ELSEVIER

Agricultural Economics 10 (1994) 257–267

AGRICULTURAL ECONOMICS

International trade in a differentiated good: Trade elasticities in the world rice market

Mercedita C. Agcaoili-Sombilla *, Mark W. Rosegrant

International Food Policy Research Institute, 1200 17th St N.W., Washington, DC 20036-3006, USA

(Accepted 26 July 1993)

Abstract

In many previous rice trade models, the commodity has been regarded as a homogeneous product. However, homogeneity is not an appropriate assumption, given the various types of rice that are traded and consumed. Parameters estimated from these models, therefore, do not reflect the real world market for rice and, hence, may mislead decision makers who use the results for policy evaluation purposes. This study uses an Armington approach to model the world rice trade as a differential good market and to derive trade elasticity parameters.

1. Introduction

Rice is the staple food of one-third of the world population. In developing Asia, rice production accounts for a large share of farm area cultivated and contributes significantly to total agricultural production. In South Asia (India, Bangladesh, Pakistan), rice accounts for 49% of average total foodgrain production in 1966 to 1988, and in Southeast Asia it accounts for 64%. For several countries, including Thailand, Pakistan and the United States, rice exports are important earners of foreign exchange.

Because of the economic and political importance of rice, a number of economic studies on the structure and conduct of its market have been undertaken. Past studies on the world rice trade have treated the commodity as a homogeneous product (Adams and Behrman, 1976; Tyers and Anderson, 1989; Zhang, 1990; Roningen and Dixit, 1989). However, the appearance, quality and taste of rice vary due to differences in the grading systems and marketing and processing facilities of trading countries. Tastes and preferences can be as important as prices in buyers' consideration. The four main types of rice consumed in the world are *indica, japonica*, glutinous and aromatic. These are further fragmented by grades and qualities as shown in Table 1, and price differentials among them can vary (Zhang, 1990). The different demand responses for the various types of rice need to be captured in modeling the international rice market.

This paper estimates an import demand system assuming that rice is a differentiated product. Product differentiation is achieved by using the Armington approach (1969) which distin-

* Corresponding author.

SSDI 0169-5150(93)E0040-T

guishes rice by country of origin. [1] The estimation of the import demand system yields expenditure and trade elasticities which are used to explain rice trade flows.

Ito et al. (1989) also employed the Armington approach to explain the international rice trade. This study extends that of Ito et al., by providing more detailed coverage of the importing and exporting countries, thereby reflecting more rigorously the interdependent relationships of rice traders; and by the use of a more flexible functional form in the estimation of the import demand system. Ito et al. used a modified CES model while this study uses the Linear Approximate/Almost Ideal Demand System (LA/AIDS) in the empirical estimation of the import demand systems. Both the modified CES and LA/AIDS are flexible, in that they allow the elasticity of substitution to vary across products and relax the homotheticity assumption in single-CES functions. However, the theoretical plausibility of the modified CES specified in double log form is questionable because of its failure to satisfy the adding-up restriction exactly (Phlips, 1983, p. 113). In LA/AIDS, the demand restrictions can be easily tested and applied.

The paper proceeds with a brief discussion of the derivation of the import demand system, its empirical estimation, and the calculation of trade and expenditure elasticities. This is followed by a description of the data used and their sources. Finally, results of the empirical analysis and policy simulations are presented and their implications for rice trade discussed.

2. Model specification and estimation

Trade models which assume product differentiation usually employ the two-stage budgeting procedure where at the first stage, a country decides how much to purchase of a commodity, and at the second stage, allocates total expenditure among different suppliers. The procedure assumes weak separability between rice and all other goods so that the marginal rate of substitution between any two rice products is independent of the quantities of any other goods con-

Table 1
Major traders by type of rice

Rice type/Quality	Major growers	Major exporters	Major importers
Brown rice: regular			S. Korea, Portugal
Brown rice: parboiled			EC 12, Canada, S. Africa
Japonica	Japan, S. Korea, N.Korea Taiwan, parts of China Australia, Mediterranean Region, Brazil, U.S.	U.S., Italy, Spain, Australia, N. Korea	Singapore, S. Korea, Central and S. America
Indica/well milled:			
broken		Thailand, Burma	Senegal, Madagascar, Mauritania, Gambia, S. Vietnam
low		Thailand, Pakistan, China, Burma	Indonesia, West Africa
medium		U.S., Thailand, Pakistan	Brazil, Hong Kong, USSR, Malaysia, Indonesia,
high		U.S., Thailand	U.S., W. Europe, Uruguay, Argentina, Iran, Iraq, Singapore, Hong Kong, Malaysia
Indica/parboiled:			
low		Burma, Thailand	Sri Lanka, Bangladesh, Liberia
high		U.S., Thailand	S. Arabia, Nigeria, EC 12, Canada, S. Africa

Source: Adapted from Slayton, 1984.

sumed. For the purpose of estimating the rice import demand system, total import expenditure (E) of each country can be treated as exogenously determined, or can be estimated endogenously, based on maximization of utility of total consumption (Armington) or through estimation of net import demand as the residual between domestic supply and consumption. In this analysis, following Ito et al., total rice import expenditures are treated as exogenous, and the set of import share demand equations derived are specified in terms of the linear form of the Almost Ideal Demand System (AIDS).

