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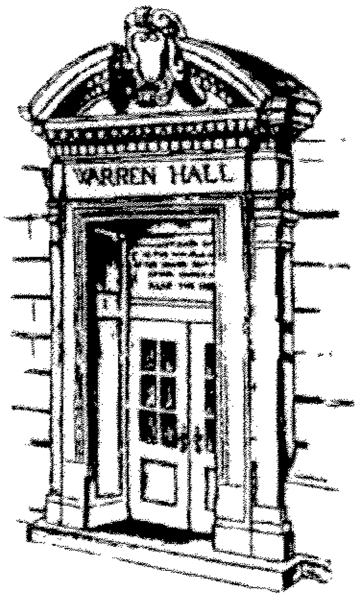

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An Economic Evaluation of the New Agricultural Trade Negotiations: A Nonlinear Imperfectly Competitive Spatial Equilibrium Approach

by

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Abstract

The objective of the research reported here is to develop a more flexible and comprehensive policy simulation model for imperfectly competitive international agricultural trade with various trade and domestic support policies. The model is a nonlinear imperfectly competitive spatial equilibrium model formulated as a MCP. The model is flexible in that it can simulate the economic effects of the following trade policies: specific duties, *ad valorem* tariffs, tariff-rate quotas, export subsidies, production subsidies, production quotas, consumption taxes and price floors, combined with various imperfectly competitive market structures. The usefulness of the model is demonstrated with an application to international wheat trade simulated under several alternative scenarios based on proposals of major countries as well as the agreement between China and the United States on China's participation in the WTO. The main empirical findings are as follows. Keeping the committed 2000 support levels under the current WTO agricultural agreements would be favorable for wheat producers in the European Community and Canada, but harmful to the United States wheat sector. There would be little structural change in the world wheat trade in a case where China joins the WTO, keeping the other countries' policies at the committed 2000 support levels. Likewise, little structural change would occur in the case where the new WTO agricultural negotiations result in agreements favorable for importing countries. However, world wheat trade would drastically change under full trade liberalization. In this case, the European Community switches from the world's leading net exporter to the world's leading net importer of wheat. Also, China and India would become major net exporting countries, and net exports by the United States, Canada, and the Cairns group such as Australia and Argentina would expand under full trade liberalization.

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An Economic Evaluation of the New Agricultural Trade Negotiations: A Nonlinear Imperfectly Competitive Spatial Equilibrium Approach

In December 2000, World Trade Organization (WTO) member countries submitted their proposals for the forthcoming agricultural negotiations. It is clear from these proposals that there is severe friction between importing and exporting countries, as well as between major oligopolistic exporting countries. The ultimate outcome that is reached will depend upon which country or blocks of countries are dominant. China's participation in the WTO is also an important factor affecting the new agreement.

A tool that is important for each member country in developing negotiation strategies for the new agreement is a generalized policy simulation model. Such models estimate the economic effects of alternative agreements, and, to be useful, must be able to adequately incorporate all of the complicated agricultural policy measures such as tariff-rate quotas, and combination of specific duties and *ad valorem* tariffs. Policy simulation models used by member countries in past international agricultural trade negotiations include AGLINK by OECD, DWOPSIM by Roningen (at USDA), IFPSIM by Ohga and Gehlar (at IFPRI), and various Applied General Equilibrium models (e.g., Anderson, *et al.*; Rae and Hertel).

The above are static and dynamic models for multi-regional and multi-commodity markets. Some of these models incorporate PSE (Producer Subsidy Equivalents) and CSE (Consumer Subsidy Equivalents) as aggregated measures of degree of agricultural support. However, these models do not separately incorporate various trade and domestic support policies such as specific duties, *ad valorem* tariffs, tariff-rate quotas, export subsidies, production subsidies, production quotas, consumption taxes and price floors. In particular, tariff-rate quotas have become one of the most important WTO policies, but it has been difficult to incorporate this policy option into these simultaneous equation models due to a non-convergence problem. In addition, these models assume perfectly competitive markets, which may be problematic since most international agricultural markets (e.g., the world wheat market) are clearly imperfectly competitive. Finally, transportation costs have ignored in these simultaneous equation models, even though transportation costs are important transaction costs, similar to tariffs, and have a major impact on international agricultural trade.

Spatial equilibrium models based on Takayama and Judge have also been applied to policy simulation (e.g., Judge and Takayama; Cox, *et al.*; Zhu, Cox and Chavas). While these models incorporate transportation costs, they can not handle *ad valorem* tariffs because they were formulated as quadratic programming problems. Rutherford introduced *ad valorem* tariffs to the model by reformulating it as a mixed complementarity problem (MCP). Subsequently, Shono introduced other trade policies such as tariff-rate quotas to her spatial equilibrium model. However, Shono specified supply (or marginal cost) and demand functions in linear form as a linear complementarity problem (LCP). Shono's model also relaxed the assumption of perfect competition, but under the assumption that all countries behave in the same ologopolistic manner. Both Shono and Rutherford did not introduce domestic support policies to their models, although these policies influenced international trade and policy as well.

The objective of the research reported here is to develop a more flexible and comprehensive policy simulation model for imperfectly competitive international agricultural trade with various trade and domestic support policies. The model is a nonlinear imperfectly competitive spatial equilibrium model formulated as a MCP. The model is flexible in that it can simulate the economic effects of the following trade policies: specific duties, *ad valorem* tariffs, tariff-rate quotas, export subsidies, production subsidies, production quotas, consumption taxes and price floors, combined with various imperfectly competitive market structures. The usefulness of the model is demonstrated with an application to international wheat trade simulated under several alternative scenarios based on proposals of major countries as well as the agreement between China and the United States on China's participation in the WTO.

The Model

Consider international trade among n ($n \geq 2$) countries. In each country, there are three administratively different markets: (1) a domestic market with no tariffs, (2) an in-quota import market with lower tariffs, i.e., the so-called minimum or current access market, and (3) an over-quota import market with higher tariffs. Products in the three markets are not differentiated by consumers, i.e., there is only one demand function in each country.

Consumers in each country are assumed to behave as price-takers. On the other hand, producers in each country are classified into two types: (1) a price-taking producer, and (2) a producer behaving as a Cournot player who maximizes profits with the expectation that his rivals will not change their supply in response to changes in his supply. Notations used in this paper are as follows:

Y_i : quantity produced in country i;

X_{ij}^{d} : quantity supplied to domestic market in country i ($i = j$);

X_{ij}^{p} : quantity exported from country i to in-quota market in country j;

X_{ij}^{s} : quantity exported from country i to over-quota market in country j;

X_{ij}^{ep} : quantity exported with export subsidy from country i to in-quota market in country j;

X_{ij}^{es} : quantity exported with export subsidy from country i to over-quota market in country j;

P_j : market price in country j ;

$C_i = C_i(Y_i)$: cost function in country i ;

$D_j = D_j(P_j)$: demand function in country j ;

ST_j^p : in-quota specific duty rate in country j ;

ST_j^s : over-quota specific duty rate in country j ;

AT_j^p : in-quota *ad valorem* tariff rate in country j ;

AT_j^s : over-quota *ad valorem* tariff rate in country j ;

$\overline{X_j^p}$: tariff-rate quota in country j ;

ES_i : specific export subsidy in country i ;

$\overline{X_i^e}$: upper limit of subsidized quantity exported in country i ;

PS_i : (specific) producer subsidy in country i ;

$\overline{Y_i}$: production quota in country i ;

$\underline{P_j}$: price floor in country j ;

CT_j : (*ad valorem*) consumption tax rate in country j ;

TC_{ij} : unit transportation cost from country i to j $(i \neq j)$;

TC_{ij}^d : unit transportation cost inside country i $(i = j)$,

where i and j are natural numbers, $ST_j^p < ST_j^s$ and $AT_j^p < AT_j^s$. All demand and cost functions are assumed to be continuously differentiable. It is also assumed that unit transportation costs are constant regardless of quantity shipped, and there is no forwarding transportation between countries.

