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Evaluating International Agricultural Policies using a Dynamic Nonlinear Imperfectly Competitive Spatial Equilibrium Model

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In this paper, a dynamic nonlinear imperfectly competitive spatial equilibrium model is developed to evaluate international and domestic agricultural policies. The objective is to develop a more flexible and comprehensive dynamic policy simulation model to examine imperfectly competitive agricultural trade with various domestic and international support policies. The model is formulated as the nonlinear complementarity problem (NCP) to a dynamic nonlinear imperfectly competitive spatial equilibrium model. In addition to being a dynamic and nonlinear generalization, the model also has the following desirable features. First, free trade agreements (FTAs), such as NAFTA, are explicitly introduced. Second, domestic support policies, such as production subsidies, deficiency payments, and production quotas, are separately introduced. Finally, the model allows for various degrees of imperfectly competitive behavior.

To illustrate its usefulness, the model is applied to international wheat trade under several alternative policy scenarios based on proposals of major countries. The dynamic simulation period for all policy scenarios is from 1999 through 2020. The simulation results are consistent with the actions and strategies of major countries in current WTO negotiations.

INTRODUCTION

Numerous studies have examined the effects of policy changes on international agricultural trade. These studies have relied upon various models to simulate alternative policy impacts, including AGLINK by OECD (1996), DWOPSIM by Roningen (1992) (at USDA), IFPSIM by Ohga and Yanagishima (1995) (at IFPRI), and GTAP models (e.g., Anderson *et al.*, 1997; Rae and Hertel, 2000). These are static and dynamic models for multi–regional and multi–commodity markets. Some of them incorporate aggregated measures for the degree of agricultural support, such as PSE (Producer Subsidy Equivalents) and CSE (Consumer Subsidy Equivalents). However, most of them have not simultaneously incorporated the vast array of trade and domestic support policies such as specific duties, *ad valorem* tariffs, tariff–rate quotas, export subsidies, production subsidies, production quotas, deficiency payments, and consumption taxes. In order to contribute to comprehensive analyses for the on–going World Trade Organization (WTO) agricultural negotiations, it is important to examine detailed policy–by–policy effects of trade and domestic policies simultaneously.

Tariff–rate quotas, in particular, have become one of the most important WTO

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policies, but it has been difficult to incorporate this policy into the simultaneous equation models above because of non–convergence problems. A recent exception is Elbehri and Pearson's inclusion of tariff–rate quotas to GTAP models. Likewise, the existence of state trading enterprises (STEs)[2] has not been considered in the comprehensive models listed above.[3] This is a serious omission because STEs have become one of the most controversial issues in ongoing WTO agricultural negotiations. STEs come in two types: exporting and importing.[4] Exporting STEs implement price discrimination between domestic and export markets as a means to maximize total sales for the country's producers.[5] Another price discrimination technique used by exporting STEs is the exporting of the same quality goods at different prices to different countries in the world market as a means to maximize pooled total revenues from export markets. Although price discrimination of this kind by private export firms is not prohibited, the practice decreases world economic welfare if the discriminated price gap is larger than transportation costs.[6] STEs with the monopoly right for buying and selling domestic products can exercise both of the above price discrimination practices with pooling schemes. However, exporting STEs such as the Australian Wheat Board (AWB)[7] can exercise these practices only among export markets.

Most of the previous models do not account for the impacts of non–tariff barriers in cases where oligopolistic firms, including exporting STEs, practice price discrimination. For example, in GTAP models, domestic and international price gaps net of tariffs are all regarded as non–tariff barriers created by importing countries. The price gaps are then converted to tariff rates and incorporated into models. Because price discrimination by exporting STEs creates domestic and international price gaps, eliminating converted tariff rates means eliminating both the non–tariff barriers and the STE's price discrimination. Therefore, in not counting the impacts of eliminating the STE's price discrimination, previous models may overstate the impacts of eliminating non–tariff barriers.

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[2] State–owned or private enterprises exporting or importing by the single desk are referred to as STEs in this paper ('single desk' denotes the authorized exclusive right for monopoly trading).

[3] Several other models have been developed to measure STEs' effects on world agricultural trade (e.g., Alston and Gray, 2000); Brooks and Schmitz, 1999; Carter *et al.*, 1979; Fulton *et al.*, 1999; Schmitz and Gray, 2000; and Suzuki and Kaiser, 2000). However, some of these models incorporated only price discrimination between domestic and export sales, while some incorporated only price discrimination among different export markets. Most models have only two regions: one country and the rest of world.

[4] Examples of exporting STEs include the Canadian Dairy Commission (CDC), the Canadian Wheat Board (CWB), the Australian Dairy Corporation (ADC), the Australian Wheat Board (AWB), and the New Zealand Dairy Board (NZDB). Examples of importing STEs include the Japanese Food Agency, the China National Cereals, Oils & Foodstuffs Import & Export Corporation (called COFCO), and the Indian Food Corporation (called FCI).

[5] When domestic prices are higher than export prices, and pooled revenues are distributed to farmers, the system is equivalent to an export subsidy.

[6] Regulation of price discriminative practices by private firms should be discussed as a harmonization problem of an international competition policy, because such practices will offset the effects of ruling STEs' price discrimination. Thus, the STE problem is closely related to the creation of an international competition policy.

[7] The AWB is no longer a monopoly buyer in the domestic market. Since deregulation occurred in 1997, Australian producers can sell their products to domestic buyers other than the AWB.

A generalized spatial equilibrium model can overcome such problem. Spatial equilibrium models based on Takayama and Judge (1971) have been successfully applied to policy simulations (e.g., Judge and Takayama, 1973; Cox *et al.*, 1999; Zhu *et al.*, 1999), however, a drawback is the difficulty in handling *ad valorem* tariffs, because they are formulated as quadratic programming problems. Shono and Kawaguchi (1999) introduced *ad valorem* tariffs, as well as other trade policies such as tariff–rate quotas, by formulating their model as a linear complementarity problem (LCP). STEs can be incorporated into spatial equilibrium models using the "dual–structure" imperfectly competitive spatial equilibrium model proposed by Kawaguchi *et al.* (1997).[8]

Spatial equilibrium models can resolve many of the difficulties of introducing transportation costs, various tariffs, STEs, and other specific policies into the analysis. However, a major drawback of previous spatial equilibrium models is their static nature. The objective of the research reported here is to develop a more flexible and comprehensive dynamic policy simulation model to examine imperfectly competitive agricultural trade with various trade and domestic support policies. The model is formulated as the nonlinear complementarity problem (NCP) to a dynamic nonlinear imperfectly competitive spatial equilibrium model. The model also has the following desirable features. First, free trade agreements (FTAs), such as NAFTA, are explicitly introduced. Second, domestic support policies, such as production subsidies, deficiency payments, and production quotas, are separately introduced. Third, the model allows for various degrees of imperfectly competitive behavior (details are described below).[9] To illustrate its usefulness, the model is applied to international wheat trade under several alternative policy scenarios based on various proposals of major countries.

THE MODEL

Producers in country i are assumed to produce wheat at period t, with production subsidies, production quotas, and deficiency payments, in the following manner. Given the expected producer price, expected per unit production subsidy, and expected yield, producers choose the optimal acreage so as to maximize their economic profit at period t. In cases where the expected price is lower than the target price, the expected producer price becomes the target price. It is assumed that producers try to adjust their acreage toward the optimal level from the previous–period level, but that they cannot realize the optimal acreage within one period. With production quotas, acreage is constrained not to exceed the upper limit. Wheat production in country i at period t is given by the total acreage multiplied by the *ex post* yield reflecting weather conditions at period t.

Ordinal middlemen (other than STEs) in country i buy wheat from producers and sell it to domestic and foreign markets at period t. They maximize their profit — defined as sales revenue plus export subsidies, minus raw product price, transportation costs, and tariffs — under constraints on total supply, tariff–rate quotas, and export quotas for

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[8] Kawaguchi, *et al's* model is similar to Nelson and McCarl (1984); Chen *et al.* (2003).

[9] Kolstad and Burris (1986) introduced imperfect competition using a spatial equilibrium model of the wheat market. Other papers with imperfect competition in the wheat market include: Alaouze *et al.* (1978); Carter and Schmitz (1979); McCalla (1966); Thursby and Thursby (1990).

export subsidies. The middlemen are assumed to buy wheat as price–takers and sell wheat as Cournot players (and price–takers in some cases).