The AIDS is derived by use of duality concepts, where it is assumed that market demands result from a preference ordering derived from a required expenditure necessary to achieve a given utility level at a given set of prices (Deaton and Muellbauer, 1980). First specify the cost function as:

$$\log C(U, p) = \alpha_0 + \sum_j \alpha_j \log p_j + \tfrac{1}{2}\sum_j \sum_i \tau_{ji}^* \log p_i + U\beta_0 \prod_j^{\beta_j} \quad (1)$$

where C denotes the cost function, U represents the unobservable utility parameter, β_0 is the non-estimable cost parameter, p_j's are prices, and α_j, τ_{ji}^*, and β_j are parameters to be estimated. By Sheppard's Lemma, the price derivative of Eq. (1) yields the quantities demanded, and multiplying by $p_j/C(U, p)$ yields the minimum expenditure function, ω_j:

$$\frac{\partial \log C(U, p)}{\partial \log p_j} = \frac{p_j q_j}{C(U, p)} = \omega_j \quad (2)$$

Logarithmically differentiating Eq. (2) and inverting the cost minimizing expenditure function yields the AIDS demand functions in expenditure (budget) form:

$$\omega_{ji} = \alpha_{ji} + \sum_i \tau_{ji} \log p_{ji} + \beta_{ji} \log(Y/P) \quad (3)$$

$$\text{for } j, i = 1, \ldots, n$$

where P is a price index defined by:

$$\log P = \alpha_0 + \sum_j \alpha_j \log p_j + \tfrac{1}{2}\sum_j \sum_i \tau_{ji}^* \log p_j \log p_i \quad (4)$$

Approximating P with the Stone's price index, $\log P^* = \Sigma_j\ \omega_j \log p_j$, yields the Linear Approximate/AIDS:

$$\omega_{ji} = \alpha_{ji} + \sum_{i=1}^{n} Y_{ji} p_{ji} + \beta_{ji} \log(E/P^*) \quad (5)$$

The dependent variables, $\omega_{ji} = E_{ji}/E_i$, are budget shares showing the proportion of rice imports from country j to total imports of country i; p_{ji} are import prices from source j; and E is country i's total rice import expenditure, obtained by summing the individual expenditures on imports from various country suppliers.

Since each equation represents an import budget share, there are as many equations as the number of the importing countries multiplied by the number of their trading partners. These equations represent the demand behavior of each trading country and, hence, are not independent from each other. Thus, the system is estimated using the seemingly unrelated regression technique in order to take account of the simultaneous nature of the equations. Because of the system's adding-up condition, the contemporaneous covariance matrix is singular. The standard procedure to correct this problem is to arbitrarily delete an equation (Berndt and Savin, 1975; Pindyck and Rubinfeld, 1981; Theil, 1980). In this case, the import demand equations for the Rest of the World (ROW) are deleted.

The adding-up property (i.e., $\Sigma_j\ \alpha_j = 1$, $\Sigma_i\ \gamma_{ji} = 0$ and $\Sigma_j\ \beta_j = 0$), the homogeneity condition (i.e., $\Sigma_j\ \gamma_{ij} = 0$) and symmetry restrictions (i.e., $\gamma_{ij} = \gamma_{ji}$) are incorporated and tested in the demand system estimation. Initial estimation indicated the presence of autocorrelation, so the final equations are estimated with correction for autocorrelation. This correction improved the significance of the parameter estimates and in some cases corrected their signs in accordance to theoretical expectations.

3. Trade elasticity estimation

Using the parameters estimated in Eq. (5), the uncompensated import price elasticities, ϵ_{ji}, and expenditure elasticities, ν_{ji} in LA/AIDS are computed using the following formula derived by Green and Alston (1990, 1991) for LA/AIDS:
- price elasticity

$$\epsilon_{ji} = \delta_{ji} + \frac{Y_{ji}}{\omega_i} - \frac{\beta_j}{\omega_j}\left[\omega_i + \sum_k \omega_k \ln P_k(\epsilon_{ki} + \delta_{ki})\right] \quad (6)$$

- expenditure elasticity

$$\nu_{ji} = 1 + \frac{\beta_j}{\omega_j}\left[1 - \sum_j \omega_j \ln P_i(\nu_{ji} - 1)\right] \quad (7)$$

where $\delta_{ji} = -1$ when $i = j$, and 0 otherwise; γ_{ji} are the coefficients of the unit import prices; β_j are the coefficients of the import expenditure variables; and ω_j are the budget shares.