Using the above notation, the producer's profit maximizing behavior in country i

can be expressed as:

$$(1)\quad \max_{Y_i, X_{ij}^d, X_{ij}^p, X_{ij}^s, X_{ij}^{ep}, X_{ij}^{es}} \pi_i = \sum_{j=1}^{n} P_j\left(X_{ij}^d + X_{ij}^p + X_{ij}^s + X_{ij}^{ep} + X_{ij}^{es}\right) - C_i(Y_i) - \sum_{j=1}^{n} TC_{ij}^d X_{ij}^d - \sum_{j=1}^{n} TC_{ij}\left(X_{ij}^p + X_{ij}^s + X_{ij}^{ep} + X_{ij}^{es}\right)$$

$$- \sum_{j=1}^{n} ST_j^p\left(X_{ij}^p + X_{ij}^{ep}\right) - \sum_{j=1}^{n} AT_j^p P_j\left(X_{ij}^p + X_{ij}^{ep}\right) - \sum_{j=1}^{n} ST_j^s\left(X_{ij}^s + X_{ij}^{es}\right) - \sum_{j=1}^{n} AT_j^s P_j\left(X_{ij}^s + X_{ij}^{es}\right)$$

$$+ ES_i \sum_{j=1}^{n}\left(X_{ij}^{ep} + X_{ij}^{es}\right) + PS_i Y_i$$

$$(2)\quad s.t.\ \sum_{j=1}^{n}\left(X_{ij}^d + X_{ij}^p + X_{ij}^s + X_{ij}^{ep} + X_{ij}^{es}\right) \le Y_i$$

$$(3)\quad \sum_{i=1}^{n}\left(X_{ij}^p + X_{ij}^{ep}\right) \le \overline{X_j^p},\ \forall j,$$

$$(4)\quad \sum_{j=1}^{n}\left(X_{ij}^{ep} + X_{ij}^{es}\right) \le \overline{X_i^e}$$

$$(5)\quad Y_i \le \overline{Y_i}$$

where Y_i, X_{ij}^d, X_{ij}^p, X_{ij}^s, X_{ij}^{ep} and X_{ij}^{es} are non-negative variables. Values for TC_{ij}^d $(i \ne j)$ and TC_{ii} are set to extremely large numbers in order that values for X_{ij}^d $(i \ne j)$, X_{ii}^p, X_{ii}^s, X_{ii}^{ep} and X_{ii}^{es} be zero. In the case where country j does not have the tariff-rate quota system, values for ST_j^p, AT_j^p and $\overline{X_j^p}$ are zero and over-quota tariff rates, ST_j^s and AT_j^s, are applied to all imports to the country.

If the producer in country i behaves as a Cournot player, the Kuhn-Tucker optimality conditions for the above maximization problem can be expressed as follows:

$$(6)\quad P_j + \frac{dP_j}{dD_j}\left(X_{ij}^d + X_{ij}^p + X_{ij}^s + X_{ij}^{ep} + X_{ij}^{es}\right) \le TC_{ij}^d + \alpha_i,\ X_{ij}^d \ge 0,$$

$$X_{ij}^d\left[TC_{ij}^d + \alpha_i - P_j - \frac{dP_j}{dD_j}\left(X_{ij}^d + X_{ij}^p + X_{ij}^s + X_{ij}^{ep} + X_{ij}^{es}\right)\right] = 0,\ \forall ij,$$

(7) $P_j+\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)\le TC_{ij}+ST_j^p+AT_j^p\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^p+X_{ij}^{ep}\right)\right\}+\alpha_i+\beta_{ij},\ X_{ij}^p\ge 0,$

$$X_{ij}^p\left[TC_{ij}+ST_j^p+AT_j^p\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^p+X_{ij}^{ep}\right)\right\}+\alpha_i+\beta_{ij}-P_j-\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)\right]=0,\ \forall ij,$$

(8) $P_j+\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)\le TC_{ij}+ST_j^s+AT_j^s\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^s+X_{ij}^{es}\right)\right\}+\alpha_i,\ X_{ij}^s\ge 0,$

$$X_{ij}^s\left[TC_{ij}+ST_j^s+AT_j^s\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^s+X_{ij}^{es}\right)\right\}+\alpha_i-P_j-\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)\right]=0,\ \forall ij,$$

(9) $P_j+\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)+ES_i\le TC_{ij}+ST_j^p+AT_j^p\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^p+X_{ij}^{ep}\right)\right\}+\alpha_i+\beta_{ij}+\gamma_i,\ X_{ij}^{ep}\ge 0,$

$$X_{ij}^{ep}\left[TC_{ij}+ST_j^p+AT_j^p\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^p+X_{ij}^{ep}\right)\right\}+\alpha_i+\beta_{ij}+\gamma_i-P_j-\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)-ES_i\right]=0,\ \forall ij,$$

(10) $P_j+\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)+ES_i\le TC_{ij}+ST_j^s+AT_j^s\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^s+X_{ij}^{es}\right)\right\}+\alpha_i+\gamma_i,\ X_{ij}^{es}\ge 0,$

$$X_{ij}^{es}\left[TC_{ij}+ST_j^s+AT_j^s\left\{P_j+\frac{dP_j}{dD_j}\left(X_{ij}^s+X_{ij}^{es}\right)\right\}+\alpha_i+\gamma_i-P_j-\frac{dP_j}{dD_j}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)-ES_i\right]=0,\ \forall ij,$$

(11) $PS_i+\alpha_i\le\frac{dC_i}{dY_i}+\delta_i,\ Y_i\ge 0,\ Y_i\left[\frac{dC_i}{dY_i}+\delta_i-PS_i-\alpha_i\right]=0,\ \forall i,$

(12) $\sum_{j=1}^{n}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)\le Y_i,\ \alpha_i\ge 0,\ \alpha_i\left[Y_i-\sum_{j=1}^{n}\left(X_{ij}^d+X_{ij}^p+X_{ij}^s+X_{ij}^{ep}+X_{ij}^{es}\right)\right]=0,\ \forall i,$

(13) $\sum_{i=1}^{n}\left(X_{ij}^p+X_{ij}^{ep}\right)\le\overline{X_j^p},\ \beta_{ij}\ge 0,\ \beta_{ij}\left[\overline{X_j^p}-\sum_{i=1}^{n}\left(X_{ij}^p+X_{ij}^{ep}\right)\right]=0,\ \forall ij,$

(14) $\sum_{j=1}^{n}\left(X_{ij}^{ep}+X_{ij}^{es}\right)\le\overline{X_i^s},\ \gamma_i\ge 0,\ \gamma_i\left[\overline{X_i^s}-\sum_{j=1}^{n}\left(X_{ij}^{ep}+X_{ij}^{es}\right)\right]=0,\ \forall i,$

(15) $Y_i\le\overline{Y}_i,\ \delta_i\ge 0,\ \delta_i\left[\overline{Y}_i-Y_i\right]=0,\ \forall i,$

where α_i, β_{ij}, γ_i and δ_i are the Lagrange multipliers for constraints (2), (3), (4), and (5), respectively. If the producer in country i behaves as a price taker, the term $\frac{dP_i}{dD_i}$ in the above conditions becomes zero.