In cases where there is an exporting STE in country k, a consignment seller, rather than ordinal middlemen, collects wheat from producers in country k and sells it to domestic and foreign markets so as to maximize total sales revenues at period t. The difference between an STE and ordinal middlemen is that raw material costs are not subtracted from STE's sales revenue, and the STE's sales revenue is allocated to producers through pooled prices. The pooled price at period t forms the expected producer price in country k at period $t+1$.

The producer price in country i at period t is determined so as to equalize producers' supply to the demand by middlemen. The producer price at period t forms the expected producer price in country i at period $t+1$. The market price in country j at period t is determined so as to equalize consumers' demand to total supply to country j. The above process is iterated at period $t+1$ as well, which forms a dynamic adjustment process of international wheat trade. We call the equilibrium at each period a "temporary spatial equilibrium," referring to temporary equilibrium theory (see Hicks, 1939, 1946; Morishima, 1996).

The model uses the following notations. Consider international wheat trade among n ($n \geq 2$) countries. In the model, i stands for a country with ordinal middlemen and k for one with an exporting STE, and therefore $i+k=n$.

$A^*_{i,t}$: optimal acreage in country i at period t;
$A_{i,t}$: actually planted acreage in country i at period t;
$A_{i,t}=F_i(A^*_{i,t}, A_{i,t-1})$: acreage adjustment function in country i;
$\overline{A_{i,t}}$: upper limit of acreage in country i at period t;
$Y_{i,t}$: quantity produced in country i at period t;
$W^e_{i,t}$: expected producer price in country i at period t;
$PS^*_{i,t}$: expected unit production subsidy in country i at period t;
$YY^e_{i,t}$: expected yield in country i at period t;
$YY_{i,t}$: *ex post* yield in country i at period t;
$C_{i,t}=C_i(A^*_{i,t})$: cost function in country i;
$N^d_{i,t}$: number of middlemen for domestic sales in country i at period t;
$N^a_{i,t}$: number of middlemen for export sales in country i at period t;
$X^d_{ij,t}$: quantity supplied to domestic market in country i at period t ($i=j$);
$X^p_{ij,t}$: quantity exported from country i to in–quota market in country j at period t ($i \neq j$);
$X^{ep}_{ij,t}$: quantity exported with export subsidy from country i to in–quota market in country j at period t ($i \neq j$);
$X^s_{ij,t}$: quantity exported from country i to over–quota market in country j at period t ($i \neq j$);
$X^{es}_{ij,t}$: quantity exported with export subsidy from country i to over–quota market in country j at period t ($i \neq j$);
$X^f_{i,t}$: raw product demand in country i at period t;
$ST^p_{j,t}$: in–quota specific duty rate in country j at period t;
$ST^s_{j,t}$: over–quota specific duty rate in country j at period t;
$AT^p_{j,t}$: in–quota *ad valorem* tariff rate in country j at period t;

$\underline{AT^{s}_{j,t}}$: over–quota *ad valorem* tariff rate in country j at period t;
$\overline{X^{p}_{j,t}}$: tariff–rate quota in country j at period t;
$\underline{ES_{i,t}}$: unit export subsidy in country i at period t;
$\overline{X^{ea}_{i,t}}$: upper limit of subsidized quantity exported in country i at period t;
$P_{j,t}$: market price in country j at period t;
$D_{j,t}=D_J(P_{j,t})$: demand function in country j;
$W_{i,t}$: producer price in country i at period t;
$TC^{d}_{ij,t}$: unit transportation cost inside country i at period t ($i=j$);
$TC^{a}_{ij,t}$: unit transportation cost from country i to j at period t ($i\neq j$);
$CT_{j,t}$: (*ad valorem*) consumption tax rate in country j at period t;

Using the above notation, several conditions can be derived. First, the following equilibrium conditions apply to producers in country i or k at period t (for country k, subscript i should be replaced with k in the following four equations). Optimal acreage is:

$$W^{e}_{i,t}YY^{e}_{i,t}+PS^{*}_{i,t}=\frac{dC_i}{dA^{*}_{it}} \tag{1}$$

The partial adjustment in acreage is:

$$A_{i,t}=F_i(A^{*}_{i,t},A_{i,t-1}) \tag{2}$$

An upper limit on acreage is imposed, represented by the following equation:

$$A_{i,t}=\overline{A_{i,t}} \tag{3}$$

Finally, *ex post* production is defined by the *ex post* yield multiplied by acreage, i.e.:

$$Y_{i,t}=YY_{i,t}A_{i,t} \tag{4}$$

The various equilibrium conditions for the middleman in country i at period t include the following set of equations. First, domestic supply is:

$$Z^{d}_{ij,t}=P_{j,t}+\frac{dP_{j,t}}{dD_j}\left(\frac{X^{d}_{ij,t}}{N^{d}_{i,t}}+\frac{X^{p}_{ij,t}+X^{s}_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-TC^{d}_{ij,t}-\alpha_{i,t}\leq 0,$$
$$X^{d}_{ij,t}\geq 0,\ X^{d}_{ij,t}Z^{d}_{ij,t}=0 \tag{5}$$

Quantity exported without export subsidy to an in–quota market in country j is represented by:

$$Z^{d}_{ij,t}=P_{j,t}+\frac{dP_{j,t}}{dD_j}\left(\frac{X^{d}_{ij}}{N^{d}_{i,t}}+\frac{X^{p}_{ij,t}+X^{s}_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-TC^{a}_{ij,t}-ST^{p}_{ij,t}$$
$$-AT^{p}_{ij,t}\left(P_{j,t}+\frac{dP_{j,i}}{dD_j}\ \frac{X^{p}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-\alpha_{i,t}-\beta_{ij,t}\leq 0,\ X^{d}_{ij,t}\geq 0,\ X^{p}_{ij,t}Z^{p}_{ij,t}=0 \tag{6}$$

Quantity exported without export subsidy to an over–quota market in country j is defined as:

$$Z^{s}_{ij,t}=P_{j,t}+\frac{dP_{j,t}}{dD_j}\left(\frac{X^{d}_{ij}}{N^{d}_{i,t}}+\frac{X^{p}_{ij,t}+X^{s}_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-TC^{a}_{ij,t}-ST^{s}_{ij,t}$$

$$-AT^{s}_{ij,t}\left(P_{j,t}+\frac{dP_{j,t}}{dD_j}\ \frac{X^{s}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-\alpha_{i,t}\leq 0,\ X^{s}_{ij,t}\geq 0,\ X^{s}_{ij,t}Z^{s}_{ij,t}=0 \tag{7}$$

Quantity exported with export subsidy to an in–quota market in country j is:

$$Z^{ep}_{ij,t}=P_{j,t}+\frac{dP_{j,t}}{dD_j}\left(\frac{X^{d}_{ij}}{N^{d}_{i,t}}+\frac{X^{p}_{ij,t}+X^{s}_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-TC^{a}_{ij,t}-ST^{p}_{ij,t}$$

$$-AT^{p}_{ij,t}\left(P_{j,t}+\frac{dP_{j,i}}{dD_j}\ \frac{X^{p}_{ij,t}+X^{ep}_{ij,t}}{N^{a}_{i,t}}\right)+ES_{j,t}-\alpha_{i,t}-\beta_{ij,t}-\gamma_{i,t}\leq 0,$$

$$X^{ep}_{ij,t}\geq 0,\ X^{ep}_{ij,t}Z^{ep}_{ij,t}=0 \tag{8}$$

Quantity exported with export subsidy to an over–quota market in country j is:

$$Z^{es}_{ij,t}=P_{j,t}+\frac{dP_{j,t}}{dD_j}\left(\frac{X^{d}_{ij}}{N^{d}_{i,t}}+\frac{X^{p}_{ij,t}+X^{s}_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t}}{N^{a}_{i,t}}\right)-TC^{a}_{ij,t}-ST^{s}_{ij,t}$$

$$-AT^{s}_{ij,t}\left(P_{j,t}+\frac{dP_{j,i}}{dD_j}\ \frac{X^{s}_{ij,t}+X^{s}_{ij,t}}{N^{a}_{i,t}}\right)+ES_{i,t}-\alpha_{i,t}-\gamma_{i,t}\leq 0, X^{ep}_{ij,t}\geq 0,\ X^{ep}_{ij}Z^{ep}_{ij,t}=0 \tag{9}$$