On the other hand, export demand elasticities, ED_j, in the presence of product heterogeneity, take into account the feedback effect of changes in the price of a product on the demand for other products. The total elasticity concept of Buse (1958) is employed to estimate these parameters as follows:

$$\text{ED}_j = \xi_j + \sum_{i=1}^{n} \kappa_{ji}\tau_{ij} \quad (8)$$

where $\xi_j = \Sigma_i\, h_{ji}\epsilon_i$ is the partial export demand elasticity; ϵ_i are the own-price elasticities of a product in different import markets; and $h_{ji} = m_{ji}/X_j$ is the market share of country i's imports in country j's total export X_j. The remaining components are the sum of the product of: κ_{ji}, the cross-import demand price elasticities for product produced in country j with respect to the price of the product produced in country i; and $\tau_{ij} = (S_{ij} - \kappa_{ij})/(\xi_i - s_i)$, the price transmission elasticity, where S_{ij} is the cross-price elasticity of supply of product produced in country i with respect to the price of the product produced in country j (this is equal to zero in the trade context), κ_{ij} is the cross-price elasticity of demand for product produced in country j with respect to the product in country i, ξ_i is partial export demand elasticity for product produced in country i, and s_i is the supply elasticity for product produced in country i.

It should be noted that the price transmission elasticity in the study differs from the "true" definition of the concept which measures the response of internal domestic prices to changes in border prices (Bredahl et al., 1979). The price transmission elasticity here focuses on the response of one country's border price to that of another country's border price.

4. Data

The most crucial data for the study are the rice trade flow between countries. The world rice market is thin (with only 4% of total production traded) and countries frequently move in and out of the international market (Siamwalla and Haykin, 1983). The thin market poses some problems in identifying consistent rice trade partners for the time period covered. To solve this problem and facilitate the estimation of the model, the world was divided into four importing regions: [2] Asia (Indonesia, India, Japan, Malaysia, and Rest of Asia); Europe (EC 12 and Rest of Europe); Middle East/Africa; and the Rest of the World. The major rice exporting countries included: Thailand, Burma/Pakistan, [3] United States, EC 12, Australia and Africa, with all other exporting countries aggregated together as the Rest of the World exporters.

The primary data on volume and value of rice imports by country of origin from 1961 to 1987 were taken from the United Nations Commodity Trade Statistics. [4] China, which accounts for about 10% of world exports, was not included in the study because it did not report its trade activities to the United Nations, and a comparable data series is not available. Unit import prices, import budget shares, and total import expenditures on rice were estimated from the UN trade data. Supplementary information on rice trade were obtained from IRRI's World Rice Statistics and USDA's Rice Commodity Situation and Outlook.

Table 2
Parameter estimates of the import demand system: Regional groups (homogeneity and symmetry restrictions imposed)

