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Implications of trade reform for agricultural markets in northeast Asia: a Korean example ☆

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Trade policy reform in the 1990s increased import access for agricultural products into Japan, South Korea and other countries of Asia. One of the most significant developments concerns rice markets in this region. Because of political sensitivity, Japan and South Korea were allowed to postpone tariffication on rice under the Uruguay Round (UR) GATT agreement.[4] In return, South Korea provided more than the expected tariff reductions for some other commodities, while Japan agreed to accelerate quantitative access for rice.

In recent decades, northeast Asian markets have been comparatively open to wheat, feed grains and cotton imports, but mostly closed for rice. With no foreign supply, rice has remained the dominant crop in these countries where it is the main staple of their traditional diets. In South Korea, rice has been planted to over 50% of cropland. Now, even with a small partial opening of rice markets but with prospects for more opening in the future, a new trend is emerging in crop production. Despite the agreement that imports would be minimal, farmers are leaving rice production in anticipation of further market opening. Resources are being diverted from rice to other crops, particularly, to non-grain crops. Unlike in the Americas or Australia, where grain including rice is an extensive crop with relatively low revenue per unit of land, in Asia grains and horticultural crops compete directly for the same land and other resources. Furthermore, in countries such as Japan or Korea, as in some regions of China, rice dominates the landscape such that even a small percentage adjustment in rice area may represent a large adjustment in the supply of other crops.

In this paper, we present a model and simulations that incorporate trade policy variables into the individual commodity supply and demand functions. Cross-commodity linkages are modeled by allowing substitution possibilities between imported and home-produced goods and through input market adjustments. The real contribution of our analysis is to focus on a neglected empirical point. During the trade negotiations, the pressure to open rice markets was considered in isolation of the impact on

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[4] In some places, we use the term 'Korea' with no prefix to refer to South Korea. We do not consider North Korea in this article.

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other markets. The cross-commodity effects within importing country agriculture were generally left aside. Cross-commodity substitution is particularly an important consideration in northeast Asia and substitution between rice and horticultural crops is a key issue. This paper shows empirically that, under a plausible range of supply and demand parameter values, these cross-commodity effects can be significant and will play an important role in the adjustment process in response to the exogenous policy shocks.

South Korea is the empirical focus of the research because of its importance in agricultural trade and the importance of policy reform in that country. South Korea has been one of the largest markets for agricultural imports. Further, a number of issues related to Korean agricultural trade also apply to Japan and other nations of Asia (Huang and David, 1993; Kako et al., 1997). Our study focuses on rice and horticultural crops for two reasons: (1) these two crop categories provide close production linkages through factor market adjustments, and (2) the importance of horticultural crops in export markets has been expanding with income growth and trade liberalization. In this paper, we demonstrate the relationship between trade policy and resulting supply responses using the example of Korean agriculture.

1. Transition in Korean agriculture: rice becoming less dominant

Rice has long been the most important crop in South Korean agriculture. Traditionally, rice is planted to more than 50% of the country's cropland, generates about 50% of total crop revenue, and has been cultivated by about 80% of crop farms. [5] For the first time in history, there are signs that this tradition may be changing.

As a member of the World Trade Organization (WTO), South Korea has begun to open its market to more foreign products. Korea eliminated non-tariff barriers and began to lower tariffs for all agricultural commodities with the exception of rice. For grains other than rice, imports were already dominant. For example, prior to the Uruguay Round Agreement (URA) in 1994, the imports of corn and wheat were already over 98% of domestic consumption (both in 1993 and 1994). The new market environment will not have much impact on the imports of these commodities. However, for commodities such as peppers, garlic, sesame seed, and fruits, tariff rate quotas have been applied, with a relatively low within-quota tariff and much higher above-quota tariffs. These commodities carry significant economic value in South Korean agriculture. For example, peppers alone generated nearly 10% of total crop revenue in 1995. Prior to the URA, the import policy for these commodities was very restrictive and previous imports were mostly arranged by the government in an effort to stabilize the domestic market in the case of short crops (Choi et al., 1998; Sumner and Choi, 1999). Immediate impacts of the URA on these commodities are expected to be modest, however tariff reduction will be significant over the next decade. (IATRC, 1994).

The most significant URA development is minimum market access for imported rice. For rice, the minimum access of 1% of base period (1995) domestic consumption, beginning in 1995, is scheduled to increase to 2% by 2000 and to 4% by 2004. This is the first time in the country's recent history that foreign rice is allowed to enter the country on a regular basis. If imports remain within the minimum access, the resulting market impact should be minimal at least until 2004. However, farmers have been responding to their anticipation of a future opening of the rice market. Table 1 shows the recent history of cropland distribution in South Korea. In the period prior to 1993, even before market opening was agreed upon, area planted to rice had begun to decline. In the post-URA period, even with a clear agreement for minimal opening of the rice market, rice land continued to decline. This may be due to the anticipation to further opening, even though imposing such opening would require re-negotiation. The shift of land out of rice may also be due to expectation that opening will happen sooner not later. While rice land declines, areas planted to vegetables and fruits and non-food crops have been increasing. Resources are being diverted from rice farming to the production of these row crops.

[5] The percentage of farm households cultivating rice has steadily fallen. About 86% of farm households cultivated rice in 1990. This had fallen to 79% by 1996.

