Import Demand Elasticities for Agricultural Products in Korea

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Abstract: This paper estimates the import demand elasticities for agricultural products in Korea. Agriculture in Korea is heavily protected by tariffs and quotas. Thus the future trade liberalization might be expected to have a destructive effect on agriculture and agricultural producers in Korea. By searching for import demand elasticities for agricultural products in both aggregated and disaggregated levels, we can predict the plausible effects of trade liberalization on agriculture. By estimating import demand elasticities for agricultural products in Korea, the following two hypotheses can be probed. First, Korea is a small country in the world agricultural market. This hypothesis will be true if import prices are exogenously given and import demands are highly elastic to import prices. Second, the more is disaggregated, the higher the import demand elasticity is. Import unit-value indexes are used as proxies for import prices in this paper. Import demand elasticities for 32 agricultural sectors in Korea are estimated. Two estimation methods are employed, which are the least squares with autoregressive correction and two-stage least squares with autoregressive correction. Endogeneity of import prices are tested using Durbin-Wu-Hausman statistic. Estimation results find that all five aggregated sectors have inelastic import demand while among 27 disaggregated sectors, 16 sectors have highly elastic import demand. These econometric estimates support the second hypothesis.

JEL Classification: F14, Q17

Keywords: Import-demand elasticity; Agricultural trade; Trade liberalization; Endogeneity of import prices; Korea.

1. Introduction

Agriculture in Korea is heavily protected by using tariffs and quotas. In terms of the average applied tariff rates, it can be claimed that Korean agricultural products are the world's most protected goods[1]. However, Korea is in a position where it has to further more liberalization of trade because it generates more than two-thirds of its GNP from international trade and has benefited from GATT-WTO sponsored free trade

[1] According to Congressional Budget Office (2005), average applied tariff rates for agricultural and food sectors of Korea and Taiwan are highest among the high income countries.

regime during its enormously fast development era. In the advent of the event such as conclusion of DDA negotiations or establishments of free trade agreements with large trading partners such as U.S, China, and Japan, tariff rates and quotas for agricultural products will be reduced significantly and it might badly harm agricultural sector in Korea. This issue is very critical in the political process for the pursuit of trade liberalization. Thus, the recognition of the effects of trade liberalization on agriculture will be very important for both policy-makers and special interest groups that have interests related to agriculture.

Import-demand elasticity estimates are important inputs into most trade policy simulation models. Thus, finding import-demand elasticities for agricultural sectors will be the first step toward recognizing the effects of liberalization of trade on agriculture. Several methods of estimating import-demand elasticities have been developed for more than three decades since Armington (1969)[2] but have never been applied to the imports of agricultural goods in Korea.

This paper presents econometric estimates of import-demand elasticities for the agricultural sectors in Korea using the data classified following HS(Harmonized System) from five aggregated agricultural sectors (grains, livestock products, dairy products, fruits, and vegetables) to 27 disaggregated agricultural sectors. Unit-value indexes are used as measures of import prices. Even though we are aware from the literature on disaggregated import-demand elasticity estimation that measurement errors which should not be ignored are present in import unit-value indexes, alternative

[2] In his 1969 IMF Staff Paper, 'A theory of demand for products distinguished by place of production,' Armington proposed the model from which a constant elasticity of substitution (CES) specification is derived. Even though Armington has never obtained estimates of elasticties of substitution between imported and domestically produced goods, those elasticities are called Armington elasticities which are based on the differentiation of products with respect to their origins and the imperfect substitution in demand between imports and domestic supply. Here we do not refer his IMF Staff paper (Armington(1969)) directly.

measures as proxies for import prices are not available[3]. The distinguishing feature of this paper is to estimate the import-demand elasticities for both aggregated and disaggregated sectors of agriculture. It will make us to be able to discern the effects of trade liberalization on each disaggregated agricultural sector from those on the agriculture as a whole. Thus from the estimation results of each disaggregated sector we can infer the different impacts of trade liberalization on each disaggregated agricultural products and producers. This inference can provide a powerful implication in a policy-sense. Also, the import-demand elasticities for the disaggregated sectors are acknowledged to be higher according to the previous literature[4]. This paper also probes if this common notion can be applied to the agriculture in Korea.

The notion that Korea is a small country in a world agricultural market plays an important role when investigating the effects of trade liberalization on agriculture. While most economists agree that trade liberalization enhances the aggregate welfare of the country, it can also generate the loss of production and welfare of the sector in which the country does not have comparative advantage. When some country is in a position of small country in that sector which means it has no market power in the world market, the cutback of trade barriers will have negative effects on production and producers' welfare of this sector. Korea is a net importer of agricultural products and the sector of agriculture is heavily protected. Thus, if Korea proves to be a small country in the world agricultural market, then it will be very likely that the production and welfare of the agricultural sector will reduce substantially by trade liberalization. We can

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[3] Shiells (1991) compared import-demand elasticity estimates based on import unit-value indexes to those using U.S. Bureau of Labor Statistics (BLS) import-price indexes and showed that using unit-value indexes did not greatly affect estimated import-demand elasticities.

[4] Panagariya, Shah, and Mishra (2001) find that the import demand elasticity for highly disaggregated sectors in a very small country such as Bangladesh is so high compared to those for aggregated sectors.

investigate this issue by estimating import-demand elasticities and testing endogeneity of import prices.

