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

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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 pre-assumption of marketing 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 $1,568 million when all trading countries comply with the free trade agreement.

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Spatial equilibrium (SE) models (Samuelson, Takayama and Judge) have long been applied to international trade analyses in agriculture. SE models are usually operated under a perfect competition assumption. However, such a simple assumption is not always acceptable since imperfectly competitive markets are thought to exist for a number of commodities. 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).

Several papers have dealt with the topic of a more general 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. These studies generally assume a particular set of imperfectly competitive market structure, and examine how closely the model results compared with actual data to identify which market structure is able to explain the observed trade pattern. In addition, the assumptions on market structure are only imposed on either the demand or supply side. Therefore, their empirical works have dealt with

the imperfectly competitive market either entirely in the exporting or importing market.

International grain markets and trader behaviors using Econometric tools have been investigated in many studies. 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. All these studies found that the international grain markets exist as imperfect competitive markets. However, these studies generally pre-assumed some particular market structure form then examined how closely the model results compared with actual data. For example, Karp and Perloff pre-assumed that China, Thailand, and Pakistan were either acting as price-takers, collusive, or Cornot-Nash game in their rice export. Also, studies in this class only dealt with some larger exporting or importing countries and excluded other small trading countries. Such a situation may be suitable for the wheat and corn market; however, in the international rice market, a small trading country may produce a large of rice quantity in domestic production such as China. These small trading countries may have a potential to compete with the major trading countries by changing supply and demand flow pattern. On the other hand, in the international rice market, there exists government intervention in most trading countries which causes the rice import or export market to be imperfect. Therefore, it is interesting to examine the behavior of all trading country in the rice market.

According to Love and Murniningtyas, international trade may be either controlled by government agencies (marketing boards or purchasing agencies) or intervention through policy. Such arrangements create the possibility of imperfect competition and strategic interaction among

market participants. In other words, the linkage between market conduct and performance as well as the linkage between market conduct and government policies in international trade need to be established. This method treats trade distortion measures as if the governments were exercising their market power in the world markets while looking after the interests of domestic producers and consumers. Therefore, it is important to consider government intervention in a model framework while estimating marketing structure.

The purpose of this study is to develop a procedure to determine the traders' behaviors without any pre-assumption of market structure in which imperfect competition of a general form on both the demand and supply sides is allowed. However, we allow any possible marketing structure to be solved in our model framework. A conjectural variation approach without any restriction (such as Cournot-Nash equilibrium) is used to identify traders' behaviors in an international market while solving noncompetitive spatial equilibria.

The model will be applied to the international rice market which includes all trading countries or regions. A very large proportion of international trade in rice is conducted on a government to government basis. Industrial countries export their rice under various concessional programs(Atkin, P162-163). Such a situation is suitable for our model development. The histories of the world rice market and trade structure are reviewed in section two. Section three outlines the basic trade model accounting for the possibility that both importers and exporters exercise market power in the global rice market. The empirical results are presented in section four and followed by concluding remarks in section five.

The Rice Market

According to the statistics by Food and Agriculture Organization (FAO) and International Rice Research Institute (IRRI), total rice production increased more than two folds during the past four decades (i.e., from 215 million metric tons in 1961 to 573 million in 1997). Asian countries produce 91-92 percent of the world total, with China and India accounting for more than 50 percent.

On the demand side, more than 90 percent of rice is consumed in Asia, with China, India and Indonesia accounting for 75 percent of total consumption. Although the per capita consumption levels in the high-income Asian countries are declining, the rapid population growth in the low-income countries is pushing rice consumption to increase continuously into the future. According to the IRRI (1997)'s estimation, the world's annual rough rice production will have to increase by almost 56 percent over the next 30 years to keep up with population growth and income-induced demand for food.

