Spatial Equilibrium Modeling with Imperfectly Competitive Markets: An Application to Rice Trade

by

Chi-Chung Chen
Assistant Professor
Department of Agricultural Economics
National Chung-Hsing University
Taichung, Taiwan, ROC
Email: mayjune@nchu.edu.tw
Tel: +886 - 4-22858137
Fax: +886 - 4-22860255

Bruce A. McCarl
Professor
Department of Agricultural Economics
Texas A&M University
College Station, TX, USA
Email: mccarl@tamu.edu
Tel: (409) 845-1706

Ching-Cheng Chang
Research Fellow
Institute of Economics, Academia Sinica, Taiwan, ROC
Email: Emily@econ.sinica.edu.tw
Tel: +886- 2-2782 2791 ext 201
Also Professor
Department of Agricultural Economics
National Taiwan University, Taiwan, ROC

Shih-Hsun Hsu
Professor
Department of Agricultural Economics
National Taiwan University, Taiwan, ROC
Email: m577@ccms.ntu.edu.tw
Tel: +886-2-2365 6329

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Abstract

A general imperfect competition spatial equilibrium model is developed to estimate the trading country behaviors in the international rice market using a conjectural variation approach. Such a model allows the possibility of an imperfect competitive market to exit on both the export and import sides without any assumption of market structure. The empirical results show that the major exporting countries, Thailand, Vietnam, and the U.S. acted as high degree of imperfect competitors(or oligopolies) while Pakistan acted as a lower degree of imperfect competitor. The importing countries such as Japan, the Philippines, Europe, Brazil, and the former USSR behaved as high degree of imperfect competitors (or oligopsonies). The empirical results also show that there are welfare gains of $1,492 million when all trading countries comply with the free trade agreement.

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I. Introduction

Spatial equilibrium (SE) models (Samuelson, Takayama and Judge) have long been applied to international trade analyses in agriculture. They are usually operated under a perfect competition assumption. However, such an assumption is not always acceptable since imperfectly competitive market behavior is thought to exist in a number of instances. For instance, investigations of the international wheat market have generated results that infer imperfectly competitive behavior in the form of a U.S.-Canada duopoly (McCalla); U.S.-Canada-Australia triopoly (Alaouze, Watson, and Sturgess); European Economic Community (EEC)-Japan duopsony (Carter and Schmitz).

Quantitative approaches to trade modeling have been developed to either examine or simulate trade under imperfect competition. International grain markets and trader behavior have been investigated in many studies using econometric tools or non-spatial approaches. McCalla; Alaouze et al.; Paarlberg and Phillip; and Carter and Schmitz focused on the international wheat market while Karp and Perloff studied in the rice export market and Karp and McCalla investigated the international corn market. These studies found that the international grain markets existed as imperfect competitive markets.

Several papers have dealt with imperfect competition treatment in SE models. Nelson and McCarl developed Cournot and conjectural variation based models which could depict certain forms of imperfect market structures, but they did not apply them empirically. Kolstad and Burris developed a SE model for wheat incorporating reaction-functions from oligopolies/oligopsonies, but focused only on cases like duopsony, duopoly and triopoly. Kawaguchi, Suzuki, and Kaiser used the conjectural variation

approach, similar to that used in Nelson and McCarl, and applied it to the Japanese domestic milk market.

All these studies using spatial or non-spatial approaches generally assumed some particular market structures and examined how closely the model results compared with actual data to identify which market structure is able to explain the observed trade pattern. For example, Karp and Perloff assumed that China, Thailand, and Pakistan were either acting as price-takers, in coalition with each other, or behaving like Cournot-Nash players in their rice export market. Kolstad and Burris assumed the international wheat market was behaved as if it were the result of traders acting under either a duopsony, duopoly, or triopoly structure. Such assumptions may bias the results as a more flexible market structure assumption may be in order. In this paper, we wish to explore more flexible assumptions in the context of the world rice market. More specifically, we develop a calibration procedure to measure the imperfect degree of trader behavior under a flexible market structure specification allowing competitive behavior spanning from perfect competition to monopoly or monopsony. To do so, a conjectural variation approach without any restriction is used to best fit trader behavior in an effort to reproduce observed trade flows. After calibration, the model can be used to assess the effects of a free trade regime on welfare distributions among the trading countries.