The raw product demand function is given by:

$$Z^{f}_{j,t}=-W_{i,t}+\alpha_{i,t}\leq 0,\ X^{f}_{i,t}\geq 0,\ X^{f}_{i,t}Z^{f}_{i,t}=0 \tag{10}$$

Several equations restrict the selling limit for exporters. The selling limit on total production is:

$$Z^{a}_{i,t}=X^{f}_{i,t}-\sum_{j=1}^{n}(X^{d}_{ij,t}+X^{p}_{ij,t}+X^{s}_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t})\geq 0,\ \alpha_{i,t}\geq 0,\ \ \alpha_{i,t}Z^{a}_{i,t}=0 \tag{11}$$

The selling limit by tariff–rate quotas in country j is:

$$Z^{\beta}_{j,t}=\overline{X^{p}_{j,t}}-\sum_{j}(X^{p}_{ij,t}+X^{ep}_{ij,t})-\sum_{k}(X^{p}_{kj,t}+X^{ep}_{kj,t})\geq 0,\ \beta_{j,t}\geq 0,\ \ \beta_{j,t}Z^{\beta}_{ij,t}=0,\ (j=1,2,\ldots,n) \tag{12}$$

The selling limit by export quotas with subsidies is:

$$Z^{\gamma}_{i,t}=\overline{X^{ea}_{i,t}}-\sum_{j=1}^{n}(X^{ep}_{ij,t}+X^{es}_{ij,t})\geq 0,\ \gamma_{i,t}\geq 0,\ \ \gamma_{i,t}Z^{\gamma}_{i,t}=0 \tag{13}$$

Values for $TC^{d}_{ij,t}$ $(i\neq j)$ and $TC^{a}_{ij,t}$ are set at extremely large numbers in order that $X^{d}_{ij,t}$ $(i\neq j)$, $X^{p}_{ii,t}$, $X^{ep}_{ii,t}$, $X^{s}_{ii,t}$, and $X^{es}_{ii,t}$ be zero. In the case where country j does not have the tariff–rate quota system, values for $ST^{p}_{ij,t}$, $AT^{p}_{ij,t}$, and $\overline{X^{p}_{j,t}}$ are zero, and over–quota tariff rates, $ST^{s}_{ij,t}$ and $AT^{s}_{ij,t}$, are applied to all imports to the country. When country j belongs to any FTA(s), country j's tariffs imposed on member countries are different from those imposed on non–member countries. The term, $\{p_{i,t}+(dP_{i,t}/dD_j)(\cdot)\}$, indicates marginal revenue "perceived" by country i's middleman in county j's market and it is equal to $p_{i,t}$ when the middleman is a price–taker.

The parameters, $\alpha_{i,t}$, $\beta_{i,t}$, and $\gamma_{i,t}$ are the Lagrange multipliers. $\alpha_{i,t}$ is the producer price, and $\beta_{i,t}$ 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, middlemen in all countries face the same shadow price for this right in country j. $\gamma_{i,t}$ is the shadow price for the right to export within the upper limit of subsidized quantity exported.

Equilibrium Conditions for the exporting STE in country *k* at period *t*

For exporting STEs, subscript i is replaced with k in the above conditions (5) through (13) after excluding condition (10). In this case, the Lagrange multiplier, $\alpha_{i,t}$, represents the opportunity costs for the STE to increase its marginal unit of domestic supply or exports. In addition, the following conditions are included.

The equilibrium condition in the producer market in country i at period t is:

$$X^T_{i,t} \leq Y_{i,t},\ W_{i,t} \geq 0,\ W_{i,t}\,(Y_{i,t}-X^T_{i,t})=0 \tag{14}$$

The pooled price in country k at period t is:

$$PR_{k,t}=\frac{\pi_{k,t}}{\sum_j (X^d_{kj,t}+X^p_{kj,t}+X^s_{kj,t}+X^{ep}_{kj,t}+X^{es}_{kj,t})}, \tag{15}$$

where $\pi_{k,t}$ is the profit realized by the exporting STE in country k at period t.

The equilibrium condition in the consumer market for country j at period t is given by:

$$\begin{aligned} &D_j\{P_{j,t}(1+CT_{j,t})\} \leq \sum_i (X^d_{ij,t}+X^p_{ij,t}+X^s_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t})+\sum_k (X^d_{kj,t}+X^p_{kj,t}+X^s_{kj,t}+X^{ep}_{kj,t} \\ &\qquad +X^{es}_{kj,t}),\ P_{j,t} \geq 0, \\ &P_{j,t}[\sum_i (X^d_{ij,t}+X^p_{ij,t}+X^s_{ij,t}+X^{ep}_{ij,t}+X^{es}_{ij,t})+\sum_k (X^d_{kj,t}+X^p_{kj,t}+X^s_{kj,t}+X^{ep}_{kj,t}+X^{es}_{kj,t}) \\ &\qquad -D_j\{P_{j,t}(1+CT_{j,t})\}]=0 \end{aligned} \tag{16}$$

With values for $Y_{i,t}$ and $Y_{k,t}$ determined by conditions (1) through (4) taken as given, a Nash equilibrium solution where conditions (5) through (14) and condition (16) are simultaneously satisfied is a temporary spatial equilibrium solution at period t. The temporary spatial equilibrium model including conditions (5) through (14) and condition (16) is formulated as a NCP (Harker and Pang, 1990; Ferris and Pang, 1997; Ferris and Kanzow, 1998).

DATA

Five major exporting countries and areas (United States, Canada, European Union, Australia and Argentina), accounting for 85 percent of total exports in the international wheat market, are included in the model. Middlemen or exporting STEs (CWB in Canada and AWB in Australia) in these countries and areas are assumed to behave as Cournot players. In addition, nine major importing countries and areas (Egypt, Brazil, Japan, South Korea, Indonesia, Mexico, the Philippines, New Zealand, and the former Soviet Union) and two major consuming countries (China and India) are included in the model. Middlemen in these 11 countries are assumed to behave as price–taking suppliers, except for the former Soviet Union (FSU), which includes 15 countries. Middlemen in the FSU are assumed to behave as Cournot players because the FSU imports a significant amount of wheat from outside the FSU and exports a lot of wheat to outside the FSU.

There are wheat importing STEs in some of the above countries, such as the Japanese Food Agency, Tajikistan Ministry of Grain Products, Uzmarkazimpex for Uzkhleboproduckt, the China National Cereals, Oils & Foodstuffs Import & Export Corporation (called COFCO), and the Indian Food Corporation (called FCI). Some of these impose mark–ups on imports within tariff–rate quotas. The WTO has ruled that the mark–ups imposed by importing STEs are equivalent to tariffs, which are already regulated under the agreements, and these can be incorporated just like ordinal tariffs and tariff–rate quotas. Therefore, there is no need for special treatment of these importing STEs in the model and we focus on the two wheat exporting STEs, CWB and AWB.

Table 1 shows domestic trade and support policies for wheat in each country. Tariff rates and tariff quotas represent levels in 2001 (World Tariff, 2000; Dohlman and Hoffman, 2000; China's Department of Agriculture, 2001; WTO, Secretariat, 2000).[10] Russia's figures are used for the FSU. The actual subsidized quantity exported in 1998 is used for the upper limit of subsidized export volume (WTO, 2000; Dohlman and Hoffman, 2000), and unit export subsidies are calculated by dividing the subsidized export value by the subsidized export volume in 1998. Specific duty rates and export subsidies are converted into U.S. dollars by using exchange rates at the end of 1998 (UN, 2000; Bank of Japan, 1997). The WTO agreements require countries to reduce the total Aggregate Measure of Support (AMS) (as opposed to the commodity–specific AMS), but because the focus here is on wheat trade we use the effective unit production subsidies for wheat in 1997 (calculated by GTAP, 2001, converted into U.S. dollars). Target prices for deficiency payments (converted into U.S. dollars) are set at the intervention price in the European Union, the government–purchase price in Japan, the administrated price in Mexico, and the loan rate in the United States. The acreage actually planted in 1998 is used as a proxy for the volume of production quotas for EU. The food consumption tax rate in 2001 is used in each country and area.

