricultural Sciences* 14(1): 68-75.

Faisal, I. M. and Parveen, S. (2004), "Food Security in the Face of Climate Change, Population Growth, and Resource Constraints: Implications for Bangladesh," *Environmental Management* 34(4): 487-498.

FAO (2003), Trade Reforms and Food Security: Conceptualizing the linkages, Food and Agriculture Organization (FAO) of the United Nations, Rome.

FAO (2011), The State of Food Insecurity in the World: How does International Price Volatility Affect Domestic Economies and Food Security?, Food and Agriculture Organization (FAO) of the United Nations, Rome.

Gerbens-Leenes, P. W., Nonhebel, S. and Krol, M. S. (2010), “Food Consumption Patterns and Economic Growth. Increasing Affluence and the Use of Natural Resources,” *Appetite* 55(3): 597-608.

Ha, W., Yi, J., Yuan, Y. and Zhang, J. (2015), “The Dynamic Effect of Rural-to-Urban Migration on Inequality in Source Villages: System GMM Estimates from Rural China,” *China Economic Review*.

Hailu, M. B. (2010), “Food Security and Agricultural Trade Liberalization,” In Society of International Economic Law (SIEL), Second Biennial Global Conference paper University of Barcelona.

Han, D. B., B. I. Ahn and M. S. Park (2012), “Classification of Country Types according to Food and Energy Securities: Focusing on Food and Energy Self-Sufficiency Rates,” *Korean Journal of Agricultural Economics* 53(4): 89-109.

Hwang, Y. S. (2009), “The Necessity, Possibility, and Policy Suggestion of Improving Food Self-Sufficiency Rate in Korea,” *Journal of Rural Development* 17(1): 29-58.

IGC (2015), Grain Market Report (GMR 460-29), International Grains Council (IGC).

Im, J. B., D. H. An and S. J. Jang (2010), “Adjusting Patterns of Production Fluctuation and Trade Transmission Effect of Major Soybean Production Countries on World Market,” *Journal of Agriculture & Life Science* 44(2): 85-96.

Ito, J. and Ni, J. (2013), “Capital Deepening, Land Use Policy, and Self-sufficiency in China's Grain Sector,” *China Economic Review* 24: 95-107.

Jayasinghe, S., Beghin, J. C. and Moschini, G. (2010), “Determinants of World Demand for US Corn Seeds: the Role of Trade Costs,” *American Journal of Agricultural Economics* 92(4): 999-1010.

Jeon, Y. H. and B. I. Ahn (2015), “Analysis of the world`s inequality and polarization of food self-sufficient rate,” *Korean Journal of Agricultural Economics* 56(1): 71-97.

Kako, T. (2009), “Sharp Decline in the Food self-sufficiency Ratio in Japan and its Future Prospects,” International Association of Agricultural Economists Conference, Beijing, China.

Kim, D. H., J. M. Mun, E. G. Kim, C. S. Kim and H. S. Lee (2014), “Impacts of Domestic Dried Jujube and Shiitake Mushroom Market by Tariff Reduction,” *Journal of Agriculture & Life Science* 48(6): 87-96.

Kim, Y. T., B. R. Kim, B. H. Lee, I. S. Jun, J. Y. Yoon, J. H. Min, J. S. Kim, J. K. Seong, W. B. Kim and J. H. Kim (2011), *Overseas Agricultural Development for Food Security(3/3)*, Korea Rural Economic Institute, Research Report R646.

Kim, Y. T., T. J. Kwon, B. R. Kim, I. S. Jun, J. Y. Yoon, M. J. Nam and U. R. Cho (2010), *Overseas Agricultural Development for Food Security (2/3)*, Korea Rural Economic Institute, Research Report R630.

Kumar, M. S. and Woo, J. J. (2010), *Public Debt and Growth*, IMF Working Paper No. 10/174 (International Monetary Fund).

Kyriacou, A. P., Muinelo-Gallo, L. and Roca-Sagalés, O. (2015), “Fiscal Decentralization and Regional Disparities: The Importance of Good Governance,” *Papers in Regional Science* 94(1): 89-107.

Lee, D. S. (2014), *An Essay on U.S. Strategies to Enhance Global Food Security and their Implications to Korea*, Korea Rural Economic Institute, Discussion Paper: W38.

Leung, P. and Loke, M. (2008), “Economic Impacts of Improving Hawaii's Food Self-sufficiency,” University of Hawaii EI-16.

Min, I. S. and P. S. Choi (2013), *STATA Panel Data Analysis*, Jiphil Media.

Minot, N. and Pelijor, N. (2010), *Food Security and Food Self Sufficiency in Bhutan*, International Food Policy Research Institute, Washington, D.C. (IFPRI) and Ministry of Agriculture and Forests (MoAF)

Nguema, I. E. and Ella, G. A. (2014), "Trade Liberalization and Food Security: For a New Green Revolution in Africa," *Journal of Food Security* 2(2): 42-50.

ODI (2008), Rising Food Prices: A Global Crisis, Briefing Paper 37, Overseas Development Institute (ODI)

OECD (2008), Rising Food Prices: Causes and Consequences, Organization for Economic Co-operation and Development (OECD)

Park, D. G. and J. H. Seung (2013), *Chaptor 17th: The policy subject of reconsideration of grain self-sufficiency*, Korea Rural Economic Institute, Research Report 609-634.