Our analytical model also extends the literature in two directions. In particular, previous imperfect competition models are limited because they

1. generally focus on either the import or the export market. For instance, McCalla and Alaouze et al. focus on the behavior of wheat exporters, while Carter and Schmitz examine wheat importers. We will calibrate both market groups to a

consistent equilibrium data set at the same time in the context of rice.

2. generally deal with the major trading countries excluding the other smaller players. Such a treatment is not suitable in the rice market, as a small trading country such as China may produce a large quantity to fulfill its self-sufficiency target. Therefore, we will look at a wide variety of market participants in the context of rice.

In Section 2, we argue that the international rice market may be characterized by strategic regimes undertaken by the governments to protect the market share of their domestic producers. Section 3 describes the major players in the global rice market. The model used in this paper is presented in Section 4. It is a spatial equilibrium model with imperfect competition based on the work of Nelson and McCarl and Kawaguchi, Suzuki, and Kaiser. Our focus is to measure the effect of government intervention on the strategic interaction among the importers and exporters. The results are discussed in Section 5. It is found that most rice trading countries behaved as imperfect competitors. The welfare implications of a free trade regime are also simulated. The paper concludes in Section 6.

II. Imperfect Competition and Strategic Trade Policies

National and international interests are not always in accord over the trade policy. A trading country has incentive to set-up either a tariff protection or an export subsidy/promotion program to maximize its own national interests at the expense of the international interests. For instance, Enke (1944) shows that an economy would benefit more from imports if the importing country acts as a monopsonist by adopting a tariff duty. Although competition is allowed amongst the consumers and producers within each country, the government is assumed to act as the guardian to national interests and be very

conscious about discriminating against foreign producers for certain commodities, and therefore, acts as a monopsonist. Nevertheless, absence of free trade imposes an international burden. Therefore, the international interest demands free trade policies irrespective of the monopsony or monopoly position of individual nations.

On the other hand, the idea that imperfect competition might call for policy intervention has been recognized by many distortion literature as introduced by Bhagwati, Ramaswami and Srinicasan(1969). Brander and Spencer (1984) argue that the imperfect competitive environment provides a simple explanation of why a government might impose tariff on foreign products. The Brander and Spencer's approach provides support for the assertion that governments could raise national income at other countries' expense by supporting national forms in international competition. Krugman (1984) and Shaked and Sutton (1984) also point out that under the imperfect competitive environment the role of a tariff is to divert profits from the importers to domestic producers and to the government treasury. As for the export subsidy policy, Brander and Spencer (1985) found that the terms of trade move against the subsidizing country whose welfare can be increased because, with imperfect competition, price exceeds the marginal cost of exports leading to a net increase in profit to offset the adverse terms of trade effects.

From the modeling perspective, trading country behaviors with the associate market structures could be cataloged into three type of policy groups: Free Trade, Trade Restriction, and Trade Extension. Free trade implies a price-taker behavior which reflects a perfect competition market. Trade restriction includes both an optimal import tariff exits in an importing country and a collusive or an imperfect competition among exporting countries which indicates that an oligopoly (or oligopsony) market exits. Trade extension

represents another type of oligopoly (or oligopsony) behaviors which distort the marketing price. Such three type catalogs of trade policy could be indicated by the value of conjectural variation(C.V.) since the value of the conjectural variation could reflect the degree of monopoly power as well as the behavior of treading country.

Following Hwang and Mai, four different equilibria could be obtained according to the value of C.V. The Cournot-Equilibrium is obtained if the C.V. is closed to 0. The equilibrium solution is more collusive than the Cournot one if the C.V. is positive but it will be a collusive equilibrium if C.V. is 1. If the C.V. is a negative, the equilibrium solution is more competitive than the Cournot one but it will be a perfect competition equilibrium while the C.V. is closed to -1. However, if the C.V. goes to a more negative, it indicates that the exporting price is higher than importing price. Such equilibrium implies that there exists a domestic or trade subsidy in an exporter.

Throughout the world, agricultural trade impediments are more complex than nonagricultural trade barriers, underscoring an urgent need for reform where the greatest distortions exist. The goal of food security will be more attainable through a concerted effort than through the efforts of individual nations pursuing separate programs aimed at food self-sufficiency.