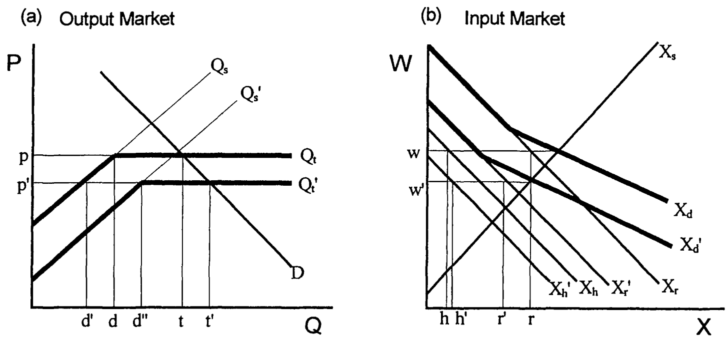

Fig. 1. Graphical illustration of cross-commodity linkages: market for horticultural crops.

Table 1
Cropland distribution in South Korea in recent years (1990–1997)

Year	Unit = 1000 ha			Total[c]
	Rice	Other grains[a]	Horticultural crops[b]	
1990	1244	425	539	2208
1991	1208	354	568	2130
1992	1157	321	582	2060
1993	1136	331	596	2063
1994	1103	300	572	1975
1995	1056	290	616	1962
1996	1050	290	583	1923
1997	1052	262	567	1881

[a] Other grains include non-rice grains as well as soybeans and other minor starch crops such as potatoes and sweet potatoes. The last inclusion was done to make the crop categories consistent with the categories later used in our simulation study.

[b] Horticultural crops include vegetables, tree fruits and minor specialty crops such as tea or medicinal crops.

[c] Total land is the use area planted to edible crops and excludes nursery, or ornamental crops.

2. A graphical illustration

To fix ideas for the model to follow, we present a simple illustration of multi-crop trade liberalization when cross-commodity interactions are incorporated (Sumner, 1995). Consider a small country producing rice and horticultural crops. In this illustration, crops are produced using only one input, and rice is a dominant crop in terms of total factor usage. Trade reform is represented by a reduction in the tariff on horticultural crops and a simultaneous increase in the import quota for rice. To make the figure simple, assume that consumers treat imported and home-produced goods as perfect substitutes. This enables us to isolate clearly the post-reform production adjustments in Fig. 1 below (this assumption is relaxed in our quantitative model). Fig. 1 illustrates the type of adjustments that will occur in the output and input markets for horticultural crops.

In Fig. 1, 'primes' are associated with the post-reform situations. Before the trade liberalization, the marginal cost schedule for domestic horticultural production in Fig. 1(a) is Q_s. With the pre-reform market price p, the market supply function is Q_t. Now, with the reform, the immediate consequence of the lower tariff would be a reduction in market price to p'. Consequently, domestic production would fall to d', and imports would increase from (t–d) to (t'–d').

However, consider the multi-crop liberalization in which the import quota for rice is expanded, at the same time horticultural tariffs fall. The initial effect of an increase in the rice import quota is a reduction in rice production, and consequently a reduction in the quantity of input demanded in rice production. When rice production is a major industry, the fall in the input price can be substantial enough to increase the production of other crops even in the presence of the now more open trade policy for these crops.

This input market situation is illustrated in Fig. 1(b). Derived input demands in horticultural crop and rice production are represented by x_h and x_r, and the total input demand and supply are represented by $X_d = (x_h + x_r)$ and X_s in Fig. 1(b). The pre-reform market situations are depicted by input quantities, h and r, and price w. The reduced domestic production of rice shifts the rice input demand curve from x_r to x_r', and the fall in the price of horticultural crops ($p \rightarrow p'$) shifts x_h to x_h'. Total input demand falls to X_d', and the new equilibrium input price is w'. The net result is a decrease in the input usage in rice production from r to r', and an increase in the input usage in horticultural crop production from h to h', despite a tariff reduction on imported horticultural crops.

Back in Fig. 1(a), the decrease in the rice input demand causes the domestic supply curve for horticultural crops to shift from Q_s to Q'_s. Domestic production will be $d'' > d$, and imports are $t' - d''$ which could be greater or less than initial imports of $t-d$. Given the total conditions, the sign depends on the magnitude of the tariff reduction, the fall in rice input demand, and, supply response of horticulture crops. This example highlights the importance of cross-commodity linkages through factor markets. As one industry contracts, incentives are created for the resources to flow into other uses. These ideas will now be made more precise with our simulations.

3. The model

This section presents the models that assess the effects of trade liberalization on crop agriculture in South Korea. Input and output markets are specified with a series of supply and demand functions, and then the market adjustments in response to the introduction of the new policy are described. In modeling these adjustments, we use an equilibrium displacement model. The basic form is due to Muth (1964). Subsequent elaborations to multiple input and output markets are found in Alston et al. (1995); Gardner (1990); Hertel (1989), and Sumner and Lee (1997).

The model is constructed to underscore some of the key features of cross-commodity linkages. The policy instruments used to represent trade liberalization include: (1) minimum access quotas for rice and (2) reductions in ad valorum tariffs on horticultural crops. The model allows for imperfect substitutability between the imported crops under tariffs and the same crops that are produced at home, with an exception of imported rice. [6] To reflect the consequences of imports of rice corresponding to an import quota, rice imports are set at a pre-specified quantity. The model does not differentiate imported from home produced rice, and thus no separate demand equation for imported rice is specified. There is no international trade in inputs, but inputs are allowed to flow between crop agriculture and the rest of the economy.