Table 2 shows the data used for specifying the demand functions, and the estimated results. Per capita demand functions are specified in a double–log form. Multiplying the per capita demand functions by population yields the aggregate wheat demand function

[10] Processed wheat products such as flour, converted into raw wheat equivalents, are included as wheat in this analysis.

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

Country or Area	Trade Policies: In–Quota Import Markets: Specific Duty ($/*ton*)	*Ad Valorem* Tariff (%)	Tariff–Rate Quotas (Million *ton*)	Over–Quota Markets: Specific Duty ($/*ton*)	*Ad Valorem* Tariff (%)	Unit Export Subsidy ($/*ton*)	Volume Limit of Subsidized Exports (Million *ton*)	Domestic Support Policies: Unit Production Subsidy ($/*ha*)	Production Quotas (Million *ha*)	Target Price ($/*ton*)	Consumption Tax for Food (%)
ARG	n.a.	n.a.	n.a.	0.000	12.500	0.000	0.000	0.000	n.a.	n.a.	21.000
AUS	n.a.	n.a.	n.a.	0.000	0.000	0.000	0.000	4.261	n.a.	n.a.	0.000
BRA	n.a.	n.a.	n.a.	0.000	12.500	0.000	0.000	16.505	n.a.	n.a.	17.000
CAN	1.280	0.000	0.350	0.000	76.500	0.000	0.000	1.660	n.a.	n.a.	0.000
CHN	0.000	1.000	9.636	0.000	114.000	0.000	0.000	−7.267	n.a.	n.a.	17.000
EGY	n.a.	n.a.	n.a.	0.000	1.000	0.000	0.000	−0.033	n.a.	n.a.	0.000
EU	0.000	0.000	0.300	101.215	0.000	42.678	14.017	5.842	17.251	126.785	9.800
IND	n.a.	n.a.	n.a.	0.000	50.000	0.000	0.000	25.128	n.a.	n.a.	0.000
IDN	n.a.	n.a.	n.a.	0.000	0.000	0.000	0.000	n.a.	n.a.	n.a.	10.000
JPN	0.000	0.000	5.740	74.863	0.000	0.000	0.000	1.302	n.a.	1140.522	5.000
KOR	n.a.	n.a.	n.a.	0.000	2.160	0.000	0.000	0.000	n.a.	n.a.	10.000
MEX	n.a.	n.a.	n.a.	0.000	67.000	6.687	0.224	0.004	n.a.	150.120	0.000
NZL	n.a.	n.a.	n.a.	0.000	0.000	0.000	0.000	−0.071	n.a.	n.a.	12.500
PHL	n.a.	n.a.	n.a.	0.000	3.000	0.000	0.000	n.a.	n.a.	n.a.	10.000
USA	n.a.	n.a.	n.a.	3.500	0.000	0.000	0.000	30.596	n.a.	94.800	6.600
FSU	n.a.	n.a.	n.a.	0.000	5.000	0.000	0.000	0.056	n.a.	n.a.	10.000

Notes. ARG: Argentina, AUS: Australia, BRA: Brazil, CAN: Canada, CHN: China, EGY: Egypt, EU: European Union, IND: India, IDN: Indonesia, JPN: Japan, KOR: Korea, MEX: Mexico, NZL: New Zealand, PHL: Philippines, USA: United States, and FSU: Former Soviet Union. With NAFTA, the United States and Canada impose no tariffs on member countries, and Mexico imposes only three percent tariffs on the United States and Canada.

Sources.; World Tariff (2000); Dohlman and Hoffman (2000); China's Department of Agriculture (2001). Tariff Quotas from WTO (2000);

Tariff Rates from World Tariff (2000); Dohlman and Hoffman (2000). Export Subsidies from WTO, Secretariat (2000); Dohlman and Hoffman (2000). Production Subsidies from GTAP (2001).

Production Quotas from FAO (2001). Consumption Taxes from World Tariff (2000); Embassies; MOF in Japan. Target Prices from OECD (2000). Exchange Rates from United Nations (2000); Bank of Japan (1997).

Table 2. Data for Demand Functions and Estimated Results

Country or Area	Population (Million People)	Per Capita Demand (*ton*)	Market Price (*$/ton*)	Per Capita Income (1,000$)	Price Elasticity	Income Elasticity	Estimated Constant
ARG	36.123	0.150	126.606	8.365	−0.320	−0.050	0.833
AUS	18.725	0.204	145.639	19.312	−0.240	−0.200	1.216
BRA	166.077	0.053	145.329	4.623	−0.460	0.400	0.303
CAN	30.221	0.269	159.002	20.396	−0.200	−0.200	1.356
CHN	1260.948	0.092	187.577	0.762	−0.100	0.300	0.171
EGY	65.505	0.187	105.499	1.324	−0.200	0.100	0.462
EU	375.570	0.227	142.364	22.704	−0.270	−0.300	2.265
IND	976.365	0.066	232.692	0.431	−0.300	0.500	0.518
IDN	206.427	0.017	183.205	0.467	−1.100	0.000	5.754
JPN	126.511	0.050	190.056	31.255	−0.100	−0.200	0.168
KOR	46.059	0.094	144.361	6.901	−0.400	0.300	0.398
MEX	95.822	0.058	142.218	4.237	−0.300	0.400	0.143
NZL	3.716	0.119	193.336	14.671	−0.220	−0.200	0.666
PHL	72.722	0.026	159.166	0.886	−0.300	0.500	0.131
USA	277.552	0.134	138.165	32.445	−0.350	−0.300	2.181
FSU	292.144	0.234	167.758	1.420	−0.250	−0.300	0.957

Sources. FAO (2001); Ohga and Yanagishima (1995); UN (2000).

for each country and area. Per capita demand is domestic supply (including imports from abroad) divided by population in each country and area. The FOB price is calculated by dividing the export value by export quantity in 1998, and is used as a proxy for the market price for the five net–exporting countries and areas. The CIF price is calculated by dividing the import value by import quantity in 1998, and the CIF price plus tariffs is used as a proxy for the market price for the other 11 net–importing countries and areas. Per capita income is per capita GDP in each country and area in 1998. Per capita demand functions are calculated using these data and price and income elasticities for per capita wheat demand for human uses estimated by Roningen, Sullivan and Dixit (1991) for the SWOPSIM model and Ohga and Yanagishima (1995) for the IFPSIM model.

Grain is usually transported by ship. The main type of ship used is the bulk carrier (called the Panamax type), and supply and demand 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(s)[11] in each country and area and the shortest route usually taken by merchant ships are 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 freight cost information for grains shipped between the U.S. Gulf Coast and Japan by Panamax bulk carrier (US$22.4 on average from 1994 to 1999, by Clarkson, 2000). Multiplying the calculated freight cost per metric ton and per nautical

[11] Since the United States, Canada, Australia, and Mexico each border two oceans, two ports for each country are used.

mile by the distance of each route provides the unit transportation costs among the countries and areas. Note that the unit transportation cost inside each country and area is assumed to be zero.

CALIBRATION OF THE TEMPORARY SPATIAL EQUILIBRIUM MODEL

The temporary spatial equilibrium model formulated as a NCP is solved using the Pathsearch Damped Newton method proposed for solving a more general Mixed Complementarity Problem (MCP) including NCP (see Ralph, 1994 and Dirkse and Ferris, 1996 for details). With production taken as given, a temporary spatial equilibrium in 1998 is solved with the following conditions to calibrate the model. First, trade volume of each country and area and change in stock in the country or area are fixed at 1998 levels. Second, the number of middlemen (including exporting STEs) for domestic and export sales in the United States, Canada, Australia, EU, Argentina, FSU, which are assumed to behave as Cournot players, is adjusted so as to make the solved market prices as close as possible to the actual levels in 1998. The adjusted number of middlemen for export sales is 4, 1, 1, 1, 10, and 3, respectively, for these countries. The number for domestic sales is 10, 6, 18, ∞, ∞, and 3, respectively (∞ being equivalent to a price taker).