III. The Global Rice Market

The Food and Agriculture Organization (FAO) and International Rice Research Institute (IRRI) statistics show that total rice production increased more than two fold during the past four decades (i.e., from 215 million metric tons in 1961 to 573 million in 1997). Asian countries produce 91-92% of the world total, with China and India accounting for more than 50%. On the demand side, more than 90% is consumed in

Asia, with China, India and Indonesia accounting for 75%. Per capita consumption levels are declining in the high-income Asian countries but rapid low-income country population growth is causing increasing Asian-wide rice consumption. IRRI (1997) projects world annual rough rice production will have to increase by almost 56 percent over the next 30 years to keep up with the increasing demand.

The amount of rice traded in the world market increased from 8 million metric tons (mt) in the 60's to about 20 million mt in the 90's. Nevertheless, only 4 to 6% of total world production is traded annually. The balance between consumption and production in conjunction with yield increases has made rice trade a residual market, which largely occurs when excess rice is available. Government interventions to enhance self-sufficiency are also important causes of this residual and occasional market (Siamwalla and Haykin, 1983). Such a market characteristic raises search costs. However, for regular buyers the prevalence of strong quality preferences plays an important role in determining the trade patterns and market shares (Yumkella, Unnevehr and Garcia, 1994). The pervasive trade distorting policies further exacerbate the market rigidity by variety and quality (Cramer, Wailes and Shui, 1993).

There have been some changes in the trading patterns in rice since the 60's. Import shifted away from Asia to the Middle East, Africa and Latin America, as many South and Southeast Asian importers increased their production. China has converted from a rice exporter into an importer while India did the reverse during the 90's. But the total import volume in most Asian countries remains relatively unstable.

Thailand, Vietnam, U.S., India, and Pakistan are major export countries. They export 80% of world volume. The increasing dominance of these five exporters

indicates they may be able to exercise market power, but evidence regarding the degree of competition is mixed. Karp and Perloff (1989) found that the rice export market is close to price taking, whereas Yumkella, Unnevehr and Garcia (1994) found non-competitiveness in high-quality rice exported by the U.S. and Thailand.

On the other hand, the competitiveness in the import markets has not received any attention. Rice import markets are characterized by substantial trade barriers with import quotas, tariffs, and bilateral agreements being prevalent along with deficiency payments, input subsidies and currency overvaluation (Cramer, Wailes and Shui, 1993). After the Uruguay Round, trade liberalization has opened some international rice markets. However, most imports are controlled by either the government or agricultural cooperatives who are trying to maintain self-sufficiency. Therefore, the perfect competition model may not be adequate to depict these strategic trade policies carried out by the governments.

IV. Imperfect Competition and Spatial Equilibrium Model

In this paper, a generalized spatial equilibrium model is developed to accommodate any degree of imperfect competition for both importers and exporters. Imperfect competition will be incorporated relying on the conjectural variations approach as in Nelson and McCarl and Kawaguchi, Suzuki, and Kaiser. Conjectural variations (CV) capture the information about competitive behavior in a single parameter. Although CV has been criticized for lack of a rigorous justification, it is analytically more convenient and no superior alternative exists as argued by Karikari.

Suppose there are m exporting and n importing countries. The inverse excess supply function for exporter i, $i=1, \ldots, m$, is assumed to be linear and defined as

$$P_i = c_i + d_i E_i , \tag{1}$$

where E_i and P_i are the volume exported and export prices and c_i, d_i are the intercept and slope of the inverse excess supply curve for the exporting country respectively. Similarly, the inverse excess demand function in importing country j, $j=1, \ldots, n$, is

$$P_j = a_j + b_j M_j , \tag{2}$$

where M_j and P_j are the import quantity and price, respectively, and a_j and b_j are the corresponding intercept and slope of the inverse excess demand curve for the importing country.

Suppose there exist positive trade between all exporting and importing countries. Let X_{ij} denote the volume shipped from exporting country i to importing country j. The following equations hold at the equilibrium point:

$$\sum_j X_{ij} = E_i , \qquad \sum_i X_{ij} = M_j . \tag{3}$$

Suppose the exporting countries exert market power through government intervention while maximizing their profit. The objective function for the exporting country i is

$$\underset{X_{ij}}{MAX} : \pi_i = \sum_j (a_j - b_j M_j) X_{ij} - (c_i + 0.5 d_i E_i) E_i - \sum_j X_{ij} t_{ij} \tag{4}$$

where t_{ij} is the transportation cost per unit. The first term in π_i represents total trade revenue generated from selling to the importing county, while the second term represents the cost of the sales which is defined as the area under the excess supply curve. The last term is the transportation cost.

