Reprinted from
AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS Vol. 71, No. 1, February 1989

Rice in Asia: Is It Becoming an Inferior Good?

Shoichi Ito, E. Wesley F. Peterson, and Warren R. Grant

Empirical results using time-series and cross-sectional data indicate that rice in Asia is becoming an inferior good. Income elasticities declined and in some cases became negative between 1961 and 1985 in most of the fourteen Asian countries studied. Accordingly, domestic demand for rice in these countries is not likely to grow as rapidly as it has in the past. As a consequence, there is a potential for excess supplies of rice to develop in Asia, putting downward pressure on rice prices. While governments in Asian countries may need to adjust their rice policies in the future, world rice suppliers may need to develop new markets for rice.

Key words: Asia, income elasticity, inferior good, rice.

The importance of rice for Asians has been well recognized in the literature (Barker, Herdt, and Rose; Coyle; Chen, Hsu, and Mao; Mears; Moon). Asians produce and consume approximately 90% of the world's rice. Their per capita annual consumption is around 100 kilograms (kg) compared with 3 to 4 kg per person in the western world.

Rice consumption in Asia has tended to decrease as incomes increase. Per capita rice consumption in Japan, for example, decreased from 125 kg in the early 1960s to 85 kg in the mid-1980s, while per capita real gross domestic product (GDP) increased by 2.8 times. As income increased, the Japanese had access to more varieties of food, and consequently their diet changed from the traditional rice diet to a more western diet of bread, red meat, and dairy products.

The purpose of this article is to examine the possibility that similar tendencies exist in other Asian countries. In particular, the relationship between rice consumption and income levels is investigated for fourteen Asian nations. Because of the importance of these countries in the world rice market, changes in consumption patterns are likely to have a significant impact on world prices and trade. Estimates of income elasticities of demand are useful in evaluating the implications of the potential changes in Asian rice consumption for other rice exporting countries such as the United States.

Rice Consumption in Asia

The fourteen Asian countries studied are those where rice is the staple food.[1] They are Bangladesh, Burma, the People's Republic of China (PRC), India, Indonesia, Japan, South Korea, Malaysia, Nepal, the Philippines, Singapore, Sri Lanka, Thailand, and Taiwan. Total rice consumption and production in these countries account for 85% of world consumption and production. The outlook for the rice economies of these countries varies. Per capita rice consumption decreased significantly in Japan, Malaysia, Nepal, Singapore, Thailand, and Taiwan, changed only slightly in Bangladesh, India, South Korea, and Sri Lanka, and increased substantially in Burma, the PRC, Indonesia, and the Philippines during the study period, 1961 through 1985 (table 1). Growth in per capita real GDP

Shoichi Ito is a research associate, E. Wesley F. Peterson is an assistant professsor, and Warren R. Grant is an adjunct professor in the Department of Agricultural Economics, Texas A&M University.

Texas Agricultural Experiment Station Technical Article No. 23323.

The authors would like to thank Oral Capps, Jr., and Carl E. Shafer for helpful comments in the development of this paper. In addition, the authors wish to acknowledge the useful suggestions of Randolph Barker at Cornell University and two anonymous reviewers.

[1] The analysis is based on data from the International Monetary Fund (IMF). Asian countries that are not members of IMF were excluded because of insufficient data.

Table 1. Annual Per Capita Rice Consumption in Asia, by Group (five-year average, milled, kg)

	1961–65	1981–85	Change (%)
Group I			
Japan	124	88	−29.0
Malaysia	132	109	−17.4
Nepal[a]	126	105	−16.7
Singapore	103	74	−28.2
Thailand	191	164	−14.1
Taiwan	161	98	−39.1
Group II			
Bangladesh	154	156	1.3
India	77	75	−2.6
South Korea	129	136	5.4
Sri Lanka	109	113	3.7
Group III			
Burma[a]	133	222	66.9
PRC[a]	81	108	33.3
Indonesia	107	157	46.7
Philippines	91	102	12.1

Note: Countries are grouped according to changes in per capita rice consumption. Group I includes countries where consumption has decreased by more than 10%, Group II those where the change has been within ±10%, and Group III, those where consumption has increased by more than 10%.
[a] Including stocks.

during the period studied was highest at 417% in South Korea, followed by Singapore's 278%, Taiwan's 251%, Sri Lanka's 162%, Indonesia's 152%, the PRC's 140%, Japan's 139%, Malaysia's 135%, and Thailand's 121% (table 2). In terms of annual per capita GDP converted to U.S. dollars, high income countries such as Japan, Singapore, Taiwan, Malaysia, and South Korea averaged more than US$2,000 per person in the mid-1980s (table 2). Thailand, the Philippines, and Indonesia are middle income countries with real per capita GDP between US$1,000 and US$500. The rest of the countries including Sri Lanka, India, the PRC, Burma, Bangladesh, and Nepal are low income countries. Nepal had the lowest per capita GDP at US$138.

Traditional rice exporters are Thailand, Burma, the PRC, Taiwan, and Nepal (USDA). India exported limited amounts after the late 1970s. The Philippines exported small quantities in the past but has been an importer of rice in recent years. Bangladesh, Indonesia, South Korea, Malaysia, Singapore, and Sri Lanka are net importers. Indonesia and South Korea, however, are almost self-sufficient today, partly because of government policy.