The amount of rice traded in the world market increased from 8 million metric tons in the 60's to about 20 million in the 90's, which is about 4 to 6 percent of total world production. The proportion of rice production that is traded internationally is small because the major rice producing countries are also major rice consumers. The introduction of high yield varieties in the major rice growing parts of Asia has made it even more of a residual market. Lack of a regular channel of trade making for relatively high search costs and government interventions to enhance self-sufficiency are also important causes for a thin market (Siamwalla and Haykin, 1983).

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 rice type 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 Asian 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, the U.S., India, and Pakistan are major export countries. They export 80 percent of world trade. The increasing dominance of these five exporters and significant government controls over exports lead to concern that they may be able to exercise market power. But evidence regarding the degree of competition is mixed. Karp and Perloff (1989) estimate the degree of competition among the exporters and find that the rice export market is close to price taking but with some degree of imperfect competition, whereas Yumkella, Unnevehr and Garcia (1994) find non-competitiveness in high-quality rice exports by the U.S. and Thailand.

On the other hand, the empirical question of whether the rice import markets are characterized by imperfect competition has not received any attention. The barriers existing in rice import markets are very complex. The major barriers are import quotas, tariffs, and bilateral agreements. Other less direct trade distorting policies include deficiency payments, input

subsidies and currency overvaluation. These trade restrictions are used by almost all developed and developing countries (Cramer, Wailes and Shui, 1993). After Uruguay Round, trade liberalization trend has opened some international rice markets. However, most imports are controlled by either the government or agricultural cooperatives to maintain their self-sufficiency levels. The imported rice are mostly distributed for specific purposes (such as processing, food aid) or by special measures to prevent their outflow into the local markets. Therefore, the perfect competition model should be modified to incorporate these common trade and domestic distortion policies. In the following section, a generalized SE imperfect competition model is developed which incorporates any degree of market structure for both importers and exporters in the world market.

An Imperfect Spatial Equilibrium Trade Model

Imperfect competition will be incorporated relying on the conjectural variations approach as in Nelson and McCarl and Kawaguchi, Suzuki, and Kaiser. Suppose there are m exporting and n importing countries. Also suppose the inverse excess supply functions for exporter $i, i = 1,...,m$, are linear and are defined as $P_i^x = c_i + d_i(E_i$ where E_i and P_i^x are the volume exported and export prices and c_i, d_i are the intercept and slope of the inverse excess supply curve for export country. Similarly, the inverse excess demand functions in importing country $j, j = 1,...n$, is $P_j^m = a_j - b_j(M_j$ where P_j^m and M_j are the import price and quantity, respectively and a and b are the intercept and slope of the inverse excess demand curve for importing country.

Suppose there is 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: $\sum_j x_{ij} = E_i$, $\sum_i x_{ij} = M_j$.

Suppose the exporting countries exert market power through government intervention to maximize profit. The objective function for the exporting country i is

$$(1) \quad \underset{x_{ij}}{Max:} p_i = \sum_j (a_j - b_j * M_j) * x_{ij} - (c_i + 0.5 * d_i * E_i) * E_i - \sum_j x_{ij} t_{ij}$$

where t_{ij} is the transportation cost per unit.

The first term in B_i represents total trade revenue generated from selling to the importing countries, 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 this objective function which is

$$(2) \quad \frac{\partial p_i}{\partial x_{ij}} = (a_j - b_j * M_j) - b_j * x_{ij}(1 + \sum_{i' \neq i} \frac{\partial x_{i'j}}{\partial x_{ij}}) - (c_i - d_i * E_i) - t_{ij}$$

$$= P_j - P_i - t_{ij} - b_j * x_{ij}(1 + \sum_{i' \neq i} \frac{\partial x_{i'j}}{\partial x_{ij}}) = 0$$

The term $\frac{\partial x_{i'j}}{\partial x_{ij}}$ in equation (2) following Varian is the conjectural variation for exporting country i, and indicates that the expected change in the i' 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 importing countries. Suppose the importing country j

maximizes consumers' surplus (or net trade surplus). Therefore, its objective function is

$$(3)\quad \underset{x_{ij}}{Max}: S_j = (a_j - 0.5 b_j * M_j) M_j - \sum_i (c_i + d_i * E_i) x_{ij} - \sum_i x_{ij} t_{ij}$$