As shown in Table 3, the temporary spatial equilibrium solution indicates that the

Table 3. The Temporary Spatial Equilibrium Solution in 1998
(Estimated Consumption, Net exports and Market Prices Compared to Observations)

Country or Area	Consumption		Net exports		Consumption	
	Observation	Estimation	Observation	Estimation	Observation	Estimation
ARG	5.408	5.416	11.094	11.085	126.606	126.050
AUS	3.811	3.812	15.554	15.553	145.639	145.352
BRA	8.757	8.481	-6.887	-6.611	145.329	155.290
CAN	8.135	8.135	17.730	17.730	159.002	159.061
CHN	115.944	117.950	-2.206	-4.212	187.577	157.633
EGY	12.263	11.341	-7.410	-6.488	105.499	155.698
EU	85.210	82.188	11.377	14.398	142.364	162.811
IND	64.712	66.855	-1.804	-3.946	232.692	209.005
IDN	3.467	4.931	-3.467	-4.931	183.205	133.015
JPN	6.276	6.321	-5.555	-5.600	190.056	180.090
KOR	4.310	4.108	-4.682	-4.480	144.361	162.837
MEX	5.519	5.368	-2.284	-2.133	142.218	155.840
NZL	0.443	0.468	-0.186	-0.211	193.336	150.537
PHL	1.901	1.879	-1.901	-1.879	159.166	166.455
USA	37.143	37.056	25.224	25.312	138.165	139.025
FSU	68.307	68.410	0.728	0.625	167.758	166.505

[12] Because the existence and uniqueness of an equilibrium solution for NCP can be proven theoretically only with very strong assumptions, it is usually proven numerically using the merit function (Fukushima, 1996). In our case, the uniqueness of solution was proven by solving the model one thousand times with widely-ranged starting values for endogenous variables.

model with the above conditions can trace the actual observations on consumption, net exports, and market prices in 1998 well.[12]

DYNAMIC SIMULATION FOR POLICY EVALUATION

For the dynamic simulation, supply functions are added to the model. As with the demand functions, price elasticities for planted acreage and the adjustment coefficients used by the SWOPSIM and IFPSIM models are applied to our model. As in the SWOPSIM and IFPSIM models, in our model the acreage response function is multiplied by yield to obtain supply in each country and area. The expected acreage is determined in response to the prior year's producer price, and is specified using a double–log functional form as:

$$\ln A^{*}_{i,t} = a^{s}_{i} + b^{s}_{i} \ln \left(W_{i,t-1} + \frac{PS_{i,t-1}}{YY^{e}_{i,t}} \right) \quad (17)$$

In addition, we use the following Nerlove–type adjustment function:

$$\ln A_{i,t} - \ln A_{t-1} = c^{S}_{i} (\ln A^{*}_{i,t} - \ln A_{i,t-1}), \quad (18)$$

where a^{S}_{i}, b^{S}_{i}, and c^{S}_{i} are parameters, b^{S}_{i} is the price elasticity of the expected acreage, and c^{S}_{i} is the adjustment coefficient.

Table 4 shows the data used for specifying the acreage response functions and the

Table 4. Data for Acreage Response Functions and Estimated Results

Country or Area	1998 Acreage (*ha*)	1997 creage (*ha*)	1997 Producer Price (*$/ton*)	93–97 Average Yield (*ton/ha*)	1997 Productio n Subsidy (*$/ha*)	Price Elasticity of Acreage	Adjustment Coefficient	Estimated Constant
ARG	5.472	5.783	154.592	2.195	0.000	0.600	0.200	−1.546
AUS	11.543	12.338	137.642	1.769	4.261	0.900	0.200	−1.669
BRA	1.409	1.522	226.210	1.610	16.505	0.380	0.200	−2.042
CAN	10.680	10.367	141.786	2.227	1.660	0.500	0.200	−0.260
CHN	29.775	30.057	203.784	3.665	−7.267	0.150	0.200	2.560
EGY	1.017	1.045	121.218	5.392	−0.033	0.300	0.200	−1.528
EU	17.251	17.320	167.724	5.467	5.842	0.500	0.200	0.268
IND	26.696	25.887	269.330	2.485	25.128	0.450	0.200	0.873
IDN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
JPN	0.162	0.169	1,140.522	3.356	1.302	0.520	0.200	−5.280
KOR	0.001	0.002	182.525	3.764	0.000	0.450	0.200	−10.104
MEX	0.769	0.772	186.423	4.205	0.004	0.550	0.200	−3.156
NZL	0.049	0.056	244.883	5.544	−0.071	0.800	0.200	−7.992
PHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
USA	23.878	21.781	105.346	2.520	30.596	0.600	0.200	−0.146
FSU	39.427	39.170	84.251	1.587	0.056	0.230	0.200	2.622

Sources. FAO (2001); GTAP (2001); Ohga and Yanagishima (1995).
Notes. Japan's producer price in 1997 is the government–purchase price in 1998. Producer prices for the United States, Canada, Australia, and FSU are "temporary spatial equilibrium" prices in 1998.

estimated values for a_i^s, with the assumption that the expected yield is equal to the mean of the previous five years (1993 to 1997). In countries and areas where middlemen are price takers, producer prices are equal to market prices (calculated as FOB and CIF prices for demand functions). Based on the adjusted number of middlemen for domestic sales used for the United States, Canada, Australia, and FSU (10, 6, 18, and 3, respectively), producer prices and pooled prices should be below market prices, due to some degree of imperfect competition in these four countries and areas. For these countries, the producer and pooled prices estimated by the above 1998 temporary spatial equilibrium solution are used. The estimated producer prices for the United States and FSU are 105.3 and 84.3 dollars per ton, respectively, and the estimated pooled prices for Canada and Australia are 141.8 and 137.6, respectively.

The following assumptions are used for the dynamic simulation to isolate the impacts of the policy changes:

a. There is no change in market structure or adjusted number of middlemen for export and domestic sales.
b. There is no change in unit transportation cost, population, and per capita income.
c. Expected producer prices are equal to the actual producer and pooled prices in the previous year.
d. There are no fluctuations in yield, i.e., expected yield is constant.
e. There are no changes in the difference between beginning and ending stocks.
f. There is no change in trade volume between each country in our model and the other countries.

Scenarios

With 1998 as the base year, the following eight scenarios are simulated to examine policy–by–policy effects separately in detail. All policy changes are made in 1999, and the values for endogenous variables are dynamically simulated until 2020.

Scenario 1: The current trade and domestic support policies, as well as STE–related policies, remain unchanged.

Scenario 2: Tariff–rate quotas are expanded by 100 percent from current levels for all counties and areas within the system (Canada, China, EU, and Japan).

Scenario 3: All tariff rates are reduced by 90 percent from current levels, except for in–quota tariffs of countries with tariff–rate quotas.

Scenario 4: Export subsidies are reduced by 100 percent from current levels for countries within the system (EU and Mexico).

Scenario 5: Production subsidies are reduced by 100 percent from current levels for all countries within the system.

Scenario 6: Target prices for deficiency payments are reduced by 20 percent from current levels for countries within the system (EU, Japan, Mexico, and United States).

Scenario 7: The CWB becomes a price taker for domestic sales.

Scenario 8: The CWB and AWB become price takers for all occasions.

Scenarios 7 and 8 are added for examining the effects of exporting STEs, which is particularly relevant for the CWB in Scenario 7 because it still has market power for both domestic and export sales, while the AWB currently has market power only for export sales.

Results

The results of the base scenario (Scenario 1) are summarized in Table 5, and they include several notable findings. First, equilibrium quantities for world trade would decrease by 5 percent from 1998 to 2020, and the world wheat market would become tighter, especially in developing countries such as Argentina, Brazil, Indonesia, and Mexico. The decrease in equilibrium quantity is accompanied by an increase in international prices due to China's entry into the WTO. It is important to note that the tightness of the wheat market may in reality be even more severe than these results suggest, because our simulation assumes no increase in population.

Second, among net exporting countries — the United States, Canada, Australia, EU, and Argentina — only Australia and EU would increase net exports (by 74.8% and 25.6%, respectively) from 1998 to 2020. The United States, Canada, and Argentina would decrease net exports. By 2020, net exports of the United States and Argentina fall to one–half of their 1998 levels. Thus, in the case where current trade and domestic policies remain unchanged in the future, the current largest net exporter, United States, would suffer serious erosion of market share to Australia and the EU. This suggests that the current reduction levels in tariffs and subsidies are more advantageous to the EU and Australia.