As commonly done in imperfect trade analysis, the optimal trade quantities will arise

from the simultaneous solution of the first-order conditions for (4) as follows:

$$\begin{aligned}\frac{\partial \pi_i}{\partial X_{ij}} &= (a_j - b_j M_j) - b_j X_{ij}(1 + \sum_{i' \neq i} \frac{\partial X_{i'j}}{\partial X_{ij}}) - (c_i + d_i E\ ) - t_{ij} \\ &= P_j - P_i - t_{ij} - b_j X_{ij}(1 + \sum_{i' \neq i} \frac{\partial X_{i'j}}{\partial X_{ij}}) \qquad = 0, \qquad \forall i, j.\end{aligned} \tag{5}$$

The term $\frac{\partial X_{i'j}}{\partial X_{ij}}$ in equation (5) following Varian is the conjectural variation for exporting country i, and indicates that the expected change in the i'^{th} country's export to country j due to changes in the volume exported by country i into importing country j.

Similar equations can be derived for the importing countries. Suppose the importing country j maximizes consumers' surplus (or net trade surplus) while exercising her market power. The objective function is as follows:

$$\underset{X_{ij}}{MAX} : \phi_j = (a_j - 0.5 b_j M_j) M_j - \sum_i (c_i + d_i E_i) X_{ij} - \sum_i X_{ij} t_{ij} \,. \tag{6}$$

The first term in ϕ_j represents the area under the importing country's excess demand curve, while the second and third terms represent the cost of acquiring imports and transportation. The first-order conditions associated with the importer's decision are:

$$\begin{aligned}\frac{\partial \phi_j}{\partial X_{ij}} &= (a_j - b_j M_j) - (c_i + d_i E_{ij}) - d_i X_{ij}(1 + \sum_{j'} \frac{\partial X_{ij'}}{\partial X_{ij}}) - t_{ij} \\ &= P_j - P_i - t_{ij} - d_i X_{ij}(1 + \sum_{j'} \frac{\partial X_{ij'}}{\partial X_{ij}}) = \qquad 0, \qquad \forall i, j.\end{aligned} \tag{7}$$

The term $\frac{\partial X_{ij'}}{\partial X_{ij}}$ in equation (7) is the conjectural variation for importing country j, which gives the change in trade to country j' from exporting country i caused by a change in the amount imported by importing country j from exporting country i.

The conjectural variations in equations (5) and (7) reflect the trading country's

strategic behavior toward trade. For example, if the term $\frac{\partial X_{i'j}}{\partial X_{ij}}$ in equation (5) is negative one, then the price difference will be equal to transportation cost, which implies that exporting country *i* is a price-taker. Otherwise, the price difference will be the transportation cost plus a positive term $b_j X_{ij}(1+\sum_{i'\neq i} \frac{\partial X_{i'j}}{\partial X_{ij}})$, which could be defined as the price mark-up (or market rent).

The conjectural variations in Nelson and McCarl and Kawaguchi, Suzuki, and Kaiser's models are assumed to be constants. This assumption implies a specific type of marketing structure or a specific trading behavior. We follow the same assumption on this parameter. Combing the two first order conditions [i.e., (5) and (7)], the profit and net surplus maximization problem for all importers and exporters can be re-specified as a net social payoff maximization problem adjusted for imperfect competitive markets. The model can be specified as follows:

$$
\begin{aligned}
\underset{X_{ij}}{Max} \quad \omega = & \sum_j \left[a_j M_j - \frac{b_j M_j^2}{2} \right] - \left[c_i E_i + \frac{d_i E_i^2}{2} \right] - \sum_i \sum_j t_{ij} X_{ij} \\
& - \sum_i \sum_j {}^{b_j}\!/_{2}\, X_{ij}^2 (1 + A_{ij}) - \sum_i \sum_j {}^{d_i}\!/_{2}\, X_{ij}^2 (1 + B_{ij}) \\
s.t. \quad & M_j - \sum_i X_{ij} \leq 0, \quad \forall j, \\
& -E_i + \sum_j X_{ij} \leq 0, \quad \forall i,
\end{aligned}
\tag{8}
$$