The first term in S_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 variables are:

$$(4)\quad \frac{\partial S_j}{\partial x_{ij}} = (a_j - b_j M_j) - (c_i + d_i E_{ij}) - d_i x_{ij} (1 + \sum_{j'} \frac{\partial x_{ij'}}{\partial x_{ij}}) - t_{ij}$$

$$= P_j - P_i - t_{ij} - d_i x_{ij} (1 + \sum_{j'} \frac{\partial x_{ij'}}{\partial x_{ij}}) = 0$$

The term $\frac{\partial x_{ij'}}{\partial x_{ij}}$ in equation (4) 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 variation in equations (2) and (4) could be interpreted as trading country's behaviors resulting from government intervention. For example, if the CV in equation (2) is negative one, then the price difference will be equal to transportation cost, which implies 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 is defined as the market rent.

The conjectural variation in an imperfect SE model under Nelson and McCarl and Kawaguchi, Suzuki, and Kaiser works are assumed as constant. Such a fixed conjectural variation reflect the interaction of trading countries in a particular time because a fixed conjectural

variation implies a particular marketing structure or specific trading behavior.

The objective function of this SE model is

$$(5)\quad \underset{x_{ij}}{Max}: \mathrm{OBJ} = \sum_j [a_j - \frac{b_j M_j^2}{2}] - \sum_i [c_i + \frac{d_i E_i^2}{2}] - \sum_i \sum_j t_{ij} x_{ij}$$
$$- \sum_i \sum_j \frac{b_j}{2} (x_{ij})^2 * (1 + A_{ij}) - \sum_i \sum_j \frac{d_i}{2} x_{ij}^2 * (1 + B_{ij}).$$

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, mathematically

$$A_{ij} = \frac{\partial x_{1j}}{\partial x_{ij}} + \frac{\partial x_{2j}}{\partial x_{ij}} + \ldots \frac{\partial x_{i-1j}}{\partial x_{ij}} + \frac{\partial x_{i+1j}}{\partial x_{ij}} + \ldots \frac{\partial x_{nj}}{\partial x_{ij}}.$$

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 importers purchases, mathematically

$$B_{ij} = \frac{\partial x_{i1}}{\partial x_{ij}} + \frac{\partial x_{i2}}{\partial x_{ij}} + \ldots \frac{\partial x_{ij-1}}{\partial x_{ij}} + \frac{\partial x_{ij+1}}{\partial x_{ij}} + \ldots \frac{\partial x_{in}}{\partial x_{ij}}.$$

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 off the transport costs. Collectively, these three terms are 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 the exporting and importing market rents due to imperfect competition.

Optimizing yields the following first order conditions

$$(6)\quad \frac{\partial \mathrm{OBJ}}{\partial x_{ij}} = [a_j - b_j M_j] - [c_i + d_i E_i] - t_{ij} - b_j (1 + A_{ij}) x_{ij} - d_i (1 + B_{ij}) x_{ij} = 0.$$

, or substituting in price terms,

(7) $P_j^m - P_i^x - t_{ij} - b_j(1+A_{ij})x_{ij} - d_i(1+B_{ij})x_{ij} = 0,$

where P_j^m is the import price for importing country j,

P_i^x is the export price for exporting country i.

A wide variability 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, therefore the trade could be defined as free trade. If A_{ij} equals zero while B_{ij} equals -1, then exporting country i acted as an imperfect competitor under a Cournot-Nash equilibrium game while importer j behaves as a price-taker. If the exporter conjectural variation is positive and importer 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.,

$$\frac{\partial x_{i'j}}{\partial x_{ij}} = \frac{x_{i'j}}{x_{ij}} \text{ for all } i' \neq i,$$

then we get the case where the whole world acts as a perfectly discriminating monopolist against that importer. If the exporter's conjectural variation is smaller than -1, it implies that a subsidy policy may exist to cause the exporting price to be 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 $[d_i(1+B_{ij})x_{ij}]$.