This paper is organized as follows. The next section reviews the existing studies that perform estimations of import-demand elasticities, Section 3 presents the model and empirical specification, and Section 4 describes the data used in the estimations. We present the estimation results in Section 5. Section 6 provides the implications of estimation results to the effects of trade policy on agriculture and limitations of this study.

2. Literature Review

The studies on estimates of import-demand elasticities at disaggregated level have appeared intermittently since Armington(1969). Stone (1979) estimated price elasticities of disaggregated import and export demand for the U.S., the European Economic Community and Japan. Shiells, Stern, and Deardorff (1986) estimated import-demand elasticities with annual data from 1962 to 1978 for 163 disaggregated sectors and obtained statistically significant elasticities for 122 sectors. Shiells *et.al* (1986) employed the log-linear specification to estimate elasticities. Reinert and Roland-Holst (1992) and Shiells and Reinert (1993) also used the same method to estimate Armington elasticities for disaggregated mining and manufacturing sectors in U.S. The import-demand elasticities estimated by Shiells *et.al* have been widely used in the literature of political economy and trade models.

Marquez (1994) examined the behavior of U.S. imports using a simultaneous equations model and bilateral data and emphasized the weakness of constant-elasticity model. Blonigen and Wilson (1999) estimated Armington elasticities for U.S. industrial sectors using a varying coefficients model and found that the variations of elasticities among sectors are due to some home bias variables and the presence of foreign-owned affiliates.

Erkel-Rousse and Mirza (2002) tried to discover the reason of low price elasticity of import-demand and argued low values of elasticities might be due to misspecification. They obtained high estimates from 1 to 13 using several econometric methods with theoretically appropriate instruments. Thomakos and Ulubasoglu (2002) estimated disaggregated import-demand elasticities for Turkey and investigated the effects of trade regime change on import-demand elasticities. Gallaway, McDaniel, and Rivera (2003) showed that average long-run estimates of Armington elasticities are two times larger than the short-run estimates.

3. The Model and Empirical Specification

In this section, we derive the testable specification of import-demand equations for agricultural products. In previous studies, a log-linear specification was commonly employed. This specification is regarded as an adequate approximation of the functional form of the import-demand equation. Based on the Armington approach, it is assumed that consumers distinguish goods by their source, which means consumers differentiate between domestic goods and their imported substitutes.

Assume that the representative consumer in Korea maximizes the Spence-Dixit-Stiglitz sub-utility function subject to his budget constraint as follows.

$$U=\left[\sum_{i=1}^{2}\sum_{j=1}^{n}\beta_{ij}x_{ij}^{\frac{\sigma_j-1}{\sigma_j}}\right]^{\frac{\sigma}{\sigma-1}} \quad (1)$$

x_{1j} stands for import demand of product j while x_{2j} stands for the demand of product *j* that is domestically produced. Suppose that there are *n* agricultural product groups. β_{ij} is geographic preference parameters for product *j* and σ_j is the constant elasticity of substitution between the domestic and the imported good *j*. A representative consumer's budget constraint for agricultural goods is as follows.

$$E=\sum_{i=1}^{2}\sum_{j=1}^{n}P_{ij}x_{ij} \quad (2)$$

So the utility maximization problem can be written as

$$Max.L=\left[\sum_{i=1}^{2}\sum_{j=1}^{n}\beta_{ij}x_{ij}^{\frac{\sigma_j-1}{\sigma_j}}\right]^{\frac{\sigma}{\sigma-1}}+\psi\left[E-\sum_{i=1}^{2}\sum_{j=1}^{n}P_{ij}x_{ij}\right] \quad (3)$$

The first-order conditions with respect to x_{1j} and x_{2j} can be combined to obtain

$$\frac{x_{1j}}{x_{2j}}=\left(\frac{\beta_{1j}}{\beta_{2j}}\right)^{\sigma_j}\left(\frac{P_{1j}}{P_{2j}}\right)^{-\sigma_j} \quad j=1,\cdots,n. \quad (4)$$

The above is derived from the consumer optimization problem specifying a sub-utility function in which the elasticity of substitution over the domestic and the imported good in the same product group is constant. Taking logs of (4) yields the following.

$$\ln\left(\frac{x_{1j}}{x_{2j}}\right)=\sigma_j\ln\left(\frac{\beta_{1j}}{\beta_{2j}}\right)-\sigma_j\ln\left(\frac{P_{1j}}{P_{2j}}\right) \quad j=1,\cdots,n \quad (5)$$

Here σ_j is Armington elasticity of product group *j*. (5) can be the functional form of the import-demand equation. Considering the data availability and the accompanied estimation difficulty, (5) can be approximated as follows.

$$\ln x_{1j} = \alpha_{0j} + \alpha_{1j} \ln P_{1j} + \alpha_{2j} \ln P_{2j} + \alpha_{3j} \ln E_j + e_j \tag{6}$$

where e_j is error term. In order to link the estimable import-demand equation and the theory tightly, more explanation about (6) will be needed. Armington approach is based upon two-stage budgeting process. This implies that a representative consumer allocates his total expenditure on agricultural products (*E*) into each product group *j* (E_j), and then determines to consume between domestic and imported goods. Under strong restrictions such as separability and homotheticity following Armington model, import shares $\left(\frac{x_{1j}}{x_{2j}}\right)$ are constant given constant relative price $\left(\frac{P_{1j}}{P_{2j}}\right)$ and independent of expenditure share on the import and domestic good *j*. Namely, for one product only the elasticity of substitution characterizes the price responses. Relaxing the assumption of homotheticity makes the import-demand or relative market share of product *j* being dependent upon the expenditure share on the domestic and imported good *j*. So we can specify the import-demand function as (6). But the problem will be induced from the treatment of expenditure shares since data on expenditure shares is not usually available. Thus, we assume that expenditure shares are a constant fraction of total expenditure *E* as follows. $E_j = \gamma_j E, 0 < \gamma_j < 1$. With this assumption, (6) can be modified as follows.