The following notational convention is used: subscript r denotes rice; subscript i denotes a home produced commodity with $i=1,\dots r,\dots, I$; subscript m denotes a commodity imported under tariff with $m=1,\dots, M$, and; subscript k denotes an input with $k=1,\dots K$.

The basic structure of the model is given in Eqs. (1)–(8).

$$D_i = f_i(\boldsymbol{p}; \boldsymbol{z}) \quad \text{Market demand for the domestically produced crop } i \tag{1}$$

$$D_m = g_m(\boldsymbol{p}; \boldsymbol{z}) \quad \text{Market demand for the imported crop } m \tag{2}$$

$$x_{ki} = \frac{\partial C_i(\boldsymbol{w}, \boldsymbol{Y_i})}{\partial w_k} \quad \text{Derived market demand for input } k \text{ in the crop } i \text{ industry} \tag{3}$$

$$X_k = h_k(w_k) \quad \text{Market supply of input } k \tag{4}$$

$$X_{\mathrm{k}} = \sum_i x_{ki} \quad \text{Equilibrium condition in the market for input } k \tag{5}$$

$$D_r = Y_r + Q_r \quad \text{Equilibrium condition in the rice market} \tag{6}$$

$$p_i = \frac{\partial C_i(\boldsymbol{w}, Y_i)}{\partial Y_i} \quad \text{Market clearing condition for home produced crop } i \tag{7}$$

$$p_m = p_{mb}[1 + \tau_m] \quad \text{Price equation for imported crop } m \tag{8}$$

Eq. (1) represents consumer demand for home produced crops, where D_i is the demand for home produced crop i, $\boldsymbol{p}=(p_1,.., p_i,.., p_I,.., p_m,.., p_M)_{1\times(I+M)}$ is a vector of domestic prices for all crops, and $\boldsymbol{z}$ is a vector of exogenous variables. Eq. (2) represents consumer demand for imported crops other than rice, where D_m is the demand for imported crop m. Assuming a well-defined industry cost function for crop

[6] For our empirical analysis, some amount of output aggregation (except of rice) was necessary. For each output aggregate, crop mixes are substantially different for the imported and domestically produced bundles. This point will be discussed Din more detail in the data section.

i, Eq. (3) represents the derived input demand where x_{ki} is the derived demand for input k from the crop i industry, $\boldsymbol{w}$ is a vector of input prices, and Y_i is the domestic production of crop i. Eq. (4) represents the market supply of input k, where X_k is the market supply of input k. Linkages between crop agriculture and the rest of the economy are represented by an upward sloping supply function of $h_k(.)$. Eq. (5) is the equilibrium condition in input markets where the market supply equals market demand. Eq. (6) is the equilibrium condition in the rice market, where the demand for rice equals the total supply of rice that is the sum of domestic production and the minimum access import quota, Q_r. Eq. (7) determines the level of domestic production for crop i under perfect competition. Finally, Eq. (8) determines the domestic prices for the crops that are imported under tariffs, where p_{mb} is the border price for the imported crop m and τ_m is the ad valorum tariff on crop m. In specifying Eq. (8), we use the small country assumption that implies that the border prices for imported commodities are determined exogenously. Note that we do not consider the policy that imposes tariff and quota simultaneously. Although we do not impose quantity restrictions for the crops that are imported under tariffs, such a case could be handled by restricting the relevant demand to be equal to the quota amount.

Totally differentiating Eqs. (1)–(8), and using log differentials to convert to elasticity form yields the following linear elasticity model. With the exception of the carets that denote proportional changes, all notation in 1–8 applies to 1′–8′.

$$\hat{D}_i = \sum_{j=1}^{I,\dots M} \eta_{ij}\hat{p}_j \tag{1'}$$

$$\hat{D}_m = \sum_{j=1}^{I,\dots M} \eta_{mj}\hat{p}_j \tag{2'}$$

$$\hat{x}_{ki} = \sum_{n=1}^{K} \gamma_n^i \sigma_{kn}^i \hat{w}_n + \hat{Y}_i \tag{3'}$$

$$\hat{X}_k = \varepsilon_k \hat{w}_k \tag{4'}$$

$$\hat{X}_k = \sum_i \lambda_k^i \hat{x}_{ki} \tag{5'}$$

$$\hat{D}_r = s_r\hat{Y}_r + (1 - s_r)\theta_r \tag{6'}$$

$$\hat{p}_i = \sum_k \gamma_k^i \hat{w}_k \tag{7'}$$

$$\hat{p}_{\mathrm{m}} = \hat{\omega}_{\mathrm{m}} \tag{8'}$$

where η_{ij} is demand elasticity of commodity i with respect to the price of commodity j; η_{mj} demand elasticity of commodity m with respect to the price of commodity j; σ_{kn}^i Allen elasticity of substitution between inputs k and n in the production of commodity i; ε_k supply elasticity for input k; λ_k^i industry share of input k used in the production of commodity i; s_r market share of domestic production for rice; γ_k^i cost share of input k in the production of commodity i; θ_r quota for rice as a percent of domestic consumption; and $\omega_m = 1 + \tau_m$.