	Constant	BurPak price	Thai price	USA price	EC 12 price	Aust. price	African price	ROW price	Expend. coef.	*F*-test Homo.	Symm.	Durbin–Watson
ASIA												
BurPak	1.024	0.086	-0.074	0.069		0.002		-0.083	-0.105	1.289	1.487	2.023
	1.831	**2.966**	**-2.468**	**2.375**		**0.254**		**-2.901**	**-1.532**			
Thai	1.610	-0.074	0.262	-0.092		-0.0003		-0.096	-0.150	2.263 *		1.710
	2.403	**-2.468**	**4.710**	**-2.301**		**-0.003**		**-2.273**	**-1.829**			
USA	-0.639	0.069	-0.092	0.029		-0.005		-0.001	0.102	0.022		2.153
	-1.201	**2.375**	**-2.301**	**0.802**		**-0.921**		**-0.046**	**1.552**			
Australia	0.087	0.002	-0.0003	-0.005		0.008		-0.004	-0.009	0.029		2.186
	1.038	**0.254**	**-0.003**	**-0.921**		**1.110**		**-0.631**	**-0.858**			
ROW	-1.083	-0.083	-0.096	-0.001		-0.004		0.185	0.162			
EUROPE												
BurPak	0.263	0.073	-0.013	0.001	-0.033	-0.012	-0.011	-0.005	-0.026	3.875 *	4.306	1.442
	1.030	**4.904**	**-3.162**	**0.007**	**-1.321**	**-2.545**	**-0.695**	**-0.248**	**-0.775**			
Thai	-0.493	-0.013	0.009	0.037	0.011	-0.007	0.007	-0.045	0.077	6.183 *		2.181
	-2.648	**-3.162**	**1.467**	**4.207**	**0.740**	**-2.023**	**0.710**	**-2.702**	**3.126**			
USA	0.143	0.001	0.037	0.025	-0.063	0.009	0.005	-0.013	0.009	7.745 *		1.713
	0.613	**0.007**	**4.207**	**0.883**	**-2.557**	**1.083**	**0.331**	**-0.764**	**0.291**			
EC 12	-0.697	-0.033	0.011	-0.063	0.208	0.008	-0.067	-0.064	0.127	2.773 *		1.593
	-1.276	**-1.321**	**0.740**	**-2.557**	**3.019**	**1.000**	**-2.318**	**-1.265**	**1.745**			
Australia	-0.082	-0.012	-0.007	0.009	0.008	0.010	0.017	-0.026	0.014	1.340		1.741
	-1.120	**-2.545**	**-2.023**	**1.083**	**1.000**	**1.736**	**4.435**	**-4.882**	**1.391**			
Africa	1.020	-0.011	0.007	0.005	-0.067	0.017	-0.042	0.090	-0.122	3.198 *		1.527
	2.093	**-0.695**	**0.710**	**0.331**	**-2.318**	**4.435**	**-1.403**	**2.435**	**-1.879**			
ROW	0.845	-0.006	-0.045	-0.014	-0.064	-0.026	0.090	0.063	-0.079			
MIDDLE EAST/AFRICA												
BurPak	0.028	0.200	-0.006	-0.158	0.014		-0.023	-0.026	0.027	5.993 *	8.854	1.246
	0.369	**4.750**	**-0.193**	**-6.001**	**1.700**		**-2.368**	**-1.062**	**2.686**			
Thai	-0.361	-0.006	0.038	-0.087	-0.028		0.026	0.058	0.071	1.864 *		1.209
	-3.398	**-0.193**	**0.899**	**-2.353**	**-2.553**		**1.950**	**1.970**	**4.960**			
USA	0.489	-0.158	-0.087	0.283	-0.004		0.015	-0.050	-0.025	0.520		2.705
	2.151	**-6.001**	**-2.353**	**6.579**	**-0.318**		**1.210**	**-1.582**	**-0.834**			
EC 12	0.066	0.014	-0.284	-0.004	0.022		-0.028	0.024	-0.001	2.206 *		1.801
	1.526	**1.700**	**-2.553**	**-0.318**	**2.686**		**-5.504**	**2.566**	**-0.261**			
Africa	0.440	-0.235	0.026	0.015	-0.028		-0.004	0.015	-0.051	1.964 *		2.440
	6.372	**-2.368**	**1.950**	**1.210**	**-5.504**		**-0.605**	**1.799**	**-5.675**			
ROW	0.339	0.186	0.313	-0.050	0.024		0.015	-0.022	-0.022			
REST OF THE WORLD												
BurPak	-0.314	-0.359	0.093	0.088	0.019	0.010	0.034	0.115	0.104			
Thai	0.243	0.093	-0.308	0.142	0.017	0.007	-0.033	0.083	0.003			
USA	1.007	0.088	0.142	-0.337	0.067	-0.004	-0.020	0.064	-0.086			
EC 12	1.631	0.019	0.273	0.067	-0.230	-0.008	0.095	0.039	-0.126			
Australia	0.994	0.010	0.007	-0.004	-0.008	-0.018	-0.017	0.030	-0.005			
Africa	-0.460	0.246	-0.033	-0.020	0.095	-0.017	0.046	-0.105	0.172			
ROW	0.899	-0.096	-0.173	0.065	0.039	0.030	-0.105	-0.226	-0.062			

Bold figures are *t*-values.
Blank entries indicate the absence of significant trade between countries/regions.
* Significant at 1% level.
Test for symmetry condition was significant for Europe and Middle East/African regions but not for Asia.

5. Import demand system parameter estimates

Results of the estimation of the import demand systems, restricted for homogeneity and symmetry, are shown in Table 2. As can be noted, homogeneity and symmetry restrictions cannot be rejected for the import demand systems estimated for Europe and Middle East/Africa. These restrictions are, however, rejected in the import demand system for Asia. [5]

The estimated model shows a good fit, with R^2 no lower than 0.80. The estimated expenditure coefficients are mostly significant. Likewise, almost all own-import price coefficients are of the expected positive signs and are significant, with t-values of 2.0 or greater. Signs are counterintuitive in only two import expenditure share equations – the Australian rice export share in Europe, and the African export share in Middle East/Africa. The positive sign suggests that as the price of a product increases, its import expenditure share also increases. More than 50% of the cross-import price parameter estimates are also significant, and their signs indicate the substitutability (positive cross-import price coefficient) or complementarity (negative cross-import price

Table 3
Uncompensated import demand price and expenditure elasticities: Regional groups (homogeneity and symmetry restrictions imposed on the parameters)