$$\ln x_{1j} = \gamma_{0j} + \alpha_{1j} \ln P_{1j} + \alpha_{2j} \ln P_{2j} + \alpha_{3j} \ln E + e_j \tag{7}$$

where $\gamma_{0j} = \alpha_{0j} + \alpha_{3j} \ln \gamma_j$. Considering that (7) is the approximation of (5), α_{1j} and

α_{2j} can be approximated as $-\sigma_j$ and σ_j respectively, and α_{0j} can be also approximated as $\sigma_j \ln\left(\frac{\beta_{1j}}{\beta_{2j}}\right)$. From the above statements, the following hypotheses can be derived. First, we can claim $\alpha_{1j} + \alpha_{2j} = 0$. Second, $\alpha_{3j} = 0$ can be claimed since, in the theoretical model with separability and homotheticity, total expenditure plays no role for determining import-demand.

Import demand of agricultural products is represented as (7) but the special characteristic of agricultural goods that should be taken into account is the seasonality. Different from other manufactured goods, the supply and demand of agricultural goods vary seasonally. In order to reflect the characteristic of seasonality, quarterly dummies will be included in the specification of import-demand of agricultural products and time variable(t) should be considered. Thus, (7) will be modified as follows.

$$\ln x_{1jt} = \gamma_{0j} + \alpha_{1j} \ln P_{1jt} + \alpha_{2j} \ln P_{2jt} + \alpha_{3j} \ln E_t + b_{2j} D_{2t} + b_{3j} D_{3t} + b_{4j} D_{4t} + e_{jt} \qquad (8)$$

where D_{2t}, D_{3t}, D_{4t} stand for second, third, fourth quarter of the year *t* respectively.

The error terms, e_{jt}, are assumed to follow a first-order autoregressive process:

$$e_{jt} = \rho_j e_{jt-1} + \varepsilon_{jt} \qquad (9)$$

where ρ_j is the autoregressive parameter ($-1 < \rho_j < 1$) and ε_{jt} is a serially uncorrelated, homoscedastic random variable with zero mean.

Two estimation methods will be employed. One is the ordinary least squares (OLS) with first-order autoregressive correction (AR(1)). This estimation method would be appropriate if the variables such as P_{1jt}, P_{2jt}, E_t are exogenously given. However, in most of the previous literature, variables that represent import-demand, import price, domestic price, and the activity variables as total expenditure have been treated as endogenous ones. One can argue that Korea is a small country in the world market for the agricultural good *j*, and then the import price P_{1jt} should be taken as given. A small country assumption also implies that import demand is highly elastic and thus, high price elasticity of import-demand (α_{1j}) is required to comply with the small country assumption in the world market. So it is necessary to test the endogeneity of right-hand side variables, especially prices, to confirm the goodness of this estimation method. The endogeneity of both domestic as well as import prices will be tested by using a Durbin-Wu-Hausman (DWH) statistic.

The other estimation method is the two-stage least squares (2SLS) with first-order autoregressive correction (AR(1)). With endogenous right-hand side variables, estimation should be performed by using instrumental variables. For this estimation to be consistent, the set of instruments needs to be properly specified. In this study the exogenous variables as interest rates and exchange rates of Korea and China, and wages and interest rates of U.S. are specified as instruments. Also lagged dependent variable and regressors are added to instruments. With this instrument list, no identification problem exists.

In this case, The Durbin-Wu-Hausman (DWH) test examines the null hypothesis that $Y^T = [P_{1j} \quad P_{2j}]$ is exogenous by checking for a statistically significant difference between the LS with AR(1) and 2SLS with AR(1) estimates of

$\beta^T = [\alpha_{1j} \quad \alpha_{2j}]$. Following Hausman (1978), the test statistic is as follows.

$$m = \left(\hat{\beta}_{2SLS} - \hat{\beta}_{LS}\right)^T \hat{V}^{-1}\left(\hat{\beta}_{2SLS} - \hat{\beta}_{LS}\right) \qquad (10)$$

where $\hat{V} = V\left(\hat{\beta}_{2SLS}\right) - V\left(\hat{\beta}_{LS}\right)$

Since m is distributed asymptotically as χ_2^2 which has critical values of 5.99 at the 5 per cent level and 9.21 at the 1 per cent level, the exogeneity test for each sector will be carried out based on the comparison between the test statistic and the critical value.

The above estimation procedures are performed for the 5 aggregated sectors (grains, livestock products, dairy products, vegetables, and fruits). Within each aggregated sector, estimations for disaggregated sectors are carried out. For the sector of grains, disaggregated sectors as barley, potatoes, soybeans, corn, oats, rye, grain sorghum, and wheat are the ones for which the above estimation procedures are performed. For the sector of livestock products, beef, pork, and poultry are the disaggregated sectors for which the above estimation methods are used. The disaggregated sectors as milk, cheese, eggs, and whey are the ones for the sector of dairy products. For the sector of fruits, the disaggregated sectors for estimation are banana, grape, kiwi, orange, and pine apple. In the sector of vegetables, the products such as cabbage, carrot, groundnuts, garlic, onion, perilla, and sesame seeds are the disaggregated sectors chosen for the estimation of import-demand equation.