For a producer in country i, β_{ij} is the shadow price for the right to export to the in-quota market in country j. Assuming that the market for this right is perfectly competitive in country j, producers in all countries should face the same shadow price for this right in country j. Throughout this paper, the competitive shadow price in country j is expressed as β_j. A relatively high shadow price means more expansion of tariff-rate quotas in country j is demanded. The parameters γ_i and δ_i are shadow prices for the right to produce within production quotas in country i, and for the right to export within the upper limit of subsidized quantity exported in country i, respectively. Condition (11) shows that the relation $\left(\alpha_i = \frac{dC_i}{dY_i} + \delta_i - PS\right)$ holds if there is any production in country i. Condition (12) shows that if $\alpha_i > 0$, then total quantity shipped is equal to total quantity produced. However, this condition also allows for excess production even if the marginal cost is positive. If domestic support policies are ignored, as assumed by Rutherford and Shono, overproduction could occur only if the marginal cost is equal to zero.

As described earlier, the market is divided into three administratively different markets in each country: domestic market, in-quota import market, and over-quota import market. Since it is assumed there is only one demand function for each country, the market equilibrium condition in country j can be expressed as follows:

(16) $D_j\{P_j(1+CT_j)\} = \sum_{i=1}^{n}\left(X_{ij}^{d} + X_{ij}^{p} + X_{ij}^{s} + X_{ij}^{op} + X_{ij}^{os}\right),\ P_j \geq \underline{P}_j,\ \forall j$, or

(17) $D_j\{P_j(1+CT_j)\} < \sum_{i=1}^{n}\left(X_{ij}^{d} + X_{ij}^{p} + X_{ij}^{s} + X_{ij}^{op} + X_{ij}^{os}\right),\ P_j = \underline{P}_j,\ \forall j$.

The spatial equilibrium model consists of conditions (6) to (17) formulated as the MCP.[1] The Nash equilibrium solution for these conditions is the spatial equilibrium solution. The solution is found by the pathsearch damped Newton method (Ralph; Dirkse and Ferris; Anstreicher, Lee and Rutherford).

Theoretically, introducing the conjectural variations concept into the above model can generalize the model to incorporate any degree of market structure from perfect competition to monopoly. However, conjectural variations in the generalized model cannot be estimated in the same manner as Iwata, or Suzuki, Lenz and Forker, in cases where X_{ij}^{p}, X_{ij}^{s}, X_{ij}^{ep}, and X_{ij}^{es} are zero, and tariff-rate quotas and limits of subsidized quantity exported are effective. Therefore, we use the above model without introducing conjectural variations, and find plausible market structures by simulating a lot of combinations of producers' marketing behavior according to Kawaguchi, Suzuki and Kaiser.

An Application

Because it is one of the most controversial areas of WTO agricultural negotiations, the model is applied to a policy simulation of international wheat trade. Five major exporting countries and areas (United States, Canada, European Union, Australia and Argentina) share about 85 percent of total exports in the international wheat market. Therefore, each of these countries and areas is assumed to behave as a Cournot player. On the other hand, producers in nine countries (China, Egypt, India, Japan, South Korea, Mexico, New Zealand, Nigeria and the former Soviet Union) are assumed to behave as price takers in simulation.

Table 1 shows domestic trade and support policies for wheat in each country. Tariff rates and tariff quotas represent levels in 2000 committed by each country under the WTO agreement (USDA, FAS; Dohlman and Hoffman; WTO). It is assumed that specific export subsidies in 2000, calculated by dividing the committed value limit by the committed volume limit, can be used within the committed volume limit even though WTO agreements require countries to reduce the volume and value of subsidized export (WTO; Dohlman and Hoffman). China's trade and domestic support policies represent levels applied in 1998 because it is currently a non-WTO member. Likewise, Russia' s figures in 1998 are used for the former USSR. Specific duty rates and export subsidies are converted into U.S. dollars by using exchange rates at the end of 1998 (UN; Bank of Japan).

The WTO agreements also require countries to reduce the total Aggregate Measure of Support (AMS) as opposed to the commodity-specific AMS. However, instead of AMS, we use the unit PSE (converted into U.S. dollars) for wheat in 1998 (OECD) as (specific) production subsidies because we are focusing only on wheat trade.[2] Because the unit PSE in 1998 is not available for these countries and areas, the unit PSE's for Argentina, China, Egypt, India, Nigeria and the former USSR are, respectively, for the years 1992, 1992, 1992, 1990, 1989 and 1990 (USDA, ERS).

Floor prices for wheat converted into U.S. dollars are set at the intervention price in the European Community, the administrated price in Japan and Mexico, and the loan rate in the United States (OECD). Although price floors are set at producer prices, this model sets the price floor at the border price in each country and area by using the relationship that the border price is equal to the producer price minus unit MPS (or Market Price Support). In each country and area with production quotas, the quantity produced in 1999 (USDA, ERS) is used as a proxy for the volume of production quotas. The consumption tax rate in 2000 is used in each country and area.

For an empirical application of the model, demand and inverse marginal cost functions in each country and area are simplified and specified as follow:

(18) $D_j = DD_j N_j = (a_j + b_j P_j) N_j$

(19) $Y_i = YY_i A_i = YY_i (c_i PP_i^{d_i})$

where DD_j and N_j are quantity demanded and population in country j, respectively; YY_i, A_i, and PP_i are yield, cultivated area and marginal cost in country i, respectively; and a_j, b_j, c_i, and d_i are parameters.

Per capita demand functions are specified in a linear form for the following reason. In this application, many combinations of producers' marketing behavior are simulated in order to find a good proxy for the actual market structure. In a case where producers in all countries and areas form a coalition to monopolize the international markets, the demand must be price-elastic in all markets. If a demand function with an inelastic constant elasticity is used in the model, there is no collusive solution. Therefore, we use a linear demand function, which is one functional form with variable price elasticities.