Third, among net–importing countries, China, New Zealand, and Japan would increase net imports. China would become the world's largest net importer. On the other hand, other net importers would experience a decrease in net imports by 21.5%, on average, from 1998 to 2020. Net imports of Mexico fall to 50 percent of their 1998 levels by 2020. The results show that China's entry into the WTO would induce decreases in net imports of developing countries, which might cause food security problems.

To economize on space, we focus our discussion of results from Scenarios 2–8 on changes in net exports and net imports among the seven major countries and areas over time (these are also illustrated in Fig. 1 to 7). Under Scenario 2, where tariff–rate quotas are expanded, China would experience a huge increase in net imports, 94.5 percentage points more than in Scenario 1 by 2020 — the largest increase of any of the scenarios considered. Japan's net imports also expand under this scenario; however, the full amount of the tariff–rate quota is not filled. The large increase in China's net imports under this scenario would contribute to increases in net exports from exporting countries. Australia and Argentina's net exports increase slightly more than in Scenario 1. The net exports of the United States increase by 6.1 percentage points more than in Scenario 1 by 2020. While Canada and the EU are net exporters, they both have tariff–rate quotas on their imports. Under Scenario 2, Canada's net exports would increase slightly more than in Scenario 1, while the EU would experience an increase in net exports by 6.4 percentage points more than in Scenario 1 by 2020. This means that increases in exports would be larger than increases in imports caused by expanding tariff–rate quotas in Canada and the EU. Thus, all net exporters would be able to increase their net exports in Scenario 2, compared to Scenario 1. China's increase in wheat imports would also affect developing countries. Although the effective tariff rates are already zero for Indonesia, its wheat imports would decrease by 6.2 point more than in Scenario 1 by 2020. Expanding tariff–rate quotas would cause tighter wheat supply and demand balance in Indonesia because there is almost no domestic wheat production there.

In Scenario 3, where there is a reduction in tariffs, China's net imports increase by 27.3 percentage points more than in Scenario 1 by 2020. However, the increase in net imports is substantially less than in Scenario 2. The United States and Australia experience an increase in net exports of, respectively, 9.6 and 9.2 percentage points more than in Scenario 1 by 2020, which is larger, in magnitude, than Scenario 2's results. The growth in net exports of the United States and Australia is a result of decreases in net exports by Canada (24.5 percentage point decrease) and the EU (4.3 percentage point decrease). In Canada and the EU, the increase in imports caused by the reduction of high over–quota tariffs exceeds the increase in exports. Thus, tariff reduction would have more significant effects on net exports of exporting countries than quota expansion would. This is also true of net imports of developing countries. Mexico's net imports increase by 18.5 percentage points more than in Scenario 1 by 2020, while Indonesia's net imports decrease by 18.2 percentage points.

The results of Scenario 4 indicate that with the elimination of export subsidies the EU's net exports would be 27.8 percentage points lower than in Scenario 1 by 2020, an amount 2.2% smaller than the current level. As noted earlier, Scenario 1 results show that the EU would have a significant increase in net exports in the case where current trade and domestic policies are kept unchanged in the future. Both results indicate that the EU's increase in exports depends heavily on export subsidies. Other exporters would experience an increase in net exports greater than in Scenario 1. For instance, net exports from the United States, Australia, and Canada increase by 4.2, 4.6, and 1.5 percentage points, respectively. Net imports in all importing countries, except India, decrease by less than 4 percentage points more than in Scenario 1 in 2020.

Under Scenario 5, where production subsidies are eliminated, all net exporters except the United States are not significantly affected. Indeed, except for the United States, there is almost no change in net exports. However, the United States would experience a decrease in net exports of 4.6 percentage points more than in Scenario 1 in 2020. Net imports from importing countries decrease by more than in Scenario 1 by 2020. This is especially true for China, which experiences a 13.2 percentage point decline in Scenario 5 relative to Scenario 1.

The results of Scenario 6, where deficiency payments are reduced, are identical to Scenario 1's results. This is due to the increase in the wheat market price, which is always higher than the target prices for all countries with the deficiency payment system.

The results of Scenario 7 indicate that detaching domestic business from the CWB would decrease Canada's net exports by 12.2 percentage points more than in Scenario 1 by 2020. This result is due to the CWB's losing market power on domestic sales. Other exporters, except for United States, would experience an increase in net exports. For instance, net exports for Australia, the EU, and Argentina grow by 3.2, 2.5, and 1.6 percentage points, respectively.

Finally, eliminating the market power of the CWB and the AWB (Scenario 8) would mainly affect Canada and Australia. However, the effects are opposite for the two countries. Australia's net exports would increase by 27.4 percentage points more than in Scenario 1 by 2020, while Canada's net exports would decrease by 7.5 points. The United States and the EU would increase their net exports by 3.8 and 3.2 percentage points, respectively, while Argentina would decrease their net exports by 3.0 points. Among importers, China would increase its net imports by 55.4 points more than in Scenario 1 in 2020. Mexico, New Zealand, the Philippines, and Egypt would increase net imports by 21.8, 12.3, 3.9, and 2.5 points, respectively, while Indonesia would decrease net imports by 12.7 point. Overall, eliminating market power of exporting STEs would loosen the supply and demand balance in wheat markets, except in Indonesia.

How are the various countries impacted by these policy alternatives? In the case where current trade and domestic policies are unchanged in the future, net exports in Australia and the EU increase, but for different reasons. Australia's net exports increase over time under all eight scenarios, even if current trade and domestic policies are significantly deregulated (Fig. 1). This result is consistent with Australia's positive position toward international deregulation, including deregulation of its own policies, as illustrated by privatization of the AWB.

By contrast, the direction of change in the EU's net exports depends on the specific policy change (Fig. 4). The EU could increase its net exports by expanding tariff–rate quotas or reducing domestic support policies (including STE–related policies). On the other hand, reducing tariff rates would cause a decrease in the EU's net exports. Reducing export subsidies would result in the most significant decreases in net exports. These results are consistent with the EU's current policy of enhancing wheat exports by limiting imports with high over–quota tariffs (about 101 dollars per *ton*) and by promoting exports with high export subsidies (about 43 dollars per *ton*). And not surprisingly, the EU is strongly against any reduction in export subsidies in the WTO negotiations.

Unlike for Australia and the EU, net exports from the United States and Canada would decrease significantly in the case where current trade and domestic policies are kept unchanged in the future. Under all eight scenarios, net exports from the United States and Canada decline over time (Fig. 2 and 3). The results also indicate that net exports from the United States would be higher, compared to the baseline policy, when all countries reduce protection levels related to tariff–rate quotas, export subsidies, and STE–related policies (Fig. 2). However, net exports from the United States are lower than the baseline results in the scenario where all countries reduce production subsidies. This result is consistent with the fact that the United States has been proposing significant trade liberalization in international negotiations while maintaining its own production subsidies.

Canada could increase net exports by reducing export subsidies and production subsidies, but reducing tariff rates would cause lower net exports than in the baseline scenario (Fig. 3). As is clear from Fig. 3, eliminating the CWB would result in the most significant decrease in net exports. Canada's net wheat exports are enhanced by limiting imports with high (76.5 percent) over–quota tariffs and by promoting exports with the exporting STE. This is consistent with the fact that the Canadian government still maintains the STE while Australia privatized it.

China is the country most significantly affected by policy changes among net–importing countries (see Fig 5). China would significantly increase net imports by expanding tariff–rate quotas (or reducing tariffs) and eliminating STEs, while reducing domestic support policies would cause decreases in net imports. China's entry into the WTO would have a large impact on world wheat trade because China would become the largest net importer in the world, and its imports would be heavily affected by international wheat policies.