	BurPak price	Thai price	USA price	EC 12 price	Aust. price	African price	ROW price	Expenditure elasticity
ASIA								
BurPak	−0.369	−0.233	0.543	–	0.020	–	−0.329	0.368
Thai	−0.151	−0.017	−0.197	–	0.006	–	−0.172	0.529
USA	0.250	−0.607	−0.955	–	−0.033	–	−0.143	1.488
Australia	0.218	0.188	−0.248	–	−0.456	–	−0.103	0.381
ROW	−0.376	−0.509	−0.112	–	−0.021	–	−0.527	1.546
EUROPE								
BurPak	−0.027	−0.144	0.055	−0.292	−0.145	−0.119	−0.002	0.673
Thai	−0.306	−0.938	0.455	−0.341	−0.154	0.047	−1.092	2.328
USA	−0.002	0.193	−0.876	−0.355	0.049	0.024	−0.079	1.046
EC 12	−0.124	0.007	−0.263	−0.498	0.014	−0.238	−0.282	1.383
Australia	−0.936	−0.567	0.552	0.176	−0.237	1.223	−2.189	1.979
Africa	−0.037	0.134	0.206	−0.170	0.171	−1.291	0.975	−0.013
ROW	−0.005	−0.166	−0.003	−0.141	−0.104	0.402	−0.666	0.683
MIDDLE EAST/AFRICA								
BurPak	−0.080	−0.041	−0.798	0.057	–	−0.117	−0.139	1.128
Thai	−0.090	−0.852	−0.541	−0.153	–	0.106	0.225	1.330
USA	−0.497	−0.274	−0.049	−0.007	–	0.051	−0.150	0.920
EC 12	0.224	−4.553	−0.048	−0.648	–	−0.446	0.393	0.976
Africa	−0.286	0.611	0.703	−0.496	–	−1.041	0.443	−0.007
ROW	−0.141	2.044	−0.266	0.166	–	0.106	−1.123	0.861
REST OF THE WORLD								
BurPak	−8.800	2.016	1.905	0.409	0.219	0.743	2.489	3.518
Thai	0.605	−3.008	0.924	0.113	0.045	−0.218	0.541	1.018
USA	0.217	0.351	−1.835	0.165	−0.010	−0.049	0.159	0.804
EC 12	0.854	12.385	3.028	−11.423	−0.347	4.308	1.790	−4.078
Australia	0.079	0.054	−0.033	−0.060	−1.142	−0.134	0.237	0.963
Africa	1.859	−0.253	−0.150	0.718	−0.129	−0.650	−0.795	2.575
ROW	−0.971	−1.745	0.657	0.398	0.303	−1.062	−3.287	0.409

– indicates the absence of significant trade between countries/regions.

coefficient) of rice products. These will be discussed in terms of trade elasticities in the next section.

6. Necessary versus luxury import rice products

The signs of the expenditure coefficients in Table 2 identify which rice products are considered necessary ($\beta < 0$) import commodities and which are luxury ($\beta > 0$) import items (Deaton and Muellbauer, 1980). The results confirm that rice is a basic necessity in the Asian countries, where β-coefficients estimated for rice from all sources are negative except those coming from the United States. As has been mentioned earlier, U.S. rice exports are primarily the premium-quality *indica* rice that command relatively high prices in the world market. On the other hand, most rice products entering the European markets are considered luxury import commodities, while in the Middle East/African markets only BurPak and Thai rice are luxury commodities. The latter result is due to the rapid increase in demand for high-quality *indica* and *basmati* rice in the Middle East and the oil-rich countries of North Africa.

7. Import demand price and expenditure elasticities

The complete matrix of price and expenditure elasticities of import demand for the different regional markets is given in Table 3. Values in Table 3 are interpreted as follows: the own-import price elasticity of demand for Burmese/Pakistani (BurPak) rice in Asia is −0.369; and the cross-import price elasticity of demand for BurPak rice in Asia with respect to the price of rice from Thailand is −0.233. Price elasticities are largely in accordance with a priori expectations, with all own-import price elasticities being negative. Cross-import price elasticities are either positive or negative. Positive cross-import price elasticities suggest substitutability between two rice products. Negative cross-import price elasticities, on the other hand, indicate a complementary relation between the products. A complementary relationship can occur for staple foods (such as rice) with a relatively fixed expenditure outlay, and own-price elasticities less than one (Pitts and Herlihy, 1982). As can be seen in Table 3, this relationship occurs in a number of cases. In such cases, when the price of one rice product goes up, consumption of other rice products may decrease.

The import demand price elasticities are generally small, especially in the Asian markets, where only the own-import demand price elasticity for U.S. rice approaches 1.0 in absolute value. [6]

Cross-import demand price elasticity estimates are similarly small. These indicate inelastic responses to price changes, which can be attributed to rice being a major staple food in the region. The elasticities, however, vary in magnitude, showing that the degree of substitutability (or complementation) between rice products from different sources are not equal. This further shows the variation in consumer demand response for rice from different countries, and demonstrates the importance of differentiating rice by quality.

In the European markets, Thai and U.S. rice import demand elasticities are also close to 1.0. These relatively high elasticity values can be explained by the growing preference for *indica* in the region, particularly in Northern Europe. An indication of this changing preference is the European Community policy of paying farmers a production subsidy of approximately $400 per hectare to convert production from *japonica* to *indica* (Bateman, 1988). Thai and U.S. rice exports in the region are primarily the *indica* type.