4. The Data

Estimation procedures for 5 aggregated sectors are based on 2-digit HS

(Harmonized System) sector-level data. For the sector of grains, among 2-digit HS (10) data, data on rice (HS 1006) is excluded and for the sector of dairy products, among 2-digit HS (04) data, data on honey and others (HS 0409, 0410) is excluded. Estimation procedures for disaggregated sectors in grains, fruits, and vegetables are based on 6-digit HS sector-level data but the ones for sectors in dairy products and livestock products are based on 4-digit HS sector-level data[5].

The disaggregated sectors for estimations are selected in accordance with the degree of importance in both import and domestic production of agricultural products in Korea. As for the domestic production in agriculture, rice is the most important agricultural product in Korea. However, rice is not included in our analysis because there is no sufficient data for import of rice[6]. The implication and limitation of excluding rice in our analysis will be discussed later. Wheat is not an important product in terms of domestic production but is selected for estimation because it is one of the largest imported agricultural goods. Since it has a long history of import, the import-demand elasticity of wheat can be a good example to anticipate the one for the product that does not have a history of import.

For each import-demand equation, import demand is the quarterly data of imported quantity and import price is the unit-value index. These data are obtained and constructed from *Statistical Yearbook of Foreign Trade* published by Korea Customs Service. *Price index of farm products received by farmers* reported by National Agricultural Cooperative Federation in Korea is employed as the proxy for domestic

[5] When the products for disaggregated sector are selected, we do not always follow the HS classification. Soybeans (HS 120100) and potatoes (HS 070190) are classified as grains and sesame seeds (HS 120740), perilla (HS 120799), and groundnuts (HS 120210) are classified as vegetables.

[6] To implement UR negotiation, Korea started to import rice in 1996 but only minimum market access quantity which is specified in the schedule can be imported. Thus the variation of import-demand of rice affected by other factors as import and domestic prices cannot be captured.

price of each product[7]. Real GDP is used as the proxy for the total expenditure and the data is available from the Bank of Korea database (http://ecos.bok.or.kr). For the instruments, data for domestic interest rate and exchange rate is obtained from the Bank of Korea database and the data for other instruments are available from the database of Korea Customs Service (http://www.kita.net).

Quarterly import-quantity series for most disaggregated sectors are from the 1st quarter of 1991 to the 4th quarter of 2004 except some sectors in which data is available for the limited period of time. The data for perilla is available from the 1st quarter of 1992 and those of garlic and carrot are available from the 4th quarter of 1993 and the 3rd quarter of 1994, respectively. The import data for grape, kiwi, and potatoes are available from the 1st quarter of 1996.

5. Estimation Results

The results of the estimations of import-demand for 5 aggregated sectors are shown in Table 1 and Table 2. Table 1 displays the import-demand elasticities when using least squares with first-order autoregressive correction (ALS) for estimation. Import-demand elasticity estimates when using two-stage least squares with first-order autoregressive correction (A2SLS) for estimation are shown in Table 2. We can find that in terms of our primary concern, import price elasticity, in the sectors of livestock products and vegetables, is statistically significant. In the case of ALS estimation, the sector of vegetables has import price elasticity around unity and for the sector of livestock products, import demand is found to be inelastic to import price. When using

[7] This index is monthly data. We transformed this data into quarterly one just by averaging monthly data.

A2SLS estimation, for both sectors import-demand is inelastic to import price. However, for other sectors, as shown in Tables 1 and 2, import price has little impact on import demand. This result indicates that among the aggregated level of sectors in agriculture, import-demands of livestock products and vegetables are responsive to changes in import prices but those of other sectors are not affected by changes in import prices.

In Tables 1 and 2, it is also demonstrated that domestic price has little effect on import demand in all 5 aggregated sectors. In both estimation methods, income elasticity of import-demand is statistically significant for all aggregated sectors except vegetables and among 4 sectors, import-demands of 3 sectors except grains are highly elastic to income (expenditure). As shown in Table 7, all parameters for quarterly dummies in all 5 aggregated sectors are statistically significant, which means that seasonality is a very important factor for determining import-demands. The above result implies that changes in real GDP as a proxy for total expenditure would be very influential in determining import-demands of most agricultural products except vegetables.

Estimation results for disaggregated sectors are illustrated in Tables 3, 4, 5, and 6. Table 3 and Table 4 reveal the results of estimation for the disaggregated sectors of grains and vegetables. These results entail that among the sectors of grains, most of the products have statistically significant import price elasticity except corn and soybeans while among the products that are classified as vegetables, only cabbage, onion and perilla have statistically significant import price elasticity. The range of these import-demand elasticities is from -1.008 to -4.015. It is quite clear that import demands of the products such as cabbages and onion are elastic to import prices. However, it is also clear that the import demands of the products as corn, soybeans, carrot, garlic, groundnut, and sesame seeds are not affected by import prices.