Subscript j in Eqs. (1′) and (2′) corresponds to the element of the price vector $\boldsymbol{p} = (p_1,.., p_i,.., p_I,.., p_m,.., p_M)_{1\times(I+M)}$. Output and input markets are competitive and the markets are initially at the long run equilibrium. These assumptions imply that technology in each industry is characterized with constant returns to scale at the zero profit point. With the specification of elasticities and shares in the above model, equilibrium adjustments to trade liberalization can be simulated by exogenously specifying a change in either quotas or tariffs. Then, the model can be solved for the resulting price and quantity changes that are required to adjust to move from initial equilibrium in the relevant product and factor markets to the new equilibrium.

Note that the assumptions implicit in the above linear elasticity model are pre-shock elasticities and various shares remain approximately constant under the market adjustments. Under these specifications, how closely our model projects the changes in the underlying system depends on the level of nonlinearity of the true model and the degree of perturbation from the initial equilibrium. These all suggest that our linearity assumptions can be most appropriately used for local perturbations.

4. Empirical implementation

Domestic demand is divided into five categories: rice, other domestically produced grains, other imported grains, domestic horticultural crops, and imported horticultural crops. Rice is singled out as a separate category, and from here forward all other grains (all except rice) are called, simply grains (either domestic grains or imported grains).

In our demand equations, a distinction is made between imported and domestically produced horticultural crops and grains. One major reason for this distinction is that within each of these aggregate commodities the shares of specific crops in imports and domestic supply are different. For example, in 1994 over 50% of domestically produced non-rice grain was barley, while barley consisted of less than 2% of grain imports. In the same year, horticultural imports were approximately evenly divided between fruits and vegetables (fruit imports were slightly larger with a 52% of tons imported). However, vegetables made up 82% of the tonnage of domestically produced horticultural crops (Ministry of Agriculture, Forestry, and Fisheries (MAFF 1994)).

Although they are different bundles, imports and domestic commodity are close substitutes. As discussed further below, this implies that the cross price elasticity between imports and the domestic commodity is neither zero nor infinity. Our model, however, does not differentiate rice by origin. This is mainly because we want to reflect the consequences of potential policy choice to import rice that competes with domestic rice. [7]

In assigning the values used in our simulation, we consider output-related and input-related parameters. The output related parameters include price elasticities of demand. The input-related parameters include cost shares, input supply elasticities and Allen elasticities of input substitution.

4.1. Output-related parameters

Marshallian price elasticities of demand are presented in Table 2. A consistent demand specification, including all of the exogenous variables, would require the various adding up properties implied by homogeneity and the budget constraint to hold. However, since the model is partial equilibrium in nature, aggregate income and prices of commodities outside of crop agriculture remain constant throughout the adjustment process and vanish from the system with total differentiation of the model. Therefore, the elasticity matrix presented in Table 2 consists only of those commodities whose prices are allowed to change. This implies that the non-zero components in the demand elasticity matrix include five own price elasticities and four cross price elasticities between imported and domestically produced goods.

Initial figures for the own price elasticities were obtained from the SWOPSIM database developed by the Economic Research Service of the US Department of Agriculture, and a food demand study by Chern and Wang (1994). These values are well within the range found in the other recent empirical literature. [8]

While there are own price elasticity estimates in the literature, we found no reliable empirical analysis dealing with cross-price elasticities between imports and home produced horticultural crops or grains in any of the East Asian countries. However, consumer choice theory together with data on budget shares and some plausible ranges for own price and income elasticities provides some guidance as to how these demands should relate to each other. The Slutsky equation in elasticity form implies that the ratio of Marshallian cross-price elasticities between goods i and j, η_{ij}/η_{ji}, is equal to expenditures on good j divided by expenditures on good i when their income elasticities are the same. With this consideration in mind, we determine the ratio of the cross-price elasticities by using share data on the value of domestic production and imports (MAFF, 1998).

[7] Imported rice is currently used for processing and not for table use. Thus, so long as we do not differentiate lower quality domestic rice from high quality domestic rice, treating domestic and foreign rice as a single commodity is consistent with this aggregation of domestic rice of differential quality. Our simulation applies to the case under which Korean rice imports are further liberalized (see also, Sumner and Choi, 1999).

[8] For the demand elasticity for rice, some of the previous study results include −0.13 for Japanese rice by Kako et al., 1997 (for the period 1970–1991), −0.254 for Korean rice by Koo et al., 1992 (for the period 1975–1989), −0.81 for Korean rice by Huang and David, 1993 (for the period 1960–1988), The study period may matter especially for the rice income elasticity (Ito et al., 1989). Course grain elasticities for Korea are estimated as –0.5 (Huang and David, 1993 at − 0.55 Kim and Lee, 1994.) Demand elasticities has estimates for horticultural crops include −0.263 for US. Fruits and vegetables (Blanciforti and Green, 1983), −0.409 for Chinese vegetables (Fan et al., 1995) and −0.0335 for US fresh vegetables and −0.4005 for fresh fruits (You et al., 1996).