Deregulation of tariff policies, especially expanding tariff–rate quotas rather than reducing tariff rates, would have the most significant effects on Japan's wheat imports (see Fig. 6). However, expanded tariff–rate quotas would not be fully met by imports,

Table 5. Simulation Results of Scenario 1 (Million *ton*)

	Demand					Net Exports				
	1998	2005	2010	2015	2020	1998	2005	2010	2015	2020
ARG	5.415	4.772	4.774	4.774	4.774	11.086	6.336	6.123	6.053	6.030
AUS	3.812	3.815	3.883	3.904	3.910	15.553	23.608	26.200	26.967	27.188
BRA	8.480	7.456	7.447	7.444	7.443	-6.610	-5.662	-5.779	-5.814	-5.825
CAN	8.135	7.446	7.439	7.438	7.438	17.730	13.812	13.239	13.067	13.014
CHN	117.946	113.757	113.753	113.753	113.753	-4.208	-6.394	-6.788	-6.917	-6.959
EGY	11.341	10.618	10.621	10.622	10.622	-6.488	-4.891	-4.798	-4.768	-4.758
EU	82.188	79.219	79.375	79.389	79.390	14.398	17.761	0.869	18.079	18.086
IND	66.854	66.595	66.588	66.587	66.587	-3.945	0.450	0.869	1.007	1.052
IDN	4.931	4.108	4.224	4.257	4.266	-4.931	-4.113	-4.229	-4.262	-4.271
JPN	6.321	5.997	5.997	5.997	5.997	-5.600	-5.613	-5.647	-5.657	-5.661
KOR	4.108	3.727	3.729	3.730	3.730	-4.480	-3.724	-3.727	-3.728	-3.728
MEX	5.368	4.729	4.723	4.722	4.722	-2.133	-1.269	-1.145	-1.102	-1.087
NZL	0.468	0.433	0.433	0.433	0.433	-0.211	-0.264	-0.287	-0.293	-0.294
PHL	1.879	1.701	1.701	1.701	1.701	-1.915	-1.700	-1.700	-1.700	-1.700
USA	37.055	33.907	33.855	33.841	33.836	25.312	16.147	14.038	13.502	13.365
FSU	68.416	62.969	62.994	62.998	62.999	0.618	-0.272	-0.202	-0.224	-0.240