Table 1. Import-Demand Estimates using OLS with AR(1)

Sector	Domestic Price Elasticity	Import Price Elasticity	Expenditure(GDP) Elasticiy	Autoregressive Parameter (ρ_j)	Adjusted R^2
Dairy Products	-0.664	0.472	1.240***	0.574***	0.968
Fruits	-0.105	0.310	4.671***	0.954***	0.968
Grains	-0.064	0.075	0.381**	0.434***	0.994
Livestock Products	0.174	-0.789***	5.384***	0.957***	0.958
Vegetables	-0.216	-1.029***	0.341	0.752***	0.970

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 2. Import-Demand Estimates using 2SLS with AR(1)

Sector	Domestic Price Elasticity	Import Price Elasticity	Expenditure(GDP) Elasticiy	Autoregressive Parameter (ρ_j)	Adjusted R^2
Dairy Products	-1.276	0.251	1.534***	0.546***	0.966
Fruits	0.079	0.244	6.284***	0.962***	0.963
Grains	-0.111	0.030	0.415**	0.449***	0.994
Livestock Products	-1.775	-0.861**	10.392***	0.962***	0.921
Vegetables	-0.865	-0.825***	0.575	0.728***	0.960

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Domestic prices rarely affect import-demands of grains and vegetables as shown in Tables 3 and 4. But for garlic, import demand is highly elastic to domestic price. Thus, the discrepancy between import price and domestic price of garlic is very significant in determining the import demand of garlic. This implies that relative price of garlic affects the import demand of it. The role of real GDP is not significant in determining the import demands of grains and vegetables except cabbage and carrot. Another characteristic related to the import-demands of grains and vegetables is that seasonality is very influential in determining import-demands. As shown in Table 8, quarterly dummies which represent seasonality are statistically significant for all the grain sectors except potatoes. For the import-demands of disaggregated vegetable sectors, quarterly dummies are not as influential as for the disaggregated grain sectors but very critical for the import-demands of products such as groundnut, perilla, and sesame as shown in Table 9.

Tables 5 and 6 present the import-demand estimates for the disaggregated sectors in fruits, dairy, and livestock products. Different from the cases of grain and vegetable sectors, both import price and real GDP are more significant for determining import-demands. Especially, import-demands of most of the fruits and livestock products are found to be elastic to import prices. We have already discovered that real GDP is not influential for import-demands of grains and vegetables. Thus, the fact that import-demands are highly elastic to total expenditure (real GDP) can be a special feature of the import-demands of fruits, dairy, and livestock products. Table 10 shows that seasonality which is represented by quarterly dummies is found out to be very significant for most of the disaggregated sectors in fruits, dairy, and livestock products. Only in the sectors of beef and cheese, seasonality is not seen to be a strong factor for determining import demands.

Considering the estimation results for both aggregated and disaggregated sectors, the first hypothesis can be acquiesced as being true for the agriculture in Korea. Among 5 aggregated sectors, only two sectors have statistically significant import prices elasticity that is inelastic to import demand. But among 27 disaggregated sectors, 16 sectors have statistically significant import price elasticity and in these cases, import demands are elastic to import prices.

The Durbin-Wu-Hausman (DWH) statistic for each sector is shown in Table 10. Among the 5 aggregated sectors, no sector has its test statistic by which the null hypothesis can be rejected. For the disaggregated sectors, the sectors of pine apple, sesame, and groundnut have the test statistics by which the hypothesis of no endogeneity can be rejected at the 1% level, while for other sectors as beef and wheat, the null hypothesis can be rejected at the 5% level. Thus, it can be derived that both domestic and import prices are exogenously given for most of the sectors. The focus of this test is the exogeneity of import prices. As Davidson and McKinnon (1993) have remarked, the DWH test is the one about the effect of any endogeneity that may be present on the estimates. So it may not be stated that the rejection of null hypothesis implies the endogenous import price. Based on the value of import price elasticity and its statistical significance, the only sector for which import price might be endogenous is pine apple. Other than that, there might be no way to deny that import prices of most agricultural products are exogenous and Korea is a small country in the world agricultural market.

Table 3. Import-Demand Estimates using LS with AR(1) for Grains and Vegetables

Sector	Import Price Elasticity	Domestic Price Elasticity	Expenditure(GDP) Elasticity	Autoregressive Parameter (ρ_j)	Adjusted R^2
Barley	-0.418	0.353	-0.055	0.231**	0.587
Corn	0.080	0.694***	-0.385	0.608***	0.982
Oats	-1.046***	0.779	0.324	0.970***	0.945
Potatoes	-1.234*	-0.048	2.149	0.667***	0.843
Rye	-2.247***	9.048*	-11.216	0.544***	0.707
Grain sorghum	-3.513***	0.774	-4.060	0.740***	0.893
Soybeans	0.062	0.027	0.255	0.616***	0.980
Wheat	-1.176***	-0.708*	0.563	0.719***	0.961
Cabbage	-1.656***	0.238	5.496**	0.916***	0.977
Carrot	-0.238	1.244	11.388***	0.511***	0.867
Garlic	0.327	3.833***	0.996	0.238	0.476
Groundnut	0.755	0.483	-1.918	0.673***	0.819
Onion	-3.047***	1.215	-2.022	0.691***	0.814
Perilla	-1.008***	0.368	0.883	0.818***	0.854
Sesame	-0.794	-0.057	0.892	0.213	0.612

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 4. Import-Demand Estimates using 2SLS with AR(1) for Grains and Vegetables