Table 2
Parameter specification[a]

	Rice	Domestic horticulture	Imported horticulture	Domestic grains	Imported grains
(A) Demand elasticity matrix					
Quantity			Price		
Rice	−0.2	0	0	0	0
Horticulture	0	−0.7	0.1	0	0
Imported horticulture	0	2.7	−0.7	0	0
Grains	0	0	0	−0.33	0.48
Imported grains	0	0	0	0.1	−0.33
(B) Input cost shares by industry					
Labor	0.29	0.54		0.45	
Other inputs	0.27	0.31		0.21	
Land	0.44	0.15		0.34	
(C) Industry factor usage shares					
Labor	0.27	0.68		0.05	
Other inputs	0.36	0.59		0.05	
Land	0.63	0.30		0.07	
(D) Allen elasticities of input substitution					
Other inputs/labor	1	1		1	
Land/labor	1	1		1	
Land/other inputs	1	1		1	
(E)Input supply elasticities to crop production					
	Labor	Other inputs	Land		
	0.2	1	0.2		

[a] Source: Share parameters are based on data published by the Korean Ministry of Agriculture Forestry and Fisheries, 1995. Earnings Charts for Crop and Livestock Farmers; 1995 Major Statistics on Agriculture Forestry and Fisheries; and Ministry of Agriculture Forestry and Fisheries, 1994. Statistical Yearbook of Agriculture, Forestry, and Fisheries. Demand elasticities obtained from SWOPSIM data base, Sullivan et al., 1989 and other literature cited in the text.

In 1994, the total value of imported grain was 4.8 times of domestic grain. This indicates that $\eta_{ij}/\eta_{ji} = 1/4.8$, where i = imported grain and j = domestic grain. In our simulations, we used the elasticities values, 0.1 and 0.48 and we did the sensitivity test using other sets of values, (0.05, 0.24) and (0.2, 0.96) that satisfy this ratio.

The same procedure applies to the specification of horticultural cross elasticities (data for the calculations are provided in the footnote).[9] The 1994 expenditures on imported horticulture are very small and are less than 4% of the expenditures on domestic horticulture. This implies that the elasticity of import quantities with respect to domestic price is more than 25 times the elasticity of domestic quantity with respect to import price. The parameters in Table 2, 2.7 and 0.1 satisfy this condition. In the sensitivity analysis, we examine a range of values that also satisfy our ratio condition.

In addition to the relative magnitudes suggested by the Slutsky equation, other considerations help fix the order of magnitudes for the cross elasticities. These considerations include: (1) own price elasticities from econometric studies are shown in Table 2; (2) each included food item has a relatively small budget share; (3) given the large budget share for the aggregate of left out goods, the income elasticity for this aggregate is near 1.0; (4) the own (Marshallian) price elasticity for the aggregate of other goods is near neg-

[9] In 1994, the total horticultural import value was 273 million won, and the value of total domestic production was 7638 million won. This implies that total value of domestic production was 27 times of horticultural imports.

ative 1.0. Putting these conditions together with the various restrictions from demand theory leads to the cross-elasticities of demand found in Table 2.

4.2. Input-related parameters

Each industry uses three inputs: land, labor, and an aggregate which we call other inputs. Included within the last input category are all other variable inputs such as fertilizer, pesticides, fuel, and capital. As presented earlier, our model requires two sets of input cost shares: industry shares for input usage, λ_k^i, and input cost shares within a specific commodity industry, γ_k^i.

Input cost shares are calculated using survey information on operating costs reported in the 1995 Earnings Charts for Crop and Livestock Farmers, supplemented with information on the rental rates for rice land reported in the 1995 Major Statistics on Agriculture, Forestry, and Fisheries. Since the former does not report the rental rate for land, to approximate the land cost, we adopted the national average of the rental rate for rice land from the latter source and assumed that this rate represents the land costs for all commodities. [10]

Input cost shares for domestic grains and horticultural crops are calculated as simple averages of selected representative crops included within each industry. To calculate input cost shares for our aggregates, we relied on the specific crops, because input information was available only for major crops. The representative crops chosen to construct the input cost shares for domestic grains are barley and corn. For horticultural crops, we chose cabbage, garlic, radishes, peppers, and apples. These crops were selected because they are the most important crops in terms of total value of production, and none of them seem to present any peculiarity in terms of the intensity of a certain input.

Industry input usage shares are calculated as a proportion of total input use by all industries. Thus, for each input, the shares across industries sum to one. The land share for each industry is calculated using data on land usage reported in the 1995 Major Statistics on Agriculture, Forestry, and Fisheries. Industry input usage shares for labor and other inputs are set equal to their expenditure shares. The survey information on operating costs per unit of land is expanded to total land areas for each crop (the survey reports costs per 0.1 ha of land).

Rice is the dominant crop in terms of land use, whereas horticultural crops are more important users of labor and other inputs. Even in South Korea, horticultural crop production is far more labor intensive than rice production. For example, in the 1995 Earnings Charts, rice farmers reported 310 hours of labor were used per hectare of rice, while apple growers reported 2390 hours of labor per hectare.

The model also requires estimates for the Allen elasticities of input substitution and input. These were not available from the econometric literature. In the base simulations, they are all set equal to one. In preliminary simulations we used values other than 1.0 for the substitute elasticity. Results are not sensitive to these substitution parameters.

The final set of parameters relate to the supply elasticities for land labor and other inputs. For cropland and farm labor these supply elasticities are set at 0.2, which reflects limited movement of these resources out of crop production. The supply elasticity for other inputs is set at 1.0 which is more elastic than those for both labor and land. The relatively low supply elasticity for labor reflects the fact that most farm labor in Korea is provided by middle-aged or older farmers who have relatively few alternatives off the farm. Reducing farm labor use in response to more imports entails largely a gradual process of older farmers' retirement and young people choosing other occupations. The parameter specification suggests a length of run under which resources at the margin move readily across crops, but face costly movement into or out of crop agriculture. We envisage a period of ±5 years as the length of run approximated in our model. Over this period, significant land or labor may move in and out of crop production, but supply functions are far from perfectly elastic. We examine more elastic supply elasticities in the sensitivity analysis.