Border prices (OECD; USDA, ESS) are used as market prices for calculating linear demand functions in each country and area. Prices for the same years as those for PSE are used for Argentina, China, Egypt, India, Nigeria and the former USSR. 1998 prices are used for other countries and areas, deflating by implicit deflators. Domestic consumption (USDA, ERS) and population (FAO) are used to calculate the per capita demand in each country and area. Per capita demand functions are calculated using these data and long-run price elasticies for per capita wheat demand for human uses estimated by Ohga and Yanagishima. As shown in table 2, multiplying the per capita demand functions by the latest (1999) estimates of population yields the aggregate wheat demand function for each country and area.

Producer prices (OECD; USDA, ESS), deflating by implicit deflators, are used as marginal costs in each country and area. The cultivated area data comes from OECD. The data years for both producer prices and cultivated areas are the same as the border prices. Cultivated areas' response functions to marginal costs are calculated using these data and long-run price elasticities of the cultivated area estimated by Ohga and Yanagishima. As shown in table 2, multiplying the response functions by the latest (1999) estimates of yield (USDA, ERS) provides the inverse marginal cost function in each country and area.

Grains are usually transported by ship. The main type of ship used is the bulk carrier (called the Panamax type). Transportation is occasional and supply and demand of the beam determines the freight. Assuming that the unit transportation cost is constant regardless of shipping volume, we estimate the unit transportation costs between ports in each country and area as follows: The main port in each country and area, and the shortest route usually taken by merchant ships is selected. The distance of the route between ports is calculated in terms of nautical miles. The freight per metric ton and per nautical mile between New Orleans and Tokyo is calculated, based on the information that the freight cost for grains between the U.S. Gulf Coast and Japan by bulk carrier (Panamax type) is US$22.4 on average from 1994 to 1999 (Clarkson). As shown in table 3, multiplying the calculated freight cost per metric ton and per nautical mile by the distance of each route provides with the unit transportation costs among the countries and areas. On the other hand, the unit transportation cost inside each country and area is assumed to be zero.

Four scenarios are simulated based on current proposals for the new WTO agricultural negotiations from major countries, and the agreement between China and the United States on China's participation in the WTO (see table 4). The four scenarios are representative of a wide range of possible outcomes for the new trade agreements, ranging from no change to proposals favoring importing countries to proposals favoring exporting countries.

Scenario 1 is the base scenario that represents the committed 2000 levels of trade and domestic support policies under the current WTO agricultural agreements. This scenario is indicative of the current market situation for world wheat trade. The in-quota *ad valorem* tariff rate in Japan is assumed to be 20 percent, and in Mexico and the United States only specific duties are imposed on over-quota imports. It is also assumed that trade and domestic policies in China and the former USSR shown in table 1 remain unchanged. All levels of other domestic policies, population, yield and unit transportation costs shown in tables 1 to 3 are used. Note that population, yield and unit transportation costs are also used in scenarios 2 to 4.

Under Scenario 2, it is assumed that China joins the WTO and all other trade and domestic support policies are the same as Scenario 1. Trade policies in China are assumed to be the committed levels for 2004 based on the 1999 agreement between China and the United States. That is, China establishes 9.636 million metric tons of tariff-rate quotas, and sets the in-quota *ad valorem* tariff rate at one percent and the over-quota *ad valorem* tariff rate at 65 percent. China's domestic policies shown in table 1 are used in this scenario.

Scenarios 3 and 4 represent the most extreme outcomes for the negotiations. Scenario 3 assumes that the new WTO agricultural negotiations result in agreements favorable for exporting countries. This scenario is close to full trade liberalization since all trade and domestic support policies except consumption taxes are eliminated in all countries and areas. On the other hand, in Scenario 4, it is assumed that the new WTO agricultural negotiations result in agreements favorable for importing countries. Here it is assumed that export subsidies are eliminated, the tariff-rate quotas are eliminated, and the current over-quota tariffs are imposed on all imports. The current domestic support policies are assumed to remain unchanged in all countries and areas.

The Results

Table 5 shows the spatial equilibrium solution for scenario 1. First, we solved scenario 1 assuming three different market structures: (1) a case where producers in all countries and areas behave as a price taker, (2) a case where they form a coalition to monopolize the international markets, and (3) a case where they behave as a Cournot player. Although solutions in the above three cases are not shown, they were not realistic solutions. For example, the first and second cases resulted in highly simplistic world trade structures. The second and third cases resulted in extremely high market prices. As shown in table 5, the solution that was the closest to the actual world wheat trade structure was the case where producers in Argentina, Australia, Canada, European Community and the United States are Cournot players, and producers in the other nine countries and areas are price takers. Therefore, we used the fifth case as the basic market structure for simulating all four scenarios.

The results for the base scenario where the committed 2000 levels remain the same are displayed in Table 5. In this situation, the European Community, United States, and Canada are the largest net exporters (net exports of 18.3, 17.6, and 15.2 million metric tons, respectively). Total word trade is almost 120 million metric tons. While the European Community is the world's largest net exporter of wheat in this scenario, it is clear that the European Community has a high degree of domestic market protection. The high domestic intervention price for wheat in the European Community results in a large amount of surplus stocks, which totals almost 17 million metric tons in the base scenario. Consequently, there is tremendous pressure to reduce the size of government stocks through large export subsidies ($1,364 million in the base case). At the same time, the relatively high market wheat price makes the European Community a particularly attractive market to other wheat exporters. This is also reflected in the results by the high shadow price for export rights into this market ($113.60 per metric ton). Thus, in spite of WTO pressure to expand tariff-rate quotas, the

European Community has a strong incentive to restrict wheat imports, as is the case in this scenario.

A similar situation exists in Canada, which also has a high degree of domestic protection in the base scenario. However, Canada supports its wheat market though a price discrimination scheme operated by the Canadian Wheat Board. Price discrimination includes a higher domestic price and a lower export price for wheat, with producers receiving a weighted-average price based on market utilization. Indeed, Canadian producers receive the highest market price for wheat in this scenario of any country ($189.28). The shadow price for the right to export into Canada is almost as high as the European Community ($105.99). As was true for the European Community, the results of the base scenario suggest that Canada has an economic incentive to resist expansion of tariff-rate quotas.

On the other hand, the United States has a relatively low degree of protection for its wheat market. Second only to the European Community in terms of net exports, the United States has one of the lowest wheat market prices among all the exporters (almost one-half the market price of Canada and the European Community). It is clear that the United States should favor expansion of tariff-rate quotas in the future trade negotiations.

The simulation results for Scenario 2 are reported in Table 6, where China is part of the WTO and all other member countries are committed to 2000 support levels. This scenario does not result in drastically different results from the previous scenario, except that China would become a net importing country by increasing imports to its upper limit of tariff-rate quotas. Consequently, total world wheat trade increases in this scenario from 120 to 129 million metric tons. However, there is little change in market prices, and no other significant structural changes in the world wheat trade in this case.

Not surprisingly, the world wheat trade situation would change considerably under full trade liberalization (all trade and domestic support policies except consumption taxes are eliminated in all countries and areas) reflected by Scenario 3 (reported in Table 7). Relative to the base scenario, world wheat trade increases by 47 percent in this scenario to 176 million metric tons. Under full trade liberalization, the European Community switches from the world's largest net exporter to the world's largest net importer of wheat (importing 10 metric tons). The market price for wheat in the European Community would fall by over 25 percent, and wheat production decreases by 35 percent compared to the base scenario. Indeed, the European Community wheat sector would suffer the largest losses by full trade liberalization.