where A_{ij} is the conjectural variation for exporting country *i* when selling to country *j* telling how other exporters selling to country *j* react to changes in country *i's* export sales. The term B_{ij} is the conjectural variation for importing country *j* when buying from country *i* telling how other importers buying from country *i* react to changes in country *j's* import

purchases. Mathematically, $A_{ij} = \frac{\sum_{i',i' \neq i}^{n} X_{i'j}}{\partial X_{ij}}$, and $B_{ij} = \frac{\sum_{j',j' \neq j}^{n} X_{ij'}}{\partial X_{ij}}$.

In this objective function, the first and second terms calculate the areas under the excess demand curves minus the areas under the excess supply curves while the third term subtracts the transport costs. Collectively, these three terms follow those from the classical spatial equilibrium model (Takayama and Judge) and represent trade under perfect competition (or free trade). The fourth and fifth terms incorporate the conjectural variations and represent, respectively, the exporting and importing market rents due to imperfect competition.

Optimizing yields the following Kuhn-Tucker conditions when trade activity exits

$$\frac{\partial \omega}{\partial X_{ij}} = \left(a_j - b_j M_j\right) - \left(c_i + d_i E_i\right) - t_{ij} - b_j(1 + A_{ij})X_{ij} - d_i(1 + B_{ij})X_{ij} = 0 . \qquad (9)$$

Substituting in price terms, equation (9) can be re-written as

$$P_j - P_i - t_{ij} - b_j(1 + A_{ij})X_{ij} - d_i(1 + B_{ij})X_{ij} = 0 , \qquad (10)$$

where P_j is the import price for importing country *j* and P_i is the export price for exporting country *i*.

A wide varieties of market behavior can be reflected through the conjectural variation terms: A_{ij} and B_{ij}. If both equal -1, then exporter *i* and importer *j* would be acting as perfect competitors as in the Takayama and Judge model. If A_{ij} equals zero while B_{ij} equals -1, then exporting country *i* acts as an imperfect competitor who will not change her exports in response to *i*'s action in a Cournot-Nash context while importer *j* behaves as a price-taker.

If the exporter's conjectural variation is positive and importer's conjectural variation

-1, then it implies that collusion or cooperation exists among exporting countries. For instance, if each derivative term in the conjectural variation A_{ij} equals the ratio of trade quantities, i.e.,

$$\frac{\partial X_{i'j}}{\partial X_{ij}} = \frac{X_{i'j}}{X_{ij}} \qquad \forall i' \neq i \quad , \tag{11}$$

then the whole world acts as a perfectly discriminating monopolist against importer j. On the other hand, if the exporter's conjectural variation is smaller than -1, it implies that a subsidy policy exists so that the exporting price is higher than the importing price. Similar statements can be made on the import side.

Finally, if the exporter and importer's conjectural variations are not simultaneously equal to -1, then both markets are imperfectly competitive. This indicates that an exporting country i's market rent is $[b_j(1+A_{ij})X_{ij}]$, while an importing country j's market rent is $[d_j(1+B_{ij})X_{ij}]$.

A calibration procedure is employed to develop values for the conjectural variations which are reflective of the market structures behind the data set. The procedure involves an initialization phase where initial values for the conjectural variations are computed based on the wedge between prices in trading countries. Subsequently, there is a refinement procedure which adjusts the estimates to make a better fit between the observed data and the model solution. Specifically the procedure involves the following steps:

Step 1: Break the countries into importers and exporters. Obtain trade flow data and border prices. For each pair of countries which have nonzero trade, determine the party likely to have market power.

Step 2: Calculate an initial estimate of the conjectural variations. The first-order

conditions in equation (10) can be solved for either A_{ij} or B_{ij} if one assumes the other is -1 and has data for the prices. For instance, by assuming the exporter i exercises market power, A_{ij} can be computed as $\frac{P_j - P_i - t_{ij}}{b_i X_{ij}} - 1$. The numerator is the price wedge between the countries above the transport costs. Similarly, B_{ij} can be computed as $\frac{P_j - P_i - t_{ij}}{d_i X_{ij}} - 1$ if the importer has the market power.