[10] The survey reports the operating costs on a given plot of land (one tenth of a hectare) for about 50 different crops in the nation. To calculate input cost shares, we aggregated the reported operating costs following the definitions of our input aggregation. Then we combined the rental rate for rice land with the information on operating costs and calculated the input cost shares for each commodity category. We also used one rental rate for land for all commodities. This is a reasonable assumption in South Korea because more than 50% of paddy land consists of fragmented plots that can be converted to other crops.

4.3. Policy scenarios

With these output specifications, we use the model to simulate the following three policy scenarios:

1. Rice import quota as a percentage of the pre-import consumption of rice is increased from 0 to 10%. This is larger than the URA imposed minimum access, but reflects a realistic expectation of what may be allowed within the next decade.
2. Ad valorum tariffs on imports of horticultural crops are reduced from 30 to 15%. This reflects the order of magnitude of tariff cuts from the URA reforms.
3. Conditions (1) and (2) are imposed simultaneously.

For each of the alternative policy scenarios, we consider the small country case in which the import prices are constant.

5. Simulation results

Before proceeding to the results of the full simulation model, let us put our results in some context. Consider briefly the effects of limited market opening for rice under the restriction of no flexibility in factor markets. That is, what would be the impact of a 10% import quota if land, labor and capital all remained fixed in rice production? This conceptual experiment will help us assess the implications of market flexibility. In this case, the quantity of domestic rice production would be frozen at its pre-quota level. Therefore, total rice available to consumers would rise by 10%, the full amount of the imports. With an own price elasticity of −0.2, the domestic price of rice falls by 50% (but, remains well above world prices).

As a consequence of frozen input usage and constant domestic production, revenue to the rice industry falls by 50%, and this must be reflected in prices of inputs. Rice accounts for about half of the country's crop revenue and about 40% of agricultural revenue. Thus, with no factor market flexibility, a rice import quota of 10% would cause agricultural income in South Korea to fall by about 25%. With no factor market adjustment, this decline would appear directly in family incomes of farm people, and a loss of income of this magnitude would indeed be devastating. We would argue that this is exactly the scenario envisaged by South Korean (and other nations') agricultural politicians. By ignoring farm flexibility, they envisage huge losses. Thus, with this scenario in mind, it is not surprising to see that they have resisted market opening so vigorously.

In the analysis that follows, we show that, although declines remain significant, even a moderate degree of factor market flexibility reduces the impacts of market opening dramatically.

We argue that some degree of flexibility is indeed the reality and that is why market opening will be much less devastating than in the inflexible scenario. Further, as Table 1 shows, adjustments are already underway, in anticipation of the political 'leadership' that will follow.

Table 3 provides the key output and input market effects under the alternative policy simulations. We are especially interested in the cross-commodity adjustments that take place in response to the policy shocks. Cross-commodity adjustments mitigate the impacts of market opening on agricultural output and factor earnings. They also affect actual import patterns that follow from more import access. Thus, these adjustments are important both to the Asian importing nations and to exporters.

As seen in Table 3a, increasing the rice quota from 0 to 10% of domestic consumption causes a decrease in domestic rice production of 8.9%. The decrease in the domestic production of rice causes input prices to fall, and therefore the production of the other commodities to rise. The 3.1% increase in horticultural crop production is larger than that for domestic grains (1.7%), mainly because the demand for grain is more inelastic. This is also why the price of grain falls by more than the price of horticultural goods (5.3 versus 4.4%). Furthermore, since domestically produced commodities are substitutes for imported commodities, the increase in domestic production due to the decrease in input prices causes a decline in imports of horticultural crops of 12%. Korea imported $402 million of fruits and vegetables in 1994. With our model parameters, a rice import quota of 10% would have reduced horticultural imports into South Korea by $48.2 million. Grain imports also decline, but because the share of domestic grain in total use is very small the resulting domestic price decline is small.

Table 3
Simulation results

(a) Regime 1: Increase in rice quota from 0 to 10% of domestic consumption[a]

Effect on outputs (% changes)

	Rice	Horticulture	Imported horticulture	Grains	Imported grains
Price	−5.6	−4.4	0.0[a]	−5.3	0.0[a]
Production	−8.9	3.1	–	1.7	–
Imports	10[b]	–	12.0	–	−0.5

Effect on inputs (% changes)

	Input price	Input usage by industry			Total input usage
		Rice	Horticulture	Grains	
Land	−8.2	−6.4	6.8	4.6	−1.6
Labor	−4.2	−10.3	2.8	0.6	−0.8
Other inputs	−3.1	−11.4	1.8	−0.5	−3.1

(b) Regime 2: reduction in the tariff on imported horticultural crops from 30 to 15%[b]

Effect on output (% changes)

	Rice	Horticulture	Imported horticulture	Grains	Imported grains
Price	−0.7	−0.8	−11.5[c]	−0.8	0.0[a]
Production	0.1	−0.6	–	0.2	–
Imports	–	–	6.0	–	0.0

Effect on inputs (% changes)

	Input price	Input usage by industry			Total input usage
		Rice	Horticulture	Grains	
Land	−0.7	0.1	−0.7	0.2	−0.1
Labor	−0.9	0.4	−0.4	0.4	−0.2
Other inputs	−0.5	0.0	−0.9	0.0	−0.5