An Approach for Optimizing the Conjectural Variations Terms

An empirical estimation procedure will be employed to find the optimal values for the conjectural variations terms which are reflective of the degree of market structures in a data set. The procedure involves an initial phase where the conjectural variations are computed based on the wedge between prices in trading countries and then a refinement procedure where the values are adjusted to achieve improved fit between 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 (7) 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, $A_{ij} = \frac{P_j^m - P_i^x - t_{ij}}{b_j(x_{ij})} - 1$ if B_{ij} = -1 for a trading pair ij where we feel the exporter has the market power. In this equation the numerator is the price wedge between the countries above the transport costs, while b_j represents the slope of j^{th} importer excess demand curve and x_{ij} is the trade flow. Similarly, B_{ij} can be computed as $\frac{P_j^m - P_i^x - t_{ij}}{d_i(x_{ij})} - 1$ if A_{ij}= -1 .

Step 3: Solve the spatial equilibrium model. Use the conjectural variation estimates (A_{ij} and B_{ij}) from step 2, then solve the spatial equilibrium model observing the quantities traded (x_{ij}).

Step 4: For each pair of countries

a) Compute the percentage deviation between optimal model trade flows

and observed trade flows. If the absolute value of this deviation is below a tolerance, the optimal trade flow is solved then go to step 4c.

b) Refine the conjectural variations since the solutions exhibit substantial deviation from observed data. The adjustment criteria depends on the sign and size of the deviation from 4a. If the solution is larger than observed data, it implies that the value of conjectural variations are underestimated to expand trade. For instance, an underestimated import tariff could allow more trade to occur. Therefore, the value of conjectural variations is increased to reduce the trade quantity. Otherwise, decrease them.

c) continue until all pairs are completed.

Step 5: If any conjectural variations were adjusted, go to step 3.

Step 6: Terminate, the conjectural variation have been adjusted to the best fit with the empirical data.

The basic nature of the CV finding approach looks for imperfectly competitive marketing structures 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 intervention. There is also additional reason why once an initial estimate of the CV's are formed we refine them through an iterative procedure. The model possesses a number of aggregate representation of regions(Appendix A). Such aggregations may cause the measurement errors in CVs because countries with very different trade practices may be being

grouped.

Application to Rice Markets

Spatial equilibrium models for rice will be specified in this imperfect competitive approach. The rice data including trade quantities and values in 1995 year are from FAO Yearbook-Trade. The elasticities of export supply and import demand are from Cramer et al. The transportation costs among trading regions basically are from Fellin and Fuller. The transportation cost is calculated as the distance of trading regions times the shipping rate of grain. Such shipping rate also depends on the shipping size. A list of all trade regions included appears in Appendix A.

The match between observed and model generated total trade data is given in Table 1. This table shows that the percentage difference for most trading regions are below 10% which validates the model.

Marketing structures and trading country's behavior can be examined by looking at the size of the estimated conjectural variations. The conjectural variations were separated into six groups as listed below in order to distinguish the marketing structures and trading countries' behaviors.

Conjectural variation Magnitude	Group Label	Code
-0.85 $\leq$ CV $\leq$ -1.00	Price-Taker	PT
-0.85 $\leq$ CV > -0.50	Low-Degree Imperfect Competitor	LDIC
-0.5 $\leq$ CV >-0.1	Middle-Degree Imperfect Competitor	MDIC
CV $\geq$-0.1	High-Degree Imperfect Competitor	HDIC

-1.00 ≥ CV >-3.00	Middle-Degree Subsidy Imperfect Competitor	MDSU
-3.00 ≥ CV	High-Degree Subsidy Imperfect Competitor	HDSU

Exporting countries' CV codes with respect to importers found in the international rice exporting markets are listed in Table 2. We found that the two major exporting countries: Thailand and the U.S. act as MDSU which indicates that these two countries' governments exercise certain type of subsidy programs to encourage rice export. Such subsidy policies may include both domestic production subsidy and export subsidy. 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 rices; 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." (P15, Wailes et al.). Similarly, the U.S. had rice farm program 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.