Step 3: Solve the spatial equilibrium model using the conjectural variation estimates (A_{ij} and B_{ij}) from step 2 and the observed quantities traded (X_{ij}).

Step 4(Refinement): For each pair of potentially trading countries

a) Compute the percentage deviation between the optimal trade flows and observed trade flows. If the absolute value of this deviation is below a tolerance level, the optimal trade flow is obtained and go to step 4(c). Otherwise, go to step 4(b).

b) Recompute the conjectural variations. We numerically adjust them based on the sign and size of the deviation in 4(a). A positive deviation implies that the conjectural variation is underestimated. For instance, an underestimated import tariff could allow more trade to occur. Therefore, the value of conjectural variations are increased to reduce the trade quantity. A negative deviation implies that the conjectural variation is overestimated and the CV is reduced.

c) Continue until all pairs are completed.

Step 5: If any conjectural variation be adjusted, go to step 3.

Step 6: Terminate because all the conjectural variations have been adjusted so that the optimal trade flow converges with the actual data.

The basic nature of this iterative approach looks for imperfectly competitive market structure between pairs of trade partners by attributing the wedge between prices in excess of the transport costs to a conjectural variation. In reality, this wedge could be caused by government interventions through its domestic or trade policies.

V. Application to Rice Markets

This model will be applied to the world rice market. The rice data including trade quantities and values in year 1995 are from FAO Trade Yearbook. The elasticities of export supply and import demand come from Cramer et al. The transportation costs among trading regions is calculated as the distance of trading regions times the shipping rate for typical ship size from Fellin and Fuller. A list of all trading regions is shown in Appendix A.

For model calibration, a comparison between observed and model generated trade flow and prices are given in Table 1. It shows that the percentage differences for most trading regions are below 10% except for Bangladesh.

The strategic behavior of a trading country can be examined by looking at the size of the estimated CV, which are shown in Tables 2 to 3. Table 2 are the values of CV for rice exporting countries with respect to their importers, while Table 3 are the C.V. values of importing countries with respect to their exporters. Overall speaking, we find most markets have highly imperfect competitive participants as their C.V. diverge from negative one. The only exceptions are Pakistan, Indonesia, and Africa.

Four classes of market behavior are defined in table 4 based on the estimated CV. A country or region exhibiting an estimated conjectural variation is close to -1 is labeled as perfectly competitive. One with an estimated CV higher than -1 but smaller than 0, is labeled as a Cournot-equilibrium trader. One exhibiting a positive CV is labeled as a highly oligopolisitc trader. An estimated CV smaller than -1, indicates that the exporting price is higher than importing price. Such situation implies that there exists a domestic or trade subsidy in an exporter which is referred as a trade subsidizer.

The C.V.'s of the two major exporting countries (Table 2), Thailand and the U.S., range from -0.75 to -2.40. This result indicates that the two exporting countries exercise certain type of subsidy programs which include the export subsidy and domestic subsidy to encourage rice export. For instance, Wailes et al. mentioned that "Thailand, however, maintains several programs that benefit manufactured products or processed agricultural products and that may constitute export subsidy. These programs include subsidized credit on some government-to-government sales of Thai rice; preferential financing for exporters in the form of packing credits; tax certificates for rebates of packing credits and rebates of taxes and import duties for products intended for re-export." (Wailes et al., p. 15). Similarly, the U.S. had farm program subsidies from 1974 to 1995. Brander and Spencer found that an export subsidy may improve welfare compared with a free trade in an imperfect competitive market in which trading countries play a Cournot game (Carter and MacLaren). Thus, these subsidy policies led Thailand and the U.S. to act as imperfect competitors in the rice market.

At least 70 percent of Australia rice production is exported. Although her export quantity occupies one quarter of Japan's rice imports, we find that Australia acts as a

price-taker in a Japan's import market. However, Australia acts as imperfect competitor with C.V.'s ranging from -1.72 to 14.06 when she trades with Indonesia and other Pacific countries. This appears top arise due to currency exchange characteristics(Wailes et al.). When the exporting country currency is under-valued, the trade impacts will be like that of an export subsidy policy.