Own-import demand price elasticities in the Middle East and African countries are small except for Thai rice (close to 1.0) and African rice (−1.041). The relatively high import price elasticity for Thai rice explains its growth in demand vis-a-vis that of U.S. rice, particularly in the Middle East countries during the 1980's, in response to price policy adjustments undertaken by both countries. The decline in world rice prices during this period has apparently favored Thai rice. The price elastic import demand for African rice, on the other hand, indicates the tendency for African consumers to shift from root crops, which is their major staple food, or from African rice (which is considered of low quality) to rice from other exporters as world rice prices fall.

The own-price elasticities of import demand in the Rest of the World countries are generally elastic in all markets. This is expected since the residual group consists of countries that significantly differ geographically and economically, many of which consume staple foods other than rice.

The expenditure elasticities (reported in the last column of Table 3) are mostly positive, indicating that rice products are regarded to be normal import goods. African rice in Europe and the Middle East/African markets and EC 12 rice in the Rest of the World market are, however, inferior import products. The inferior good nature of African rice is a plausible result, since African rice is of relatively inferior quality compared to rice from other countries. Consumer attitudes in the Rest of the World toward the EC 12 rice, on the other hand, is possibly an influence of the EC's market protection policies. Rice products from almost all sources are expenditure-elastic in Europe and Middle East/African markets. Only U.S. rice is expenditure-elastic in Asia.

8. Export demand elasticities

Partial and total export demand elasticities, calculated as described above, are shown in Table 4. Domestic price elasticities of supply and demand and income elasticities of demand for rice used in computation of the Buse elasticities are taken from Agcaoili-Sombilla (1991) and reported in the first footnote to Table 4. For comparative purposes, Column 1 of Table 4 depicts elasticities calculated under the assumption of product homogeneity. This assumes a single clearing price (implicit in the assumption of product homogeneity) and uses data on aggregate quantities of exports, domestic supply and demand, and the domestic supply and demand elasticities. Demand elasticities for the world market are derived by summing the trade weighted regional and country elasticity estimates. The trade weights

Table 4
Export demand elasticities [a] (computed at the means)

Export countries	Perfect substitutes [b]	Imperfect substitutes [c]							
		Partial elasticities				Total elasticities			
	World (1)	Asia (2)	Europe (3)	Mid/Afr. (4)	World (5)	Asia (6)	Europe (7)	Mid/Afr. (8)	World (9)
Bur/Pak	−1.39	−2.213	−0.063	−0.932	−1.101	−0.907	−0.827	−0.714	−0.684
Thailand	−0.64	−3.182	−1.629	−2.153	−2.090	−2.574	−1.393	−2.286	−1.887
USA	−0.67	−2.227	−1.300	−1.408	−1.453	−1.752	−0.542	−1.154	−1.087
EC 12	−1.46	−0.617	−0.920	−1.658	−0.918	−0.493	−1.305	−1.663	−0.778
Australia	−1.65	−1.974	−0.320	–	−0.739	−1.857	−0.184	–	−0.678
Africa	−9.3	–	−1.348	−1.735	−0.792	–	−0.765	−1.812	−0.731
ROW	–	−2.838	0.180	−1.381	−1.436	−2.838	0.373	−0.588	−1.137

[a] Domestic price supply and demand elasticities by country are, respectively: India, 0.05 and −0.06; Indonesia, 0.01 and −0.04; Japan, 0.01 and −0.04; Malaysia, 0.18 and −0.04; Rest of Asia, 0.05 and −0.05, Africa, 0.04 and −0.34; Middle East, 0.43 and −0.48; EC12, 0.16 and −0.55; Rest of Europe, 0.85 and −0.05; Australia, 0.75 and −0.47; Burma/Pakistan, 0.09 and −0.12; Thailand, 0.11 and −0.02; U.S.A., 0.14 and −0.55.

[b] Computed using domestic price supply and demand elasticities, weighted by the share of exports to total demand and to total supply, respectively. No export demand elasticity is reported for ROW in column (1) since domestic supply and demand elasticities were not computed for the ROW group of exporters in the study.

[c] Computed using price elasticities derived from import demand system parameters.

are the percentages of total competing exports sent to each importing region/country.

The elasticities derived under the assumption that rice is a homogeneous product show that export demand of the commodity faced by most of the exporters is generally elastic. The exceptions are Thailand and the United States, the two major exporters of the commodity, where export demand elasticities were estimated at −0.64 and −0.67, respectively. These results are expected since the magnitude of the export demand elasticities in absolute terms depend on the share of the exporter in supplies and demands of other regions in the market. The most elastic estimates are those for the African (−9.3) and Australian exporters (−1.65).