The other major exporting country Vietnam acted as a HDIC which indicates that Vietnam acted as a highly monopolist country with respect to her importers. It also reveals that

the price is highly distorted in the market between Vietnam and her trading partners through a licensing system and the government. Pakistan acted as either LDIC or PT which is consistent with Karp and Perloff's finding. Other exporting countries, such as Taiwan, India, and Myanmar also acted as HDIC, therefore, the prices in these markets are highly distorted as well.

The importer's behavior is listed in Table 3 and it shows that Africa, Bangladesh, Indonesia, and Korea DRP are price-takers. It implies these importing markets have no trade barrier. However, Japan, Europe, the former USSR, Brazil, and the Phillippines acted as HDIC. It suggests strong government intervention exist in their import markets and create price distortions. 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, Europe has high import levies on rice import.

Finally, it is interesting to evaluate the economic results for the simulation of WTO agreement. A free trade model is simulated here. The 1995 year situation represents the non-free trade base while all negative one conjectural variation for both importers and exporters represent the free trade. The welfare of non- free trade v.s. free trade is listed in Table 4. It shows a $1,568 million gain in the international rice market where the importing market contributes $1,154 million(74%) and the exporting country gain by $413 million if all trading countries comply with the free trade agreement. This result provides further evidence of the benefit of free trade.

Concluding Comments

This paper developed a general spatial equilibrium model which incorporated imperfect competition based on the conjectural variations approach. The model allows a procedure to be

used which solves for the marketing structure across a large number of trading countries which best fits the data. The procedure was applied to international rice markets. Most rice trading countries were found to behave as imperfect competitors in the international rice market. Such empirical results reflect that a certain degree of government interventions existed in both exporting and importing countries. The total welfare gain will be $1,568 million without any government intervention.

Table 1. Model Solution and Deviations from Observed Data

	Model Solutions (tons)	Observed Data (tons)	Deviations (%)
I. Importers			
Bangladesh	111125	908934	-87.77
China	1658982	1784104	-7.01
Indonesia	3360443	3530297	-4.81
Japan	19651	18335	-7.18
Korea DPR	533918	731172	-26.98
Phillippines	297345	294347	1.02
Other Asia	5594177	5377512	4.03
Other N&C	1629256	1569571	3.80
Europe	1157864	1096053	5.64
Former USSR	268598	262506	2.32
Brazil	933288	957075	-2.49
Africa	3894308	4148294	-6.12
TOTAL	**19458955**	**20678200**	**-5.89**
II. Exporters			
Taiwan	191491	185690	3.12
India	4885471	5512300	-11.37
Myanmar	403505	391590	3.04
Pakistan	1941146	1852200	4.80
Thailand	5800857	6197920	-6.41
Vietnam	2350975	2297200	2.34
USA	2563661	2859270	-10.34
Other S.Amer	802069	865880	-7.37
Australia	520186	510850	1.83
TOTAL	**19459361**	**20672900**	**-5.87**

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. Exporter Behavior with Respect to Exporters in Rice Markets

Exports' Behavior	Importing Marketing Structure
Taiwan	HDIC
India	MDIC
Myanmar	HDIC
Pakistan	LDIC or PT
Thailand	MDSU or PT
Vietnam	HDIC
USA	MDSU
Other S. Amer	HDSU
Australia	HDSU

Note: PT represents a price taker;
LDIC represents a Low-degree imperfect competitor;
MDIC represents a Middle-degree imperfect competitor;
HDIC represents a High-degree imperfect competitor,
MDSU represents a Middle-degree subsidy,
HDSU represents a High-degree subsidy.