Park, H. I., H. C. Kang, H. N. Kim, S. H. Lim and W. S. Moon (2011), *New Food Security Strategies in the Age of Global Food Crises*, Samsung Economic Research Institute, Issue Report.

Park, J. H., H. S. Lee and S. G. You (2007), "A Study of Urban Households' Characteristics and Rice Consumption Expenditure," *Journal of Agriculture & Life Science* 41(1): 35-43.

Pinckney, T. C. (1993), "Is Market Liberalization Compatible with Food Security?: Storage, Trade and Price Policies for Maize in Southern Africa," *Food Policy* 18(4): 325-333.

Pyakuryal, B., Roy, D. and Thapa, Y. B. (2010), "Trade Liberalization and Food Security in Nepal," *Food Policy* 35(1): 20-31.

Schneider, U. A., Havlík, P., Schmid, E., Valin, H., Mosnier, A., Obersteiner, M., Bottcher, H., Skalsky, R., Balkovic, J., Sauer, T. and Fritz, S. (2011), "Impacts of Population Growth, Economic Development, and Technical Change on Global Food Production and Consumption," *Agricultural Systems* 104(2): 204-215.

Schuster, M. and Maertens, M. (2015), "The Impact of Private Food Standards on Developing Countries' Export Performance: An Analysis of Asparagus Firms in Peru," *World Development* 66: 208-221.

Schwarz, C. and Kripfganz, S. (2015). Estimation of linear dynamic panel data models with time-invariant regressors, European Central Bank, Working Paper Series (No. 1838).

Seong, J. K. (2013), *Global Food Crisis and Practical Proposal for Improvement of Korean Food Self-Sufficiency*, Korea Rural Economic Institute, World Agriculture 152: 65-90.

Seshamani, V. (1998), "The Impact of Market Liberalization on Food Security in Zambia," *Food Policy* 23(6): 539-551.

Siddig, K. H. and Mubarak, A. M. (2013), "Food Self-Sufficiency versus Foreign Currency Earnings in the Sudanese Irrigated Agriculture," *Journal of the Saudi Society of Agricultural Sciences* 12(1): 19-25.

Sung, M. H., T. H. Kim, B. J. Woo, S. H. Chai, J. H. Seung and J. E. Park (2008), *A Study on Developing Alternative Policy for Stably Securing Grains: Early Warning System and Overseas Agricultural Investment*, Korea Rural Economic Institute, Research Report C2008-42.

Tanaka, T. and Hosoe, N. (2011), "Does Agricultural Trade Liberalization Increase Risks of Supply-Side Uncertainty? Effects of Productivity Shocks and Export Restrictions on Welfare and Food Supply in Japan," *Food Policy* 36(3): 368-377.

Tilman, D., Balzer, C., Hill, J. and Befort, B. L. (2011), "Global Food Demand and the Sustainable Intensification of Agriculture," *Proceedings of the National Academy of Sciences* 108(50): 20260-20264.

Trostle, R. (2010), *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices*, USDA Outlook WRS-0801.

van Oort, P. A. J., Saito, K., Tanaka, A., Amovin-Assagba, E., Van Bussel, L. G. J., van Wart, J., de Groot, H., van Ittersum, M. K., Cassman, K. G. and Wopereis, M. C. S. (2015), "Assessment of Rice Self-Sufficiency in 2025 in eight African countries," *Global Food Security* 5: 39-49.

Yoon, Y. G., Y. S. Kim, J. W. Kim, Y. J. Nho, K. W. Park, C. R. Han and M. K. Hong (2013), *Study on Workplace Dynamics Using the Workplace Panel Survey*, Korea Labor Institute.

Appendix

List of 150 countries

Importer	Exporter
Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Armenia, Austria, Bahamas, Bangladesh, Barbados, Belarus, Belize, Benin, Bolivia (Plurinational State of), Botswana, Brazil, Brunei, Darussalam, Bulgaria, Burkina, Faso ,Cambodia, Cameroon, Central African Republic, Chad, Chile, China, Colombia, Congo, Costa Rica, Côte d'Ivoire, Croatia, Czech Republic, Cuba, Cyprus, Democratic People's Republic of Korea, Denmark, Djibouti Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Fiji, Finland, Gabon, Gambia, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, India, Indonesia, Iran (Islamic Republic of), Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Lao, People's Democratic Republic Lebanon, Lesotho, Liberia, Libya, Lithuania, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Peru, Philippines, Poland, Portugal, South Korea, Romania, Rwanda, Saint Vincent and the Grenadines, Sao Tome and Principe, Saudi Arabia, Senegal, Sierra Leone, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Switzerland, Syrian Arab Republic, Tajikistan, Timor-Leste, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom, United Republic of Tanzania, Vanuatu, Venezuela, Yemen, Zambia, Zimbabwe, Russian Federation, Ukraine, Uzbekistan	Argentina, Australia, Canada, France Germany, Guyana, Paraguay, Sweden Thailand, U.S.A, Uruguay, Vietnam, Hungary