Canada and the United States remain as the largest net exporters of wheat under full trade liberalization. Relative to the base scenario, Canada actually experiences an increase in net exports (from 15.2 million metric tons to 19.3). Trade liberalization results in a 23 percent increase in production. The higher production results in a 25 percent decrease in the market price in Canada. Net exports from the United States also expand in the full trade liberalization case, increasing from 17.6 to 20.2 million metric tons. Unlike Canada, however, the increase in net exports is due to a slightly lower domestic demand, which, in turn, is due to a higher domestic wheat price in the United States. The magnitude of the domestic price increase is 34 percent under this scenario. Prices become higher in less protected exporting countries, like the U.S., Australia and Argentina, because low export prices distorted by various protection measures increase under deregulation, while domestic prices become lower in heavily protected countries, like the European Community, Canada, and Japan. Thus, market prices would be leveled in the whole world by a freer trade. Also, China and India would become major net exporting countries, and net exports by the Cairns group such as Australia and Argentina would expand under full trade liberalization.

The last scenario is the opposite of the third, in that it assumes export subsidies and tariff-rate quotas are eliminated, the current over-quota tariffs are imposed on all imports, and the current domestic support policies are maintained (Table 8). In this scenario, world wheat trade is the lowest (117 million metric tons). Compared with the baseline scenario, the more restricted trade barrier scenario results in no significant structural changes in world wheat trade. Table 8 also shows that some importing countries such as Japan and Mexico would have larger increases in their domestic production.

Concluding Remarks

In this paper, we developed a nonlinear spatial equilibrium model for analyzing policy issues relating to world trade. By formulating the model as a mixed complementarity problem, this model can incorporate a diverse set of trade and domestic support policies. For instance, the developed model is capable of including the following policies: specific duties, *ad valorem* tariffs, tariff-rate quotas, export subsidies, production subsidies, production quotas, consumption taxes and price floors. Moreover, unlike many previous models that assume a perfectly competitive market structure, the model developed here can be combined with various imperfectly competitive market structures.

The usefulness of this model was demonstrated with an application to international wheat trade. The model was simulated under several policy scenarios based on proposals of major countries on the new WTO agricultural negotiations, and the agreement between China and the United States on China's entry to the WTO.

The main empirical findings are as follows. Keeping the committed 2000 support levels under the current WTO agricultural agreements would be favorable for wheat producers in the European Community and Canada, but harmful to the United States wheat sector. There would be little structural change in the world wheat trade in a case where China joins the WTO, keeping the other countries' policies at the committed 2000 support levels. Likewise, little structural change would occur in the case where the new WTO agricultural negotiations result in agreements favorable for importing countries. However, world wheat trade would drastically change under full trade liberalization. In this case, the European Community switches from the world's leading net exporter to the world's leading net importer of wheat. Also, China and India would become major net exporting countries, and net exports by the United States, Canada, and the Cairns group such as Australia and Argentina would expand under full trade liberalization.

The model can be used for policy simulation of international trade under any other intermediate policy scenarios. Any other products can be incorporated in the model. Many other trade and domestic support policies can also be incorporated in the model, such as export taxes, production taxes and consumption subsidies, by redefining these policies as negative export subsidies, negative production subsidies and negative consumption taxes, respectively. We also can incorporate price ceilings as well as price floors using the MCP formulation. Moreover, transferring shipments from country to country can be introduced in the model by refining it according to Lin and Kawaguchi.

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Notes

[1] Harker and Pang, Ferris and Pang, and Ferris and Kanzow present excellent surveys on complementarity problems including MCP and their applications.

[2] Both AMS and PSE consist of monetary transfers from consumers to producers and from the governments to producers. One of the differences between AMS and PSE is that PSE includes "green box" policies, but AMS does not.

Table 1. Trade and Domestic Support Policies in Each Country and Area

(Unit: U.S. dollars per metric ton, million metric tons and percents)

Country or Area	Trade Policies							Domestic Support Policies			
	In-Quota Import Market			Over-Quota Import Market		Specific Export Subsidy	Upper Limit of Subsidized Quantity Exported	(Specific) Production Subsidy	Production Quota	Consumption Tax for Food	Price Floor
	Specific Duty	*Ad Valorem* Tariff	Tariff-Rate Quota	Specific Duty	*Ad Valorem* Tariff						
Argentina	n.a.	n.a.	n.a.	0.000	0.000	0.000	0.000	0.440	n.a.	21.000	n.a.
Australia	n.a.	n.a.	n.a.	0.000	0.000	0.000	0.000	10.374	n.a.	10.000	n.a.
Canada	1.241	0.000	0.227	0.000	76.500	14.693	8.851	9.275	n.a.	0.000	n.a.
China	n.a.	n.a.	n.a.	0.000	114.000	0.000	0.000	-36.000	n.a.	17.000	n.a.
Egypt	n.a.	n.a.	n.a.	0.000	5.000	0.000	0.000	48.000	n.a.	10.000	n.a.
EU	0.000	0.000	0.300	113.596	0.000	101.544	13.436	149.588	96.888	9.800	142.294
India	n.a.	n.a.	n.a.	0.000	100.000	0.000	0.000	-66.000	n.a.	0.000	n.a.
Japan	0.000	0-20.000	5.740	475.779	0.000	0.000	0.000	1275.087	n.a.	5.000	1282.154
South Korea	n.a.	n.a.	n.a.	0.000	1.800	0.000	0.000	454.900	n.a.	10.000	n.a.
Mexico	0.000	50.000	0.605	90.000	67.000	24.183	0.312	47.552	n.a.	0.000	143.500
New Zealand	n.a.	n.a.	n.a.	0.000	0.000	0.000	0.000	0.000	n.a.	12.500	n.a.
Nigeria	n.a.	n.a.	n.a.	0.000	150.000	0.000	0.000	349.000	n.a.	5.000	n.a.
U.S.	n.a.	n.a.	n.a.	3.500	2.800	25.065	14.522	61.200	n.a.	8.250	94.800
The Former USSR	n.a.	n.a.	n.a.	0.000	5.000	0.000	0.000	39.000	n.a.	0.000	n.a.

Source: Tariff Rates from USDA, FAS; Dohlman and Hoffman. Tariff Quotas from WTO; Dohlman and Hoffman. Export Subsidies from WTO; Dohlman and Hoffman.
Production Subsidies from OECD; USDA, ESS. Production Quotas from USDA, ERS. Consumption Taxes from Embassies and MOF in Japan. Price Floors from OECD.
Exchange Rates from United Nations, Bank of Japan.

Note: The tariff rates in countries and areas with no tariff-rate quotas are shown in columns of over-quota import market.
Mexico and the U.S. can select the higher of specific duty or *ad valorem* tariff in their over-quota import markets.