Sector	Import Price Elasticity	Domestic Price Elasticity	Expenditure(GDP) Elasticity	Autoregressive Parameter (ρ_j)	Adjusted R^2
Barley	-1.751*	-3.597	-1.869	0.315***	0.534
Corn	0.140	0.592***	-0.252	0.597***	0.982
Oats	-1.166**	-0.013	0.041	0.913***	0.943
Potatoes	-1.165	0.824	3.726**	0.589***	0.792
Rye	-0.462	10.881	-12.859	0.563***	0.616
Grain sorghum	-3.083***	0.387	-4.164	0.748***	0.889
Soybeans	-0.063	-0.853	1.663	0.714***	0.969
Wheat	-1.070***	0.300	-0.952	0.647***	0.952
Cabbage	-1.760***	-0.059	10.992***	0.968***	0.975
Carrot	-0.487	1.399	11.432***	0.544*	0.865
Garlic	-0.876	5.077***	0.646	0.142	0.439
Groundnut	0.611	4.040***	-0.772	0.484***	0.786
Onion	-4.015***	0.443	-4.873	0.655***	0.796
Perilla	-0.438	1.902	0.533	0.787***	0.828
Sesame	-0.112	-1.101	1.531**	0.017	0.429

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 5. Import-Demand Estimates using LS with AR(1) for Fruits, Dairy and Livestock Products

Sector	Import Price Elasticity	Domestic Price Elasticity	Expenditure(GDP) Elasticity	Autoregressive Parameter (ρ_j)	Adjusted R^2
Cheese	-2.045***	-0.227	3.742**	0.945***	0.987
Eggs	0.616***	0.000	1.231***	0.725***	0.969
Milk	-0.766	-1.730	0.882	0.237*	0.685
Whey	0.419***	0.547	1.531***	0.525***	0.972
Banana	0.205	-0.139	3.518***	0.953***	0.953
Grape	2.260	-0.341	5.970***	0.459**	0.733
Kiwi	0.947**	-0.001	2.335***	0.638***	0.944
Orange	-1.808***	-0.068	9.046***	0.747***	0.977
Pine apple	-0.195	0.157	2.478***	0.833***	0.953
Beef	-4.673***	-3.418**	6.451**	0.765***	0.849
Pork	-1.069***	-0.904**	1.816***	0.758***	0.912
Poultry	-1.818***	-0.003	4.448***	0.989***	0.968

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 6. Import-Demand Estimates using 2SLS with AR(1) for Fruits, Dairy and Livestock Products

Sector	Import Price Elasticity	Domestic Price Elasticity	Expenditure(GDP) Elasticity	Autoregressive Parameter (ρ_j)	Adjusted R^2
Cheese	-2.138***	-0.483	4.843*	0.938***	0.987
Eggs	0.725**	0.056	1.206***	0.715***	0.968
Milk	-1.087	-0.777	0.274	0.250*	0.680
Whey	0.403**	0.321	1.719***	0.523***	0.972
Banana	0.189	-0.089	5.573***	0.965***	0.948
Grape	4.895**	-0.834	7.714***	0.508**	0.690
Kiwi	1.018**	-0.220	2.363***	0.646***	0.943
Orange	-1.901**	0.249	8.854***	0.614***	0.976
Pine apple	-1.416***	0.887**	1.783***	0.472***	0.910
Beef	-7.628***	-2.163	2.068	0.873***	0.799
Pork	-1.463	-2.048*	2.505***	0.642***	0.891
Poultry	-1.371**	-0.465	1.755**	0.821***	0.957

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 7. Estimates of Seasonality for the Aggregated Sectors

sector \ coefficient	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$
Dairy Products (LS)	0.704*** (13.567)	1.134*** (18.629)	1.345*** (19.131)
Dairy Products (2SLS)	0.666*** (10.755)	1.088*** (14.75)	1.279*** (14.151)
Fruits (LS)	0.663*** (9.331)	0.946*** (12.017)	0.952*** (6.498)
Fruits (2SLS)	0.497*** (4.065)	0.771*** (5.675)	0.627** (2.375)
Grains (LS)	0.690*** (42.094)	1.086*** (59.14)	1.358*** (54.434)
Grains (2SLS)	0.685*** (39.671)	0.946*** (54.385)	1.343*** (42.695)
Livestock Products (LS)	0.649*** (11.789)	1.101*** (17.105)	1.342*** (18.171)
Livestock Products (2SLS)	0.677*** (11.381)	1.129*** (15.683)	1.409*** (17.489)
Vegetables (LS)	0.595*** (12.167)	1.056*** (21.715)	1.352*** (19.655)
Vegetables (2SLS)	0.577*** (8.453)	1.051*** (18.005)	1.318*** (13.73)

Note: The numbers in ( ) are t-statistics.