Columns 2 to 5 of the same table show the partial export demand elasticities while the last four columns show the total export demand elasticities. As can be noted, the partial elasticities are different from the total export demand elasticities, but their differences are relatively small for most countries. This is due to the relatively small values of price transmission elasticities, indicating that a price change for one rice product does not have a significant impact on prices of other rice products. [7] The small price transmission elasticities may be due to the market protection policies practiced by many rice-trading countries. These seem to create distinct areas of price determination, between which rice prices bear little relation to each other. This further shows the relative independence of the different rice markets from each other, thereby, providing stronger support for the assumption that rice products from one country cannot perfectly substitute for rice products from other countries.

In the export demand elasticity formulation, rice products are either competing or complementary with rice products from other sources, depending as to whether their total export demand elasticities (ED_j) are less than or greater than their corresponding partial export demand elasticities (ϵ_j) in absolute terms. Rice from the different exporters are generally competing products. In the Middle East/African markets, rice from the different suppliers are shown to be complementary to each other, possibly as a result of institutional arrangements and food aid and other special assistance programs afforded to many African countries.

Table 5 shows the average total export demand elasticities computed for periods from 1962/67 to 1982/87. It depicts the relative performance of the different export markets over time. Export demand for Thai rice has remained elastic throughout all periods in all regional markets. The export market for United States weakened in the 1970's but recovered in 1982/87 as a result of the policy reforms embodied in the Agricultural and Security Act of 1985, which made U.S. rice prices more competitive vis-a-vis the other exporters. The average export demand elasticities facing Australia are relatively small, re-

Table 5
Total export demand elasticities, 1962/67–1982/87

Exporters	Importers								
	Asia			Europe			Middle East/Africa		
	1962/67	1972/77	1982/87	1962/67	1972/77	1982/87	1962/67	1972/77	1982/87
BurPak	−2.28	−0.38	−1.03	−0.92	−0.32	−0.83	−0.84	−0.65	−0.41
Thailand	−1.29	−2.11	−2.36	−1.46	−0.86	−1.52	−2.65	−1.97	−1.98
USA	−6.86	−1.1	−2.51	−0.14	0.07	−0.43	−1.34	−0.99	−0.68
EC 12	−0.75	−0.29	−0.59	−0.75	−1.01	−13.89	−1.63	−1.68	−1.7
Australia	−0.64	−2.06	−1.96	0.14	−0.004	−0.42	–	–	–
Africa	–	–	–	−1.29	−0.79	−0.57	−1.69	−1.63	−1.65
ROW	−0.8	−3.21	−2.19	−0.05	−0.44	0.6	−0.34	−0.61	0.05

Computed using mean expenditure for periods indicated.

flecting its long-term export market development strategy while maintaining overall export volume in balance with traditional market requirements.

9. Conclusions

This paper has utilized an Armington approach to model the world rice trade as a differential good market. Results of this study show the large cross-country variation in trade elasticities under the differentiated product assumption. The elasticities clearly indicate the larger response in the volume of rice trade to export price changes than would be predicted from the own-price elasticities of imports. They, likewise, confirm the strong competition between the United States and Thailand in the world export market, an indication of the strong tendency for any aggressive pricing policy in major exporting countries to significantly affect relative market shares. Various country policies are expected to have a differential impact in the world rice market, which is characterized by highly elastic export demand responses, in a very unstable import market. The detailed matrix of trade elasticities provides the foundation for analyzing the differential impact on rice trade of government policies, such as changes in import or export taxes and subsidies.

The incorporation of a differentiated rice product is an important component in modeling the world rice trade. Because the world rice market is a residual market, a further significant extension would be the incorporation of dynamic supply and demand effects in trade models. Further research in rice trade modeling should include endogenous determination of key factors that determine supply and demand, including both direct response and changes in investment and government policies, all of which determine the future developments and trade patterns of rice.

Endnotes

[1] Ideally, the rice trade model would be estimated with differentiation by each of these types of rice but time series data are not available at this level of disaggregation. However, among the large exporting countries, there appears to be fairly clear distinctions according to type and quality of rice exports to particular regions. For example, Burma and China predominantly supply low-quality *indica* rice, and sales are mostly to other Asian countries or to Africa. In contrast, the U.S. sells mainly the high-quality *indica* to Europe and the Middle East. Thailand exports both high and low-quality *indica* and its markets for the two types are geographically dispersed and differentiated. Differentiation by country of origin, therefore, closely approximates differentiation by type and quality.

[2] Japan actually exported rice for some years during the study period as a result of high support prices afforded to the domestic producers. Without this protection, Japan would be importing rice (Cramer et al., 1990).

[3] Burma ceased to be a major rice exporter in the mid-70s at the time Pakistan started to play a more significant role in rice trade. This is the reason for the aggregation despite the differences in product quality.

[4] Edited UN data on bilateral (country-to-country) rice exports and imports are available through 1990 from the USDA. However, the detailed value of trade data required to generate the implicit prices on bilateral trade have not been fully edited after 1987. The trade value data which are currently available for the years 1988–90 are both internally inconsistent and inconsistent with the 1962–1987 data set developed for the research reported here.