Table 2. Demand and Inverse Marginal Cost Functions in Each Country and Area

(Unit: million people and metric tons per ha)

Country or Area	Demand Function			Inverse Marginal Cost Function		
	Per Capita Demand Function	Price Elasticity	Population	Response Function of Cultivated Area	Price Elasticity	Yield
Argentina	d=0.16845-0.00055P	-0.32	36.577	$L= 0.31628P^{0.60}$	0.60	2.553
Australia	d=0.34949-0.00068P	-0.24	18.701	$L= 0.16427P^{0.90}$	0.90	2.016
Canada	d=0.29091-0.00044P	-0.20	30.857	$L= 1.08847P^{0.50}$	0.50	2.591
China	d=0.10074-0.00006P	-0.10	1274.107	$L=14.91401P^{0.15}$	0.15	3.947
Egypt	d=0.21283-0.00030P	-0.20	67.226	$L= 0.18256P^{0.30}$	0.30	6.550
EU	d=0.28258-0.00057P	-0.27	375.049	$L= 1.69804P^{0.50}$	0.50	5.693
India	d=0.07862-0.00009P	-0.30	998.056	$L= 2.66081P^{0.45}$	0.45	2.583
Japan	d=0.05419-0.00003P	-0.10	126.505	$L= 0.00454P^{0.52}$	0.52	3.450
South Korea	d=0.11786-0.00038P	-0.40	46.48	$L= 0.00007P^{0.45}$	0.45	5.000
Mexico	d=0.07169-0.00014P	-0.30	97.365	$L= 0.05606P^{0.55}$	0.55	4.429
New Zealand	d=0.16803-0.00024P	-0.22	3.828	$L= 0.00114P^{0.80}$	0.80	5.000
Nigeria	d=0.00820-0.00002P	-0.93	108.945	$L= 0.01421P^{0.20}$	0.20	1.286
U.S.	d=0.16994-0.00042P	-0.35	276.218	$L= 1.55619P^{0.60}$	0.60	2.873
The Former USSR	d=0.47948-0.00055P	-0.25	291.587	$L=13.69191P^{0.23}$	0.23	1.575

Source: Population from FAO□Yield from USDA, ERS. Price elasticities from Ohga and Yanagishima.

Table 3. Unit Transportation Cost of Grains among Countries and Areas (Unit: U.S. dollars per metric ton)

From / To	Argentina (Buenos Aires)	Australia (Sydney)	Canada (Montreal)	China (Shanghai)	Egypt (Port Said)	EU (Rotterdam)	India (Mumbai)	Japan (Tokyo)	South Korea (Pusan)	Mexico (Tampico)	New Zealand (Wellington)	Nigeria (Lagos)	U.S. (New Orleans)	The Former USSR (Sankt Petersburg)
Argentina (Buenos Aires)	0.000	17.580	15.781	27.355	17.648	15.539	20.236	26.137	26.943	15.730	14.617	10.547	15.249	18.710
Australia (Sydney)	17.580	0.000	26.715	11.351	20.329	28.352	14.745	10.643	10.439	22.508	3.029	22.442	22.336	31.773
Canada (Montreal)	15.781	26.715	0.000	28.916	12.480	8.062	19.945	26.779	27.833	8.219	23.821	12.571	7.521	9.633
China (Shanghai)	27.355	11.351	28.916	0.000	17.759	25.782	11.439	2.568	1.171	24.708	13.130	25.127	24.537	28.923
Egypt (Port Said)	17.648	20.329	12.480	17.759	0.000	8.023	7.464	19.393	18.509	16.590	22.545	12.270	15.887	10.907
EU (Rotterdam)	15.539	28.352	8.062	25.782	8.023	0.000	15.487	27.416	26.622	12.600	27.769	10.221	11.895	2.963
India (Mumbai)	20.236	14.745	19.945	11.439	7.464	15.487	0.000	13.073	12.098	24.054	16.960	17.531	23.351	18.589
Japan (Tokyo)	26.137	10.643	26.779	2.568	19.393	27.416	13.073	0.000	1.676	22.572	12.353	26.755	22.400	30.715
South Korea (Pusan)	26.943	10.439	27.833	1.171	18.509	26.622	12.098	1.676	0.000	23.603	13.005	25.826	23.400	29.663
Mexico (Tampico)	15.730	22.508	8.219	24.708	16.590	12.600	24.054	22.572	23.603	0.000	19.614	14.747	1.796	18.491
New Zealand (Wellington)	14.617	3.029	23.821	13.130	22.545	27.769	16.960	12.353	13.005	19.614	0.000	23.892	19.442	30.923
Nigeria (Lagos)	10.547	22.442	12.571	25.127	12.270	10.221	17.531	26.755	25.826	14.747	23.892	0.000	14.100	13.110
U.S. (New Orleans)	15.249	22.336	7.521	24.537	15.887	11.895	23.351	22.400	23.400	1.796	19.442	14.100	0.000	14.424
The Former USSR (Sankt Petersburg)	18.710	31.773	9.633	28.923	10.907	2.963	18.589	30.715	29.663	18.491	30.923	13.110	14.424	0.000

Source: Lloyd's; Japan Shipping Exchange; Clarkson.

Note: Selected ports in parentheses.

Table 4. Policy Assumptions (Unit: percents and million metric tons)

Policy Instruments		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Trade Policies	In-Quota Tariff	Extended	China:1(*Ad Valorem*) Others: Extended	Removed	Removed
	Over-Quota Tariff	Extended	China:65(*AdValorem*) Others: Extended	Removed	Extended
	Tariff-Rate Quota	Extended	China: 9.636 Others: Extended	Removed	Removed
	Export Subsidy	Extended	Extended	Removed	Removed
Domestic Support Policies	Production Subsidy	Extended	Extended	Removed	Extended
	Production Quota	Extended	Extended	Removed	Extended
	Consumption Tax	Extended	Extended	Extended	Extended
	Price Floor	Extended	Extended	Removed	Extended

Table 5. Spatial Equilibrium Solution for Scenario 1 (Unit: million metric tons and U.S. dollars per metric ton)