Table 8. Estimates of Seasonality for the Disaggregated Sectors (Grains)

coefficient / sector	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$
Barley (LS)	0.888***	0.961***	1.213***
	(5.037)	(6.276)	(4.478)
Barley (2SLS)	0.734***	0.906***	0.818**
	(3.423)	(5.474)	(2.168)
Corn (LS)	0.747***	1.133***	1.47***
	(24.27)	(36.587)	(28.142)
Corn (2SLS)	0.735***	1.123***	1.448***
	(21.612)	(33.562)	(24.041)
Oats (LS)	0.629***	1.071***	1.28***
	(6.46)	(11.791)	(6.53)
Oats (2SLS)	0.638***	1.08***	1.319***
	(4.541)	(8.587)	(4.696)
Potatoes (LS)	0.213	0.087	-0.184
	(1.235)	(0.406)	(-0.648)
Potatoes (2SLS)	0.147	0.296	-0.269
	(0.77)	(0.902)	(-0.874)
Rye (LS)	1.937**	3.449***	4.543***
	(2.353)	(4.813)	(3.443)
Rye (2SLS)	2.278*	3.181***	4.463**
	(1.98)	(3.315)	(2.262)
Grain Sorghum (LS)	0.799**	1.092***	1.904***
	(2.662)	(3.785)	(3.335)
Grain Sorghum (2SLS)	0.846	1.16**	1.992
	(1.424)	(2.30)	(1.596)
Soybeans (LS)	0.733***	1.146***	1.454***
	(22.426)	(34.277)	(25.153)
Soybeans (2SLS)	0.629***	1.055***	1.215***
	(7.71)	(14.204)	(6.821)
Wheat (LS)	0.662***	1.073***	1.313***
	(10.892)	(18.139)	(11.564)
Wheat (2SLS)	0.785***	1.182***	1.574***
	(9.416)	(15.021)	(9.701)

Note: The numbers in ( ) are t-statistics.

Table 9. Estimates of Seasonality for the Disaggregated Sectors (Vegetables)

sector \ coefficient	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$
Cabbage (LS)	0.157 (0.766)	0.61^{***} (3.184)	0.258 (0.617)
Cabbage (2SLS)	-0.275 (-0.859)	0.21 (0.761)	-0.682 (-1.025)
Carrot (LS)	-0.034 (-0.094)	1.188^{***} (2.929)	0.821 (1.633)
Carrot (2SLS)	-0.012 (-0.032)	1.174^{**} (2.40)	0.791 (1.343)
Garlic (LS)	0.831 (1.352)	1.796^{***} (2.778)	2.257^{***} (3.091)
Garlic (2SLS)	0.926 (1.398)	1.819^{**} (2.675)	2.335^{***} (3.06)
Groundnut (LS)	1.059^{***} (5.542)	1.472^{***} (7.185)	2.412^{***} (7.803)
Groundnut (2SLS)	0.944^{***} (4.362)	1.363^{***} (5.81)	2.198^{***} (6.734)
Onion (LS)	1.333^{*} (1.97)	1.612^{**} (2.29)	2.019^{**} (2.248)
Onion (2SLS)	1.274 (0.99)	1.446 (1.095)	2.057 (1.322)
Perilla (LS)	0.451^{***} (3.575)	0.725^{***} (5.861)	1.00^{***} (4.305)
Perilla (2SLS)	0.479^{***} (2.901)	0.733^{***} (4.764)	1.045^{***} (3.181)
Sesame (LS)	1.252^{***} (4.893)	1.937^{***} (7.178)	2.231^{***} (8.277)
Sesame (2SLS)	0.974^{**} (2.494)	1.887^{***} (5.635)	2.127^{***} (6.073)

Note: The numbers in ( ) are t-statistics.

Table 10. Estimates of Seasonality for the Disaggregated Sectors (Dairy and Livestock Products)

coefficient / sector	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$
Beef (LS)	0.609* (1.919)	1.236*** (3.856)	0.939* (1.874)
Beef (2SLS)	1.187 (1.342)	1.803** (2.354)	1.922 (1.325)
Pork (LS)	0.589*** (8.754)	1.028*** (14.24)	1.044*** (8.079)
Pork (2SLS)	0.620*** (8.386)	1.005*** (9.815)	0.813*** (2.856)
Poultry (LS)	0.376*** (4.34)	0.841*** (10.534)	0.707*** (3.98)
Poultry (2SLS)	0.558*** (7.581)	0.991*** (13.392)	1.10*** (7.764)
Cheese (LS)	0.379** (2.619)	0.745*** (5.643)	0.637** (2.067)
Cheese (2SLS)	0.286 (1.513)	0.663*** (4.025)	0.448 (1.012)
Eggs (LS)	0.595*** (15.115)	0.975*** (24.271)	1.155*** (19.313)
Eggs (2SLS)	0.596*** (9.266)	0.973*** (16.498)	1.153*** (13.18)
Milk (LS)	1.089*** (5.47)	1.615*** (7.629)	1.875*** (7.47)
Milk (2SLS)	1.132*** (5.503)	1.651*** (7.584)	1.98*** (7.269)
Whey (LS)	0.635*** (12.793)	1.072*** (19.943)	1.228*** (16.847)
Whey (2SLS)	0.614*** (10.907)	1.051*** (17.458)	1.19*** (13.79)

Note: The numbers in ( ) are t-statistics.

Table 11. Estimates of Seasonality for the Disaggregated Sectors (Fruits)

coefficient / sector	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$
Banana (LS)	0.572*** (7.061)	0.936*** (12.255)	0.813*** (4.587)
Banana (2SLS)	0.41*** (3.666)	0.792*** (7.515)	0.464*** (1.829)
Grape (LS)	1.482*** (4.972)	1.479*** (4.789)	0.797** (2.689)
Grape (2SLS)	1.879*** (4.649)	1.863*** (4.585)	0.871** (2.591)
Kiwi (LS)	1.589*** (13.873)	2.253*** (16.823)	2.287*** (14.399)
Kiwi (2SLS)	1.599*** (12.998)	2.266*** (15.623)	2.276*** (13.788)
Orange (LS)	0.334*** (2.908)	0.567*** (4.514)	-0.32* (-1.779)
Orange (2SLS)	0.32** (2.117)	0.528*** (3.026)	-0.314 (-1.402)
Pine Apple (LS)	0.511*** (7.123)	0.758*** (10.468)	0.756*** (5.822)
Pine Apple (2SLS)	0.622*** (6.296)	0.84*** (7.944)	0.981*** (7.776)

Note: The numbers in ( ) are t-statistics.