[5] Previous studies have similarly rejected both restrictions in their empirical estimates (Deaton and Muellbauer, 1980; Fulponi, 1989; Mergos and Donatos, 1988). An explanation for this is the exclusion of some factors that play significant role in demand. The incorporation of additional variables, however, does not imply that consumers are less responsive to price and income changes. A time variable was included in some preliminary estimates supposedly to capture changes in tastes and preferences but results were not satisfactory. It either accounted for virtually all changes in the dependent variable or, at the other extreme, was not significant at all. Lagged variable terms, such

as past import demand share, may be more effective in capturing habit effects, but this type of dynamic approach involves an entirely different analytical procedure.

[6] These results are consistent with import demand elasticities computed in earlier studies. See, for example, Zhang (1990) and Roe et al. (1986).

[7] The small price transmission elasticities maybe due to the market protection policies practiced by many rice-trading countries. These seem to create distinct areas of price determination, between which rice prices bear little relation to each other.

References

Adams, F.G. and J.R. Behrman (1976) Econometric Models of World Agricultural Commodity Markets. Ballinger, Cambridge, MA.

Agcaoili-Sombilla, M. (1991) The world rice market: a model of product differentiation. Ph.D. dissertation, University of Minnesota.

Armington, P.S. (1969) A theory of demand for production distinguished by place of production. International Monetary Fund Staff Papers, 16: 159–176.

Bateman, M.J. (1988) Economic effects of Japan's rice policy on the U.S. and world rice economics. Commodity Information Inc.

Berndt, E.R. and N.E. Savin (1975) Estimation and hypothesis testing in single equation systems with autoregressive disturbances. Econometrica, 43: 937–957.

Bredahl, M.E., W.H. Meyers and K.J. Collins (1979) The elasticity of foreign demand for U.S. agricultural products: the importance of the price transmission elasticity. Am. J. Agric. Econ., 61: 58–63.

Buse, R.C. (1958) Total elasticities – a predictive device. J. Farm Econ., 40: 881–891.

Cramer, G.C., E.J. Wailes, J.M. Goroski and S. Phillips (1990) The impact of liberalizing trade on the world rice market: a spatial model including rice quantity. Special Report 153, Arkansas Agricultural Experiment Station, University of Arkansas.

Deaton, A. and J. Muellbauer (1980) An Almost Ideal Demand System. Am. Econ. Rev., 70: 312–326.

Fulponi, L. (1989) The Almost Ideal Demand System: An application to food and meat groups for France. J. Agric. Econ., 40: 82–92.

Gardiner, W.H. and P.M. Dixit (1987) Price elasticity of export demand: concepts and estimates. FAER Report 228, U.S. Department of Agriculture, Economic Research Service.

Green, R. and J. Alston (1990) Elasticities in AIDS Model. Am. J. Agric. Econ., 72: 442–445.

Green, R. and J. Alston (1991) Elasticities in AIDS models: a clarification and extension. ERS/USDA Tech. Bull. 1720.

Ito, S., D. Chen and E.W.F. Peterson (1989) Modeling international trade flows and market shares for agricultural commodities: a modified armington approach for rice. Department of Agricultural Economics, Texas A&M University, College Station.

Mergos, G.J. and G.S. Donatos (1989) Demand for food in Greece: An Almost Ideal Demand System Analysis. J. Agric. Econ., 40: 178–184.

Phlips, L. (1983) Applied Consumption Analysis. North-Holland, Amsterdam.

Pindyck, R. and D.L. Rubinfeld (1981) Econometric Models and Economic Forecasts. McGraw-Hill, New York.

Pitts, E. and P. Herlihy (1982) Perverse substitution relationships in demand studies: the example of butter and margarine. J. Agric. Econ., 33: 37–46.

Roe, T., M. Shane and D.H. Vo (1986) Price responsiveness of world grain markets: the influence of government intervention on import demand elasticity. ERS/USDA Tech. Bull. 1720.

Roningen, V. and P. Dixit (1989) Economic implications of agricultural reforms in industrial market economies. Staff Report AGES 89-36, USDA Economic Research Service, Washington, DC.

Siamwalla, A. and S. Haykin (1983) The world rice market: structure, conduct and performance. IFPRI Res. Rep. 39, International Food Policy Research Institute.

Slayton, T.M. (1984) Some pieces of the world rice puzzle. ERS/USDA Rice Outlook and Situation Report, PP 11–30.

Theil, H. (1980) The System-Wide Approach to Microeconomics. Basil Blackwell, Oxford.

Tyers, R. and K. Anderson (1989) Price elasticities in international food trade: synthetic estimates from a global model. J. Policy Modeling, 11: 315–344.

Zhang, B. (1990) An econometric model of the world rice market. Masters thesis, University of Arkansas.