	To \ From	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Volume of Trade: In-Quota Import Market	Argentina	n.a.	n.a.	0.088	n.a.	n.a.		n.a.	0.202	n.a.		n.a.	n.a.	n.a.	n.a.
	Australia	n.a.	n.a.	0.140	n.a.	n.a.		n.a.	0.378	n.a.		n.a.	n.a.	n.a.	n.a.
	Canada	n.a.	n.a.	n.a.	n.a.	n.a.	0.193	n.a.	0.263	n.a.		n.a.	n.a.	n.a.	n.a.
	China	n.a.	n.a.		n.a.	n.a.		n.a.	3.728	n.a.		n.a.	n.a.	n.a.	n.a.
	Egypt	n.a.	n.a.		n.a.	n.a.		n.a.	0.056	n.a.		n.a.	n.a.	n.a.	n.a.
	EU	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.	0.539	n.a.		n.a.	n.a.	n.a.	n.a.
	India	n.a.	n.a.		n.a.	n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	Japan	n.a.	n.a.		n.a.	n.a.		n.a.	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.
	South Korea	n.a.	n.a.		n.a.	n.a.		n.a.	0.006	n.a.		n.a.	n.a.	n.a.	n.a.
	Mexico	n.a.	n.a.		n.a.	n.a.		n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	New Zealand	n.a.	n.a.		n.a.	n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	Nigeria	n.a.	n.a.		n.a.	n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	U.S.	n.a.	n.a.		n.a.	n.a.	0.107	n.a.	0.568	n.a.	0.605	n.a.	n.a.	n.a.	n.a.
	The Former USSR	n.a.	n.a.		n.a.	n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
Volume of Trade: Over-Quota Import Market	Argentina	n.a.	0.560			0.390				0.076		0.042		2.634	5.026
	Australia	0.356	n.a.			0.638	0.068			0.690		0.070		3.588	5.322
	Canada	0.316	0.589	n.a.		0.725	3.765			0.278		0.044		4.967	8.416
	China				n.a.										
	Egypt					n.a.									
	EU	1.397	1.231	2.069		1.811	n.a.			1.253	0.293	0.090		10.402	17.632
	India							n.a.							
	Japan								n.a.						
	South Korea									n.a.					
	Mexico										n.a.				
	New Zealand		0.086									n.a.			
	Nigeria												n.a.		
	U.S.	1.403	1.314	2.100		1.650	14.264			1.316		0.099		n.a.	15.718
	The Former USSR														n.a.
Import		3.472	3.780	4.397	0.000	5.214	18.397	0.000	5.740	3.613	0.898	0.345	0.000	21.591	52.114
Demand for Domestic Product		0.417	1.005	1.880	110.340	5.314	43.629	53.787	0.684	0.000	4.219	0.168	0.068	12.298	68.608
Total Demand		3.889	4.785	6.277	110.340	10.528	62.026	53.787	6.108	3.613	5.117	0.513	0.068	33.889	120.722
Market Price		78.521	118.140	189.280	118.294	101.469	187.136	162.747	155.856	92.171	124.928	115.111	340.613	99.846	114.233
Shadow Price[a] [illegible]		n.a.	n.a.	105.987	n.a.	n.a.	113.600	n.a.	3.823	n.a.	37.649	n.a.	n.a.	n.a.	n.a.

Country	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Supply to Domestic Market	0.417	1.005	1.880	110.340	5.314	43.629	53.787	0.684	0.000	4.219	0.168	0.068	12.298	68.608
Export	9.018	11.250	19.556	3.728	0.056	36.717	0.000	0.000	0.006	0.000	0.086	0.000	39.144	0.000
Net Export	5.546	7.470	15.159	3.728	-5.158	18.320	0.000	-5.740	-3.607	-0.898	-0.259	0.000	17.553	-52.114
Total Supply	9.435	12.255	21.436	114.068	5.370	80.346	53.787	0.684	0.006	4.219	0.254	0.068	51.442	68.608
Production	9.435	12.255	21.436	114.068	5.370	56.888	53.787	0.684	0.006	4.219	0.254	0.068	52.577	68.608
Shadow Price[b] [illegible]	n.a.	n.a.	14.693	n.a.	n.a.	101.544	n.a.	n.a.	n.a.	0.000	n.a.	n.a.	25.065	n.a.
Shadow Price[c] [illegible]	n.a.	n.a.	n.a.	n.a.	n.a.	39.125	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note: Blank spaces indicate zero.

a. Shadow price on the right to export to the in-quota market.

b. Shadow price for the right to export within the upper limit of subsidized quantity exported.

c. Shadow price on the right to produce within the production quota.

Table 6. Spatial Equilibrium Solution for Scenario 2 (Unit: million metric tons and U.S. dollars per metric ton)

	From / To	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Volume of Trade – In-Quota Import Market	Argentina	n.a.	n.a.	0.104		n.a.		n.a.	0.064	n.a.		n.a.	n.a.	n.a.	n.a.
	Australia	n.a.	n.a.	0.124	1.466	n.a.		n.a.	0.226	n.a.		n.a.	n.a.	n.a.	n.a.
	Canada	n.a.	n.a.	n.a.		n.a.	0.284	n.a.	0.124	n.a.		n.a.	n.a.	n.a.	n.a.
	China	n.a.	n.a.		n.a.	n.a.		n.a.	4.510	n.a.		n.a.	n.a.	n.a.	n.a.
	Egypt	n.a.	n.a.			n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	EU	n.a.	n.a.		4.133	n.a.	n.a.	n.a.	0.401	n.a.		n.a.	n.a.	n.a.	n.a.
	India	n.a.	n.a.			n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	Japan	n.a.	n.a.			n.a.		n.a.	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.
	South Korea	n.a.	n.a.			n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	Mexico	n.a.	n.a.			n.a.		n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	New Zealand	n.a.	n.a.			n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	Nigeria	n.a.	n.a.			n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
	U.S.	n.a.	n.a.		4.038	n.a.	0.017	n.a.	0.416	n.a.	0.605	n.a.	n.a.	n.a.	n.a.
	The Former USSR	n.a.	n.a.			n.a.		n.a.		n.a.		n.a.	n.a.	n.a.	n.a.
Volume of Trade – Over-Quota Import Market	Argentina	n.a.	0.390			0.398				0.094		0.032		2.744	5.164
	Australia	0.322	n.a.			0.598				0.660		0.056		3.402	5.058
	Canada	0.329	0.415	n.a.		0.729	3.801			0.290		0.034		5.044	8.508
	China		1.174		n.a.										
	Egypt					n.a.									
	EU	1.415	1.060	2.104		1.817	n.a.			1.268	0.293	0.079		10.501	17.753
	India							n.a.							
	Japan								n.a.						
	South Korea		0.006							n.a.					
	Mexico										n.a.				
	New Zealand											n.a.			
	Nigeria												n.a.		
	U.S.	1.367	1.110	1.997		1.606	13.960			1.284		0.086		n.a.	15.435
	The Former USSR														n.a.
Import		3.433	4.155	4.329	9.636	5.148	18.062	0.000	5.741	3.596	0.898	0.287	0.000	21.691	51.918
Demand for Domestic Product		0.437	0.802	1.912	102.638	5.374	43.797	53.787	0.684	0.000	4.219	0.236	0.068	12.099	68.686
Total Demand		3.870	4.957	6.241	112.274	10.522	61.859	53.787	6.108	3.596	5.117	0.523	0.068	33.790	120.604
Market Price		79.322	105.655	191.897	94.305	101.801	187.858	162.747	155.856	92.987	124.928	104.976	340.613	100.649	114.994
Shadow Price[a] (Tariff Quota)		n.a.	n.a.	107.498	16.822	n.a.	113.600	n.a.	27.812	n.a.	35.230	n.a.	n.a.	n.a.	n.a.