The C.V. found for Vietnam ranges from 3.59 to 5.10 indicating Vietnam acts as a highly oligopolistic country with respect to her importers. It also reveals that the price is highly distorted in the market between Vietnam and her trading partners, which may be accomplished through the complex licensing system. Pakistan is found to act as a price taker which is consistent with Karp and Perloff's earlier findings. Other exporting countries, such as Taiwan, India, and Myanmar, also act as highly oligopolistic imperfect competitors. Therefore, the prices in these markets are highly distorted as well.

The C.V.'s for the importers are listed in Table 3. The results show that Africa, Bangladesh, and Indonesia are all price-takers. However, Japan, Europe, the former USSR, Brazil, and the Phillippines act as highly oligopsonistic imperfect competitors. Japan has maintained high domestic price supports and tight import restrictions on rice import. The producer subsidy equivalence (PSE) for rice is nearly 90 percent of output values in 1991-93 (Hayami and Godo). Similarly, the EU impose high levies on rice import because high production costs make their rice uncompetitive in most markets (Childs). Their C.V.'s range from 13.4 to 14.2.

Finally, it is interesting to evaluate the costs of the imperfect competition. A free trade model is simulated when both the exporters' and importers' conjectural variations are equal to -1. A $1,492 million gain is globally possible where importers gain $1,098

million (or 74% in total) and exporters $394 million(Table 5).

VI. Concluding Comments

This paper developed a general spatial equilibrium model which incorporates imperfect competition based on a conjectural variations approach. The procedure does not make a priori assumptions on competitive behavior. It can handle many counties at once including importers and exporters as well as small countries. In addition, both trade restrictions, such as import tariffs and trade expansions such as export subsidies can be captured by the conjectural variation terms.

The procedure was applied to the international rice market. Most rice trading countries were found to behave as imperfect competitors. The total welfare gain will be $1,491 million without any government intervention.

Table 1. Model Calibration to Observed Data

	Quantity			Price		
	Model Solutions (tons)	Observed Data (tons)	Deviations (%)	Model Solutions ($US/ton)	Observed Data ($US/ton)	Deviations (%)
I. Importers						
China	1851101	1784104	3.76	261.58	264.00	-0.92
Indonesia	3288034	3530297	-6.86	285.37	280.34	1.79
Japan	19564	18335	6.71	758.94	771.35	-1.61
Korea DPR	674770	731172	- 7.71	240.76	229.35	4.97
Korea REP	288	240	7.28	476.56	497.26	-4.16
Philippines	304479	294347	3.44	311.55	314.20	-0.84
Other Asia	5248108	5377512	-2.41	406.46	400.43	1.51
Other N&C	1568183	1569571	-0.09	334.75	334.58	0.05
Europe	1164886	1096053	6.28	589.49	612.48	-3.75
Former USSR	263440	262506	0.36	344.01	344.32	-0.09
Bangladesh	100105	908934	-88.99	311.51	170.97	82.20
Brazil	944895	957075	-1.27	380.82	379.60	0.32
Africa	4154434	4148294	0.15	295.02	295.21	-0.07
TOTAL	19582287	20678200	-5.29			
II. Exporters						
Taiwan	188495	185690	1.51	213.92	212.75	0.55
India	4972379	5512300	- 9.79	225.77	235.99	-4.33
Myanmar	399974	391590	2.14	192.34	191.53	0.42
Pakistan	1895017	1852200	2.31	276.47	249.88	10.64
Thailand	5738435	6197920	-7.41	290.51	314.92	-7.75
Vietnam	2294304	2297200	-0.13	191.37	191.49	-0.06
USA	2763176	2859270	- 3.36	312.36	323.17	-3.34
Other S.Amer	790683	865880	-8.68	363.38	370.04	-1.80
Australia	539737	510850	5.65	427.18	397.65	7.43
TOTAL	19582200	20672900	-5.27			

Note: Numbers in the observed data are the import data reported in FAO times 1.118 in order to balance with total export in 1995 FAO statistics.