(c) Regime 3: simultaneous changes in rice quota from 0 to 10% and tariff from 30 to 15%[c]

Effect on output (% changes)

	Rice	Horticulture	Imported horticulture	Grains	Imported grains
Price	−6.3	−5.2	−11.5[c]	−6.1	0.0[a]
Production	−8.7	2.5	–	2.0	–
Imports	10[b]	–	−6.0		−0.6

Effect on inputs (% changes)

	Input price	Input usage by industry			Total input usage
		Rice	Horticulture	Grains	
Land	−8.8	−6.2	6.1	4.8	−1.8
Labor	−5.1	−10.0	2.4	1.0	−1.0
Other inputs	−3.6	−11.5	0.9	−0.4	−3.6

[a] Due to the small country assumption, the prices for imported horticultural crops and imported grains are held constant.
[b] Rice imports as a percent of domestic consumption. Initial rice quota is equal to zero.
[c] Percent change in the prices of imported horticultural crops is determined by the percent change in the tariff.

The effects of reducing the tariff on horticultural crops from 30 to 15% are shown in Table 3b. The primary response is a substitution in consumer demand due to the decrease in the relative price of horticultural imports. Imports of horticultural crops increase by 6% while domestic production decreases by 0.6%. All other changes in prices, production, and imports are less than 1% in absolute value. The tariff reduction by itself has quite small effects on domestic agriculture even though it is important for exporters and consumers of imported goods.

When both trade policies are introduced simultaneously there is a more complicated adjustment process than in either of simulations reported above. As shown in Table 3c, when the rice quota expands and tariffs fall, there is still a decline in domestic rice production by 8.7%. Now, the production of horticultural crops increases by 2.5% and there is a 6% decrease in horticultural imports. Horticultural crop production expands due to the cross-commodity linkages through the factor markets. Decreasing the tariff on imported horticultural crops results in a lower market price. However, the increase in the rice quota reduces the production costs of domestic horticultural crops. Therefore, even under a lower tariff, as a result of cross-commodity linkages, horticultural imports decline. The effects of the outward shift of the supply of domestically produced horticultural crops outweigh the positive effect on import quantity due to the lower import price. Note also that the cross-commodity substitution effects are strong enough that there is an increase in the amount of all three inputs used by the horticultural crop industry. This is the type of factor movements that corresponds to the input market depicted in Fig. 1(b).

It is interesting to investigate the income and factor market implications of these policies. When both quota and tariff policies are in place, the revenue from rice farming falls by about 15%, the sum of percentage changes in price (−6.3%) and production (−8.7%). Input prices also decline under this policy. The price of crop land falls by 8.8% and crop land usage falls by 1.8%. Crop labor wage falls by 5.1% while labor usage falls by 1.0%. Often times, in agriculture crop land owners are also crop labor owners, particularly in a country like South Korea where the average farm size is only 1.2 ha. With trade liberalization for crop agriculture, land income declines by 10.6% and at the same time its labor income declines by 6.1%. This implies a total income loss of between 6.1 and 10.6%, depending on shares of factor earnings.

In order to better understand how robust these results are, we conducted sensitivity analysis by considering alternative value for key parameters. We checked the sensitivity of the model results to the alternative values of elasticities, including own output price, cross price, and input supply elasticities. For each elasticity, we first determine a reasonable range around the initial value, and using the two boundary values in the range, we simulated the model for the 3rd regime, that applies both quota increase and tariff cuts. In most cases, we chose the elasticity range wide enough so that the range includes all reasonable elasticity values.

Table 4a presents the sensitivity results on own price elasticities. The elasticity ranges examined are −0.1 and −0.7 around the initial value of −0.2 for rice, −0.2 and −1.25 around the initial value of −0.7 for horticultural crops, and −0.08 and −0.83 around −0.33 for grains. Our results indicate that the alternative specifications of own elasticities, in general, change the price or production results by small amounts or almost none in some cases. However, the own price elasticity of horticultural crops is more crucial for changes in horticultural imports than other own price elasticities. The changes in horticultural imports range between −2.2 and −13% for the own elasticity range between −0.2 and −1.25. The sensitivity results related to the own price elasticities of imported commodities not reported in Table 4a. Under our small country assumption, a change in demand elasticity of imported goods results in only own-quantity effects with no cross-commodity effects.

Table 4b presents the sensitivity results on cross price elasticities. For the ranges examined, we chose the sets that meet the ratio requirements discussed earlier for both horticultural and grain crops. As shown in the table, when the set of cross elasticities for horticultural crops is 0.05 and 1.35, horticultural imports now increase, implying that the direction is reversed from our base run results. Recognizing the cross elasticities to be one of the key parameters that could reverse the direction of imports, we investigated the threshold parameter value. Among the sets meeting the ratio requirement, horticultural imports change the sign from minus to plus at (0.061, 1.647), with any values less than these, changes in horticultural imports become

Table 4
Sensitivity analysis and simulation results (% change)