Country	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Supply to Domestic Market	0.437	0.802	1.912	102.638	5.374	43.797	53.787	0.684	0.000	4.219	0.236	0.068	12.099	68.686
Export	8.990	11.912	19.558	5.684	0.000	40.824	0.000	0.000	0.006	0.000	0.000	0.000	41.921	0.000
Net Export	5.557	7.757	15.229	-3.952	-5.148	22.762	0.000	-5.741	-3.590	-0.898	-0.287	0.000	20.230	-51.918
Total Supply	9.427	12.714	21.470	108.322	5.374	84.621	53.787	0.684	0.006	4.219	0.236	0.068	54.020	68.686
Production	9.427	12.714	21.470	108.322	5.374	98.888	53.787	0.684	0.006	4.219	0.236	0.068	54.020	68.686
Shadow Price[b] ([illegible])	n.a.	n.a.	14.693	n.a.	n.a.	101.544	n.a.	n.a.	n.a.	0.048	n.a.	n.a.	25.965	n.a.
Shadow Price[c] ([illegible])	n.a.	n.a.	n.a.	n.a.	n.a.	49.135	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note: Blank spaces indicate zero.

a. Shadow price for the right to export to the [illegible] market.

b. Shadow price for the right to export [illegible] quantity exported.

c. Shadow price for the right to produce [illegible].

Table 7. Spatial Equilibrium Solution for Scenario 3 (Unit: million metric tons and U.S. dollars per metric ton)

	From / To	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Volume of Trade	Argentina	n.a.	0.090	0.346		0.252	5.384	0.234			0.234	0.012	0.038	2.256	3.654
	Australia	0.250	n.a.	0.390	1.268	0.478	5.714	1.822	0.088	0.342	0.332	0.038	0.044	3.138	3.840
	Canada	0.278	0.154	n.a.		0.620	10.326	1.362	0.011		0.513	0.016	0.061	4.899	7.272
	China		2.554	1.368	n.a.	1.056	4.488		5.626	1.294		0.050			
	Egypt					n.a.									5.164
	EU	1.253	0.731	1.217	3.590	1.558	n.a.	5.241	0.210	0.864	1.030	0.058	0.145	9.748	15.272
	India					4.834	8.266	n.a.							2.236
	Japan								n.a.						
	South Korea									n.a.					
	Mexico			1.787							n.a.				
	New Zealand											n.a.			
	Nigeria												n.a.		
	U.S.	0.977	0.639	1.055	2.664	1.158	16.663	3.584	0.174	0.681	1.005	0.053	0.115	n.a.	11.433
	The Former USSR														n.a.
Import		2.758	4.168	6.163	7.522	9.956	50.841	12.243	6.109	3.181	3.114	0.227	0.403	20.041	48.871
Demand for Domestic Product		0.323	0.527	0.741	103.226	0.000	22.405	44.701	0.185	0.003	1.884	0.274	0.049	9.645	67.429
Total Demand		3.081	4.695	6.904	110.748	9.956	73.246	56.944	6.294	3.184	4.998	0.501	0.452	29.686	116.300
Market Price		114.957	124.577	142.142	113.227	130.985	139.008	123.521	115.795	114.398	133.923	126.356	132.091	133.951	142.111
Shadow Price[a] (Tariff Quota)		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Country	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Supply to Domestic Market	0.323	0.527	0.741	103.226	0.000	22.405	44.701	0.185	0.003	1.884	0.274	0.049	9.645	67.429
Export	12.500	17.744	25.512	16.436	5.164	40.917	15.336	0.000	0.000	1.787	0.000	0.000	40.201	0.000
Net Export	9.742	13.576	19.349	8.914	-4.792	-9.924	3.093	-6.109	-3.181	-1.327	-0.227	-0.403	20.160	-48.871
Total Supply	12.823	18.271	26.253	119.662	5.164	63.322	60.037	0.185	0.003	3.671	0.274	0.049	49.846	67.429
Production	12.823	18.271	26.253	119.662	5.164	63.322	60.037	0.185	0.003	3.671	0.274	0.049	49.846	67.429
Shadow Price[b] (Subsidized Export)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Shadow Price[c] (Production Quota)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note: Blank spaces indicate zero.

a. Shadow price for the right to export to the in-quota market.

b. Shadow price for the right to export within the upper limit of subsidized quantity exported.

c. Shadow price for the right to produce within the production quota.

Table 8. Spatial Equilibrium Solution for Scenario 4 (Unit: million metric tons and U.S. dollars and metric ton)

	From / To	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Volume of Trade	Argentina	n.a.	0.564			0.388			0.136	0.082		0.042		2.672	5.082
	Australia	0.362	n.a.			0.636	0.140		0.274	0.694		0.070		3.618	5.366
	Canada	0.315	0.588	n.a.		0.717	3.966		0.182	0.278		0.044		4.964	8.415
	China				n.a.				1.890						
	Egypt					n.a.									
	EU	1.393	1.229	2.125		1.799	n.a.		0.403	1.249	0.336	0.090		10.380	17.605
	India							n.a.							
	Japan								n.a.						
	South Korea								0.006	n.a.					
	Mexico										n.a.				
	New Zealand		0.086									n.a.			
	Nigeria												n.a.		
	U.S.	1.399	1.312	2.156		1.638	14.344		0.426	1.312	0.478	0.099		n.a.	15.691
	The Former USSR														n.a.
Import		3.469	3.779	4.281	0.000	5.178	18.450	0.000	3.317	3.615	0.814	0.345	0.000	21.634	52.159
Demand for Domestic Product		0.424	1.008	1.938	110.842	5.364	43.602	53.787	0.786	0.000	4.262	0.168	0.068	12.276	68.591
Total Demand		3.893	4.787	6.219	110.842	10.542	62.052	53.787	4.103	3.615	5.076	0.513	0.068	33.910	120.750
Market Price		78.344	117.967	193.492	112.071	100.859	187.021	162.747	590.419	91.990	128.139	114.938	340.613	99.671	114.064
Shadow Price[a] (Tariff Quota)		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Country	Argentina	Australia	Canada	China	Egypt	EU	India	Japan	South Korea	Mexico	New Zealand	Nigeria	U.S.	The Former USSR
Supply to Domestic Market	0.424	1.008	1.938	110.842	5.364	43.602	53.787	0.786	0.000	4.262	0.168	0.068	12.276	68.591
Export	8.966	11.160	19.469	1.890	0.000	36.609	0.000	0.000	0.006	0.000	0.086	0.000	38.855	0.000
Net Export	5.497	7.381	15.188	1.890	-5.178	18.159	0.000	-3.317	-3.609	-0.814	-0.259	0.000	17.221	-52.159
Total Supply	9.390	12.168	21.407	112.732	5.364	80.211	53.787	0.786	0.006	4.262	0.254	0.068	51.131	68.591
Production	9.390	12.168	21.407	112.732	5.364	96.888	53.787	0.786	0.006	4.262	0.254	0.068	52.777	68.591
Shadow Price[b] (Subsidized Export)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Shadow Price[c] (Production Quota)	n.a.	n.a.	n.a.	n.a.	n.a.	49.135	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note. Blank spaces indicate zero.

a. Shadow price for the right to export to the in-quota market.

b. Shadow price for the right to export within the upper limit of subsidized quantity exported.

c. Shadow price for the right to produce within the production quota.

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