Table 2. Conjectural Variations for Rice Exporters with Respect to Importers

Exporting Country	Taiwan	India	Myanmar	Pakistan	Thailand
Importing Country					
Bangladesh				-2.02	-1.53
China	27.55		23.63	-1.11	-1.29
Indonesia	36.67	0.38	29.35	-0.59	-1.40
Japan		0.38		-0.97	-1.00
Korea DRP				-1.12	-1.09
Korea REP				-0.99	-1.01
Philippines		0.38			-1.01
Other Asia		0.38	30.58	0.58	-0.75
Other N&C		0.38		-0.75	-1.02
Europe	26.81	0.38		-0.49	-0.88
Former USSR		0.38		-0.89	-1.00
Brazil					-0.94
Africa	30.95	0.38	26.12	-0.50	-1.22

Exporting Country	Vietnam	USA	Other S.Amer	Australia
Importing Country				
Bangladesh		-2.35		
China	4.17	-1.95		-9.14
Indonesia	5.10	-2.40		-14.06
Japan		-1.16		-0.93
Korea REP		-1.17		
Philippines	3.59	-1.22		
Other Asia	5.31	-0.78	-1.95	-1.72
Other N&C		-1.18	-2.52	-2.45
Europe	3.88	-0.91		0.03
Former USSR		-1.18		
Brazil	4.09	-1.04	-1.96	
Africa	4.41	-1.79	-5.64	-8.95

Table 3. Conjectural Variations for Rice Importers with Respect to Exporters

Importing Country	Bangladesh	China	Indonesia	Japan	Korea DRP	Korea REP	Philippines
Exporting Country							
Taiwan		-0.06	-0.99				
India			-0.62	2411.94			2.06
Myanmar		0.21	-0.82				
Pakistan	-0.41	-0.12	-1.03	939.57	-1.11	10312	
Thailand	-1.23	-0.81	-1.04	1342.74	-1.11	20516	2.06
Vietnam		0.75	-0.52				2.06
USA	-1.23	-1.11	-1.04	1101.07		13931	2.06
Other S.Amer							
Australia		-1.11	-1.04	913.20			

Importing Country	Other Asia	Other N&C	Europe	Former USSR	Brazil	Africa
Exporting Country						
Taiwan			14.22			-0.96
India	1.29	-0.52	13.40	5.66		-0.43
Myanmar	0.17					-0.80
Pakistan	-0.16	-0.41	13.90	6.07		-0.99
Thailand	0.05	-0.52	13.40	6.34	2.09	-1.00
Vietnam	0.68		13.40		1.34	-0.57
USA	-0.12	-0.52	13.40	5.66	1.68	-1.00
Other S.Amer	-0.19	-0.52			1.43	-1.00
Australia	-0.20	-0.52				-1.00

Table 4. Trading Country Behavior in the International Rice Market

Trade Type	Free Trade	Trade Restriction		Trade-Expansion
Marketing Behavior	Price-Taker	Cournot-Equilibrium Trader	Highly Oligopolisitc Trader	Trade-Subsidizer
Exporting Country	Thailand USA Pakistan		Taiwan India Myanmar Vietnam	Thailand USA Australia OtherS.America
Importing Country	Bangladesh Indonesia Africa	Other Asia Other N&C	Japan Korea REP Philippines Europe Former USSR Brazil	China

Table 5. Welfare Comparison with and without Free Trade

	Non-Free Trade (million dollars)	Free Trade (million dollars)	Gain by Free Trade (million dollars)
Importers	4765.01	5862.60	1097.59
Exporters	2694.14	3088.54	394.40
Total Welfare	7459.15	8951.14	1491.99

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Appendix A. Trade region definition in a spatial equilibrium model

Importing Regions	Countries
Bangladesh	Bangladesh
China	China
Indonesia	Indonesia
Japan	Japan
Korea DRP	Korea DRP
Korea REP	Korea REP
Philippines	Philippines
Other Asia	Afghanistan, Cambodia, Iran, Iraq, Lao, PDR, Malaysia, Nepal, Sri Lanka, Turkey, other Asia
Other N&C Amer.	Costa Rica, Cuba, Dominican, Mexico, Panama, other N&C America
Europe	Italy, Portugal, Spain, other Europe
Former USSR	Former USSR
Brazil	Brazil
Africa	Africa
Exporting Regions	**Countries**
Taiwan	Taiwan
India	India
Myanmar	Myanmar
Pakistan	Pakistan
Thailand	Thailand
Vietnam	Vietnam
USA	USA
Other South America	Argentina, Colombia, Ecuador, Guyana, Peru, Surinam, Uruguay, Venezuela, other South America
Australia	Australia