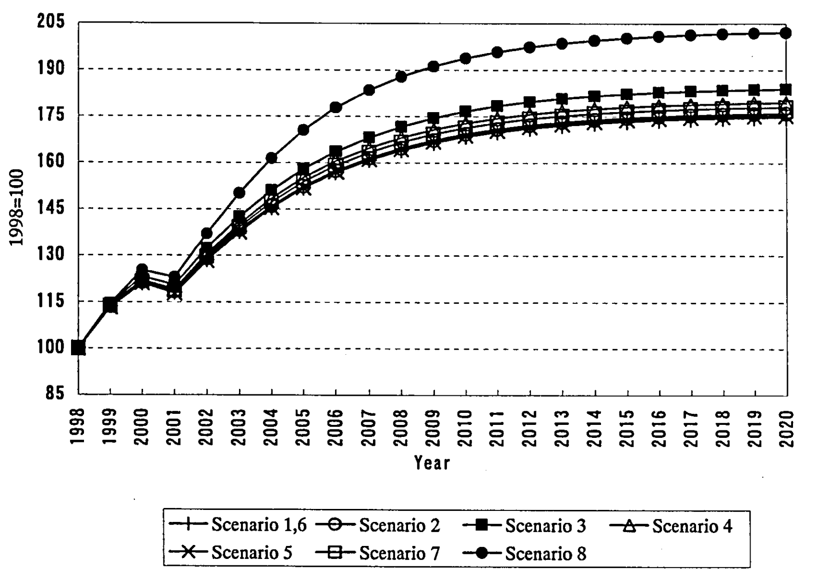

Fig. 1. Estimated Changes in Net–exports of Australia

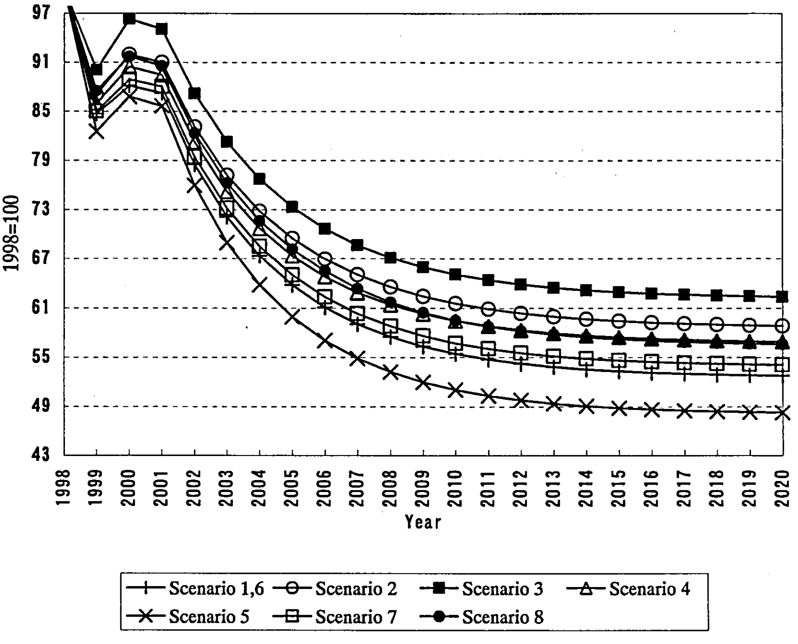

Fig. 2. Estimated Changes in Net-Exports of United States

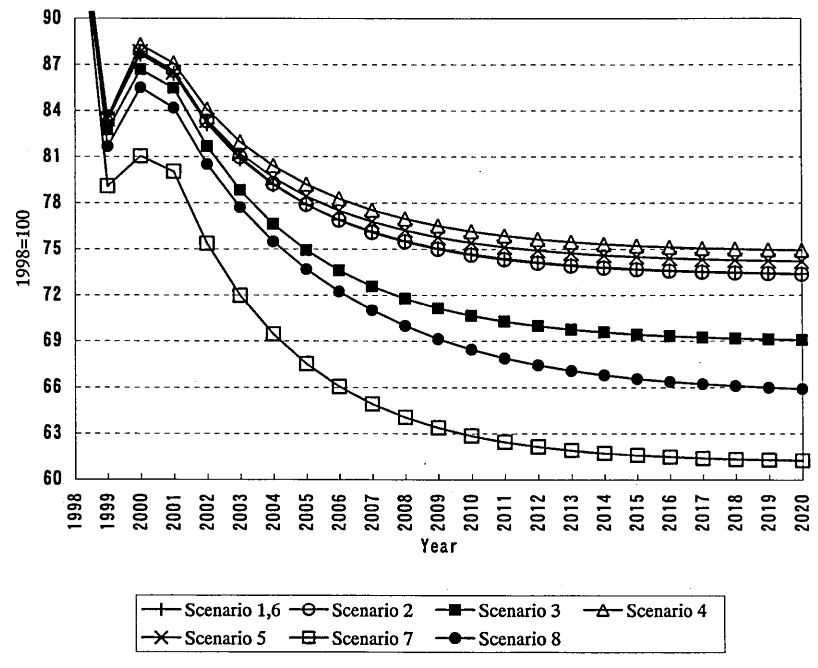

Fig. 3. Estimated Changes in Net-Exports of Canada

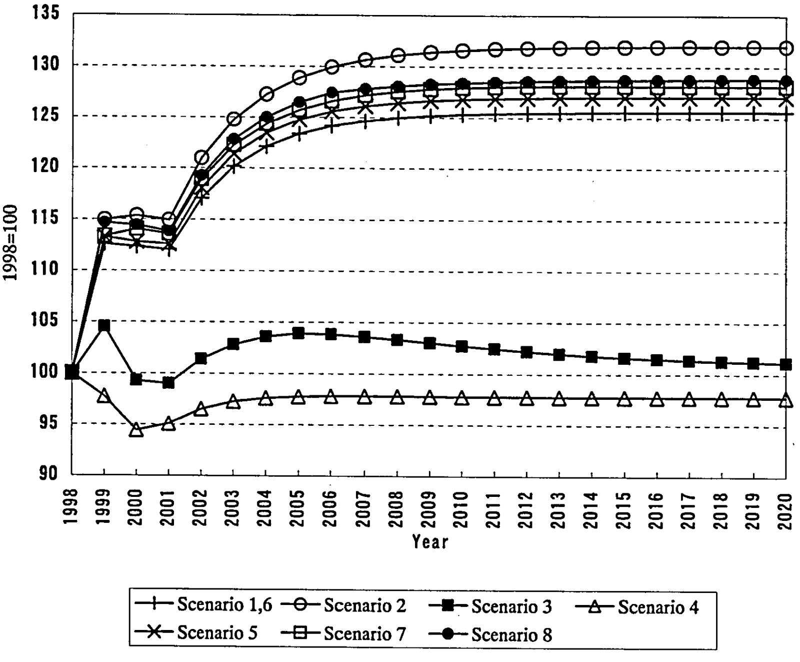

Fig. 4. Estimated Changes in Net–Exports of European Union

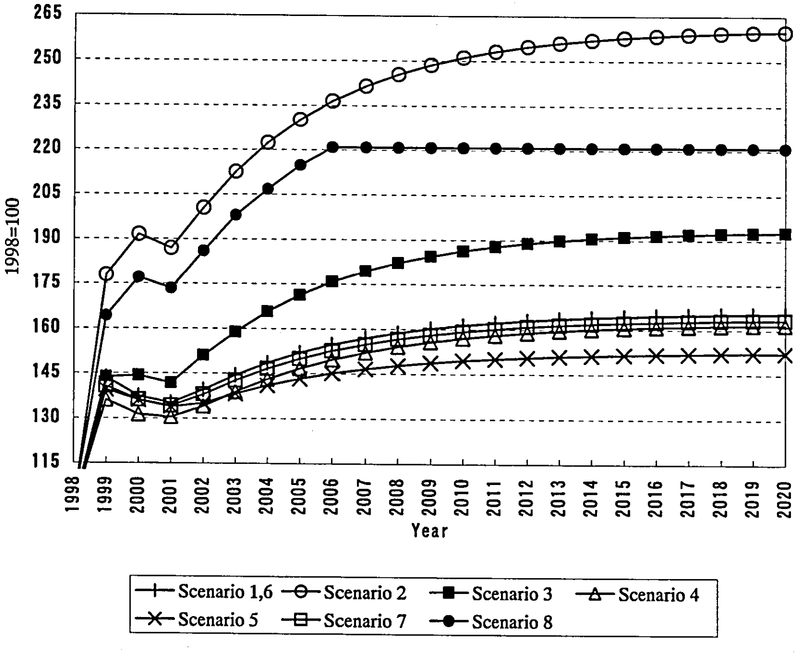

Fig. 5. Estimated Changes in Net–Imports of China

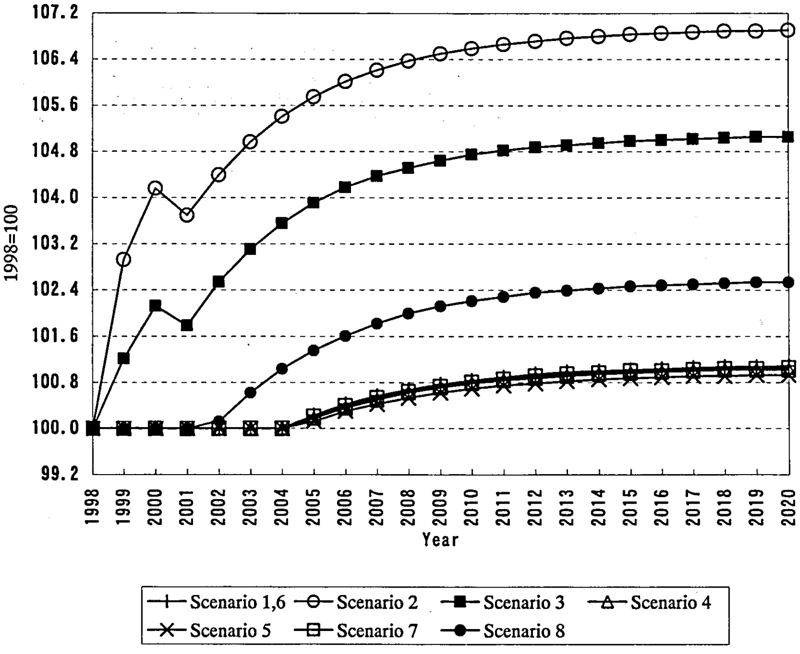

Fig. 6. Estimated Changes in Net-Imports of Japan

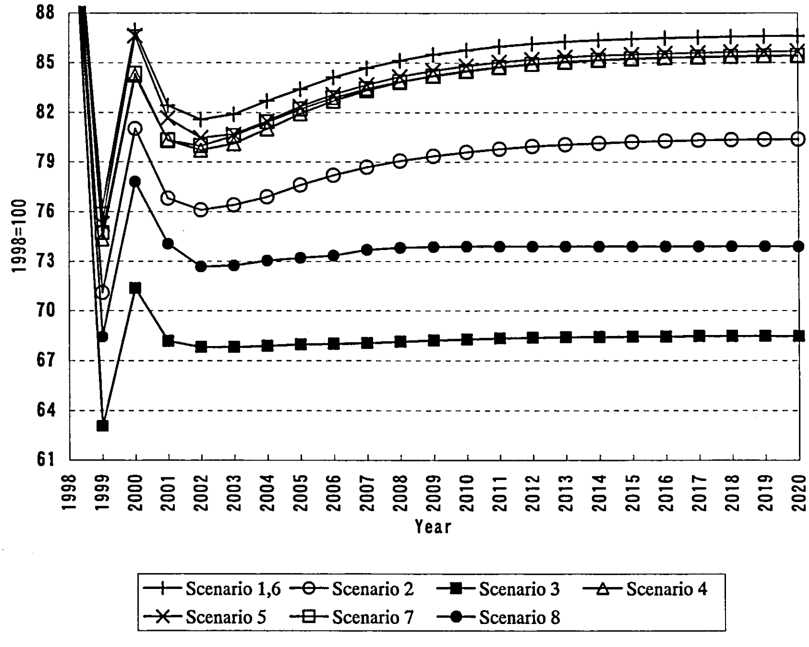

Fig. 7. Estimated Changes in Net-Imports of Indonesia

because over 90 percent of national wheat consumption is currently imported in Japan, and a further expansion of the quotas with filling–up obligation is not a realistic requirement based on market forces.

Although the effective tariff rates are already zero for Indonesia, its wheat imports would decrease by any reduction of trade and domestic support policies in the world (see Fig. 7). Decreases in imports would cause food security problems in Indonesia because there is almost no domestic wheat production there. Trade liberalization might have such side effects on some importing countries because of tighter international supply and demand.

CONCLUSIONS

In this paper, a dynamic nonlinear imperfectly competitive spatial equilibrium model was developed to evaluate international and domestic agricultural policies. The objective was to develop a more flexible and comprehensive dynamic policy simulation model to examine imperfectly competitive agricultural trade with various domestic and international support policies. The model was formulated as the nonlinear complementarity problem (NCP) to a dynamic nonlinear imperfectly competitive spatial equilibrium model. In addition to being a dynamic and nonlinear generalization, the model also has the following desirable features. First, free trade agreements (FTAs), such as NAFTA, were explicitly introduced. Second, domestic support policies, such as production subsidies, deficiency payments, and production quotas, were separately introduced. Finally, the model allowed for various degrees of imperfectly competitive behavior.

To illustrate its usefulness, the model was applied to international wheat trade under several alternative policy scenarios based on proposals of major countries. The dynamic simulation period for all policy scenarios was from 1999 through 2020. The simulation results were consistent with the actions and strategies of major countries in current WTO negotiations.

If current trade and domestic policies are unchanged in the future, Australia and EU would experience an increase in net exports, while the United States and Canada would have a significant decrease in net exports. Australia's net exports would increase over time in any deregulated situation, which is consistent with Australia's positive position toward trade liberalization. On the other hand, net exports from the EU would decrease with the reduction of over–quota tariffs and export subsidies, which is consistent with the EU's opposition to any reduction in export subsidies. Net exports of the United States would be lower if all countries reduced production subsidies, which is consistent with the fact that the United States has been proposing significant trade liberalization in international negotiations while maintaining its own production subsidies. Canada's net exports would be lower if over–quota tariffs were reduced and exporting STEs eliminated. This is consistent with the fact that the Canadian government still maintains a STE while Australia has privatized it. China is the country most significantly affected by policy changes among net–importing countries. China's entry into the WTO would have a large impact on world wheat trade because China would become the largest net importer in the world, and its imports would be heavily affected by international wheat policies. Although the effective tariff rates are already zero for Indonesia, its wheat imports would decrease with any reduction of trade and domestic support policies in the world. Decreases in imports would cause food security problems in Indonesia because there is almost no domestic wheat production there. Trade liberalization might have such side effects on some importing countries because of tighter international supply and demand.

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