Table 12. Durbin-Wu-Hausman (DWH) Tests for the Aggregated Sectors

Sector	m (DWH statistic)	H_0: $Y^T = [P_{1j} \quad P_{2j}]$ is exogenous	
		5%	1%
Dairy Products	1.412	Accept H_0	Accept H_0
Fruits	0.571	Accept H_0	Accept H_0
Grains	0.891	Accept H_0	Accept H_0
Livestock Products	1.672	Accept H_0	Accept H_0
Vegetables	5.329	Accept H_0	Accept H_0

Table 13. Durbin-Wu-Hausman (DWH) Tests for the Disaggregated Sectors (Grains, Vegetables)

Sector	m (DWH statistic)	H_0: $Y^T = [P_{1j} \quad P_{2j}]$ is exogenous	
		5%	1%
Barley	3.099	Accept H_0	Accept H_0
Corn	1.252	Accept H_0	Accept H_0
Oats	1.073	Accept H_0	Accept H_0
Potatoes	2.114	Accept H_0	Accept H_0
Rye	2.185	Accept H_0	Accept H_0
Grain Sorghum	1.397	Accept H_0	Accept H_0
Soybeans	1.998	Accept H_0	Accept H_0
Wheat	8.004	Reject H_0	Accept H_0
Cabbage	1.225	Accept H_0	Accept H_0
Carrot	0.957	Accept H_0	Accept H_0
Garlic	5.417	Accept H_0	Accept H_0
Groundnut	16.71	Reject H_0	Reject H_0
Onion	2.526	Accept H_0	Accept H_0
Perilla	1.833	Accept H_0	Accept H_0
Sesame	49.924	Reject H_0	Reject H_0

Table 14. Durbin-Wu-Hausman Tests for the Disaggregated Sectors (Dairy and Livestock Products)

Sector	m (DWH statistic)	H_0: $Y^T = [P_{1j} \quad P_{2j}]$ is exogenous	
		5%	1%
Cheese	0.121	Accept H_0	Accept H_0
Eggs	0.178	Accept H_0	Accept H_0
Milk	0.959	Accept H_0	Accept H_0
Whey	0.522	Accept H_0	Accept H_0
Banana	0.032	Accept H_0	Accept H_0
Grape	3.042	Accept H_0	Accept H_0
Kiwi	0.305	Accept H_0	Accept H_0
Orange	3.337	Accept H_0	Accept H_0
Pine Apple	12.822	Reject H_0	Reject H_0
Beef	6.447	Reject H_0	Accept H_0
Pork	1.618	Accept H_0	Accept H_0
Poulty	3.798	Accept H_0	Accept H_0

6. Policy Implications and Limitations

It is very important for the country in which agriculture is heavily protected to obtain reliable import-demand elasticities since the effects of reducing trade barriers for agriculture can be derived from those elasticities. This paper shows that both domestic and import prices rarely affect import-demands in the aggregated level except in the sectors of vegetables and livestock products. In the disaggregated level, import-demands of the products that are classified as livestock products tend to be highly elastic to import prices. A special feature of these products is that import-demands of these products are also very highly elastic to income (real GDP) and income is more significant factor than import price for determining import-demands of fruits and livestock products.

The results of this paper point out the following implications. First, the loss of agricultural production as a whole thanks to the reduction of trade barriers such as tariff reduction will be less than expected because of rare impact of import prices on import demands. Second, in the sectors of fruits, dairy, and livestock products, income is very critical for import-demands. Third, even though not all the products have statistically significant import price elasticity, for the products that have statistically significant import price elasticity, import-demands are elastic to import prices. This implies that tariff reduction will bring about much increase in import-demands of these products and remarkable loss of domestic production of these sectors.

From the above three implications, we can derive several recommendations for the policies prepared for trade liberalization of agricultural products. The policies in response to the reduction of trade barriers for the agriculture ought to be focused on differential impacts of trade liberalization on disaggregated sectors. For the agricultural products whose import demands are elastic to import prices, it is expected that the decline of import prices by tariff reduction results in the increase in import demands, and then loss of domestic production of these products. Thus, the policies for these sectors should be the ones that help to restructure these sectors rather than the ones resulting in excess supply. For the sectors whose import demand is highly elastic to income, the increase in demand will be anticipated as income rises from economic growth. Trade liberalization will induce rapid economic growth and then accordingly increase the demand of the goods in the sectors of fruits, dairy and livestock products that have high income elasticity. For those goods, policies that provide the structure for efficient markets will be required rather than the ones only for protecting producers.

This study has two critical limitations. One is that the import price elasticity derived is based on the unit-value index as a proxy for import price. It is well known that unit-value index creates large measurement error and lowers the estimated import price elasticity. The other limitation which is more serious is that rice is excluded in our analysis. Rice is the most important agricultural product in Korea as it is known that the annual value of rice production is approximately one-third of the annual value of total agricultural production. Thus the analysis excluding rice has its limitation on explaining the effects of trade liberalization on agriculture in Korea.

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