(a) Sensitivity to alternative own output price elasticities[a]								
		Base elasticities	Alternative elasticity specification					
			Rice		Horticulture		Grains	
			−0.1	−0.7	−0.2	−1.25	−0.08	−0.83
% change in price	rice	−6.3	−6.7	−4.9	−8.7	−5.1	−6.4	−6.1
	horticulture	−5.2	−5.5	−4.1	−7.8	−3.8	−5.3	−5.0
	grains	−6.1	−6.4	−4.7	−8.6	−4.7	−6.2	−5.8
% change in production	rice	−8.7	−9.3	−6.5	−8.3	−9.0	−8.7	−8.8
	horticulture	2.5	2.7	1.7	0.4	3.6	2.6	2.4
	grains	2.0	2.1	1.6	2.8	1.5	0.5	4.8
% change in imports	horticulture	−6.0	−6.8	−3	−13	−2.2	−6.2	−5.5
	grains	−0.6	−0.6	−0.5	−0.9	−0.5	−0.6	−0.6
(b) Sensitivity to alternative cross price elasticities between domestic and imported crops[b]								
					(H, IH) (0.05, 1.35)	(H, IH) (0.2, 5.4)	(G, IG) (0.24, 0.05)	(G, IG) (0.96, 0.2)
% change in price	rice	−6.3			−6	−7	−6.3	−6.3
	horticulture	−5.2			−4.8	−6	−5.2	−5.2
	grains	−6.1			−5.7	−6.8	−6.1	−6.1
% change in production	rice	−8.7			−8.8	−8.6	−8.7	−8.7
	horticulture	2.5			2.8	1.9	2.5	2.5
	grains	2			1.9	2.2	2	2
% change in imports	horticulture	−6			1.6	−24	6	−6
	grains	−0.6			−0.6	−0.7	−0.3	−1.2
(c) Sensitivity to alternative input supply elasticities and simulation results under different elasticity specifications[c]								
			Land		Labor		Other inputs	
			0.1	0.7	0.1	0.7	0.5	1.5
% change in price	rice	−6.3	−6.9	−4.7	−6.6	−5.6	−6.9	−6.0
	horticulture	−5.2	−5.5	−4.4	−5.6	−4.1	−5.8	−4.9
	grains	−6.1	−6.5	−4.7	−6.4	−5.1	−6.5	−5.8
% change in production	rice	−8.7	−8.6	−9.1	−8.7	−8.9	−8.6	−8.8
	horticulture	2.5	2.7	1.9	2.7	1.7	2.6	2.3
	grains	2.0	2.2	1.6	2.1	1.7	2.2	1.9
% change in imports	horticulture	−6	−6.8	−3.7	−7	−3.1	−7.6	−5.1
	grains	−0.6	−0.7	−0.5	−0.6	−0.5	−0.7	−0.6

[a] Basic elasticities: rice = 0.2; horticulture = 0.7; grains = −0.33.
[b] Basic elasticities: (H, IH) = (0.1, 2.7) (G, IG) = (0.48,0.1). H: domestically produced horticultural crops, IH: imported horticultural crops.
[c] Basic elasticities: land = 0.2, labor = 0.2 other inputs = 1. G: domestically produced other grains, IG: imported other grains.

positive with the combination of a rice import increase and a horticultural tariff cut.

Next, we investigated the sensitivity of our results to input supply elasticites. We altered the land and labor supply elasticities to be 0.1 or 0.7, and other inputs to be 0.5 or 1.5. For these ranges of input supply elasticities, changes in domestic production was in general less significant, than price changes. Horticultural imports also did not change in a large magnitude within the elasticity ranges examined.

When the supply elasticity of input is larger, there is a reduction in input quantity adjustment. This implies that the change in domestic production is also smaller. Our baseline result on horticultural imports

— a reduction in imports despite a reduction in tariff — is due to input adjustment. We therefore, investigate the threshold input supply elasticities that change the direction of horticultural import adjustments. The threshold labor elasticity was found at 2.49, holding two other elasticities at the base values. For land, the threshold elasticity was 19.43 (with 1 for other inputs and 0.2 for labor). These are very large input supply elasticities and indicate that input supply elasticities are not be the important factor in determining our simulation results, within a reasonable range of the parameter space.

Finally, we also investigated the sensitivity of results to the input substitution parameters. Alternative parameters investigated range from 2.0 to 0.5 (from the base 1.0). In all these cases, the results changed very little.

6. Conclusions

This paper models cross-commodity substitution on both the demand and supply sides to examine the implications of liberalizing trade policy on the crop sector of an agricultural importing country. The concept of cross-commodity substitution is widely recognized. This study underscores and demonstrates the importance of cross-commodity substitution between rice and horticultural crops in northeast Asia. This is an important case with far reaching implications both within Asia and for exporters.

During trade negotiations, the pressure to open rice markets was considered in isolation of the impact on other markets. Indeed, negotiators and industry representatives and economists projected that opening markets would expand imports of all agricultural products. The cross-commodity effects within importing country agriculture were generally left aside (USDA Office of Economics, 1994). This paper shows that, under a plausible range of supply and demand parameter values, these cross-commodity effects can be important.

The effects in exporting regions may be significant. Ironically, the same export regions that most anticipated rice exports to Northeast Asia when markets open more fully (California and Australia) also produce the very horticultural crops that are likely to replace rice on Asian farms (including those in China, Taiwan and Japan). The planting behavior of Korean farmers suggests that they may expect more liberalization in the near future and are positioning themselves ahead of the fact. Finally, it is ironic that the policy expectations reflected in this rice planting behavior may be self-fulfilling. If South Korean farmers continue to plant less rice, then the government may indeed decide to import high quality rice in order to meet domestic demand without significantly higher prices for table rice.

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