Table 3. Importer Behavior with Respect to Exporters in Rice Markets

Importer's Behavior	Exporting Marketing Structure
Bangladesh	PT
China	MDSU
Indonesia	PT
Japan	HDIC
Korea DRP	PT
Phillippines	HDIC
Other Asia	MDIC
Other N&C	LDIC
Europe	HDIC
Former USSR	HDIC
Brazil	HDIC
Africa	PT

Table 4. Welfare Comparison with and without Free Trade

	Non-Free Trade (million dollars)	Free Trade (million dollars)	Gain by Free Trade (Million Dollars)
Importers	4708.05	5862.60	1154.55
Exporters	2675.08	3088.54	413.46
Total Welfare	7383.13	8951.14	1568.01

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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
Phillippines	Phillippines
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	
Taiwan	Taiwan
India	India
Myanmar	Myanmar
Pakistan	Pakistan
Thailand	Thailand
Vietnam	Vietnam
USA	USA
Other S. Amer	Argentina, Colombia, Ecuador, Guyana, Peru, Surinam, Uruguay, Venezuela, other South America
Australia	Australia

Appendix B Conjectural variations found in Rice markets

Table I. Conjectural Variations for Rice Exporter with Respect to Importer

Exporting Country	Taiwan	India	Myanmar	Pakistan	Thailand
Importing Country					
Bangladesh				-2.020	-1.525
China	34.783		27.301	-1.135	-1.360
Indonesia	46.187	0.581	34.301	-0.493	-1.490
Japan		0.581		-0.965	-0.991
Korea DRP				-1.125	-1.087
Phillippines		0.581			-1.009
Other Asia		0.581	33.255	0.577	-0.746
Other N&C		0.581		-0.752	-1.008
Europe	32.412	0.581		-0.490	-0.872
Former USSR		0.581		-0.864	-0.993
Brazil					-0.921
Africa	36.548	0.581	28.793	-0.503	-1.211

Exporting Country	Vietnam	USA	Other S.Amer	Australia
Importing Country				
Bangladesh		-2.410		
China	4.770	-2.211		-11.179
Indonesia	5.926	-2.765		-17.334
Japan		-1.214		-0.918
Phillippines	4.036	-1.287		
Other Asia	5.713	-0.841	-1.914	-1.717
Other N&C		-1.238	-2.484	-2.453
Europe	4.283	-0.965		0.029
Former USSR		-1.231		

Brazil	4.673	-1.067	-1.903	
Africa	4.810	-1.851	-5.603	-8.957

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

Importing Country	Bangladesh	China	Indonesia	Japan	Korea DRP	Phillippines
Exporting Country						
Taiwan		-0.664	-1.037			
India			-0.655	2437.839		3.400
Myanmar		-0.395	-0.858			
Pakistan	-0.123	-0.732	-1.069	965.476	-1.132	
Thailand	-0.944	-1.421	-1.076	1368.640	-1.132	3.400
Vietnam		0.148	-0.557			3.400
USA	-0.944	-1.725	-1.076	1126.972		3.400
Other S.Amer						
Australia		-1.725	-1.076	939.108		

Importing Country	Other Asia	Other N&C	Europe	Former USSR	Brazil	Africa
Exporting Country						
Taiwan			13.746			-0.968
India	0.969	-0.520	12.920	6.500		-0.437
Myanmar	-0.149					-0.802
Pakistan	-0.479	-0.461	13.424	6.909		-0.991
Thailand	-0.269	-0.520	12.920	7.184	2.352	-1.003
Vietnam	0.362		12.920		1.600	-0.578
USA	-0.436	-0.520	12.920	6.500	1.945	-1.003
Other S.Amer	-0.511	-0.520			1.693	-1.003

Australia	-0.520	-0.520		-1.003