The Food and Agriculture Organization of the United Nations (FAO) in 1971 derived income elasticities of demand for various commodities based on data in the 1950s and 1960s. Their income elasticities for rice were at .10 for Burma and Singapore, .20 for Malaysia, the Philippines, and Thailand, .30 for South Korea, Nepal, Pakistan, and Taiwan, .40 for

Table 2. Growth of Per Capita GDP between 1961 and 1985 (domestic currencies, deflated by CPI, five-year average)

	1961–65	1966–70	1971–75	1976–80	1981–85	Δ(%)[a]	GDP[b] in U.S.$
Bangladesh			1,875	2,131	2,226	19[c]	144
Burma	1,131	931	1,015	1,019	1,224	8	171
PRC	179	231	290	344	429	140	222[e]
India	1,468	1,450	1,587	1,806	1,924	31	252
Indonesia		132	178	246	333	152[d]	519
Japan	894	1,391	1,839	1,964	2,140	139	10,456
South Korea	210	315	529	930	1,085	417	2,052
Malaysia	1,655	1,930	2,345	3,314	3,895	135	2,237
Nepal	1,621	1,711	1,672	1,769	1,614	0	138
Philippines	3,372	3,838	4,344	5,294	5,132	52	603
Singapore	3,169	4,396	6,895	8,759	11,972	278	7,206
Sri Lanka	2,026	2,277	2,786	4,172	5,299	162	371
Thailand	6,938	9,012	10,766	13,504	15,303	121	752
Taiwan	32,044	46,322	68,441	93,751	112,548	251	3,033

Note: Units and domestic currencies are taka in Bangladesh, kyats in Burma, yuan in the PRC, rupees in India, 1,000 rupiah in Indonesia, 1,000 yen in Japan, 1,000 won in S. Korea, ringgit in Malaysia, rupees in Nepal, pesos in the Philippines, Singapore dollars in Singapore, rupees in Sri Lanka, baht in Thailand, and Taiwan dollars in Taiwan.
[a] Change in percentage between 1961–65 and 1981–85 periods.
[b] The figures are per capita GDP converted to U.S. dollars in 1985 except for Burma, India, Indonesia, Japan, S. Korea, Malaysia, Singapore, and Taiwan, for which the figures are for 1984.
[c] Between 1971–75 and 1981–85 periods.
[d] Between 1966–70 and 1981–85 periods.
[e] Per capita national income in U.S. dollars.

the PRC, India, Kampuchea, Laos, Sri Lanka, and South Vietnam, .70 for Indonesia, and −.10 for Japan (table 3). In the FAO report, Japan was the only country where rice was estimated to be an inferior good, that is, a good for which the income elasticity of demand is negative.[2] Two years later, Daly et al. reported a negative income elasticity for rural areas in South Vietnam. They showed income elasticities of rice ranging from −.1 to −.15 in rural areas and from .25 to .35 for the whole nation.

Income elasticities for South Korea, estimated by Moon in 1975, were .124 for urban areas and .329 for rural areas. The Korea Rural Economics Institute (KREI) in 1984 estimated income elasticities of −.245 and .263 in the South Korean urban and rural areas, respectively. Wong, in 1976, found income elasticities in Thailand to be .0559 and .0613 for the short run and the long run, respectively. Wong's elasticities were much more inelastic than the elasticity estimated earlier by the FAO for the nation. More recently, an income elasticity estimated by Mann in 1982 for Thailand was negative, −.024, indicating that rice in Thailand may now be an inferior good.

Mears, in 1981, estimated an income elasticity for Indonesia to be .319, less elastic than the .70 estimated earlier by the FAO. In 1980, Chen's income elasticity of −.44 for Taiwan was much lower than the FAO's .30. Ito, Wailes, and Grant in 1985 reported inelastic or negative income elasticities for Asian countries: −.218 for Burma, −.079 for India, .308 for Indonesia, −.189 for Japan, .102 for South Korea, −.534 for Pakistan, .243 for the Philippines, −.131 for Thailand, and −.081 for Taiwan. The studies reviewed suggest that income elasticities for rice in Asian countries are becoming smaller over time.

None of the studies cited above explicitly analyzed the change in income elasticities, particularly the change in the sign of the elasticities. Barker, Herdt, and Rose suggest that specific rice consumption patterns among Asian countries are "unique for each country" and also that demand increases for cereal grains vary depending upon income level. Thus, they state that one should estimate "different income elasticities for different countries and expect them to change over time," (pp. 166–67).[3] It is useful, therefore, to investigate Asian rice consumption patterns among countries using a time-series and cross-sectional analysis method. Because rice consumption patterns in Asia seem to be continuously changing even in the 1980s, it is essential to include recent data in the analysis. The results from such analyses will provide more specific information on Asian rice consumption as well as implications for the future, particularly for development strategies in Asian nations and rice trade for the rest of the world.

Methodology

Given the results reported in the previous section, it is important to model Asian rice consumption in a manner that allows the income elasticities to vary with level of income. The evidence suggests that per capita rice consumption in Asia is positively related to income up to a certain level after which an inverse relationship occurs. A model that reflects these relationships is the log-inverse-log model (FAO):

$$(1a) \quad Q = \mathrm{EXP}(a - bY^{-1})Y^{-c}, \text{ or}$$

$$(1b) \quad \ln Q = a - bY^{-1} - c \ln Y, \qquad (b > 0,\ c > 0),$$

where a, b, and c are estimated coefficients, Q is consumption, and Y is income.

In this model, the derivative of Q with respect to Y is

$$(2) \quad \partial Q/\partial Y = (b/Y^2 - c/Y)Q.$$

Thus, given that $Q > 0$,

$$(3) \quad \partial Q/\partial Y > 0 \quad \text{if } b/Y > c, \text{ and}$$

$$(4) \quad \partial Q/\partial Y < 0 \quad \text{if } b/Y < c.$$

Equations (3) and (4) indicate that if b/Y is greater than c, consumption increases as income increases, reaching a maximum at $b/Y = c$, and that consumption begins to decrease as income keeps on increasing. If equation (3)

[2] The definition of an inferior good is based solely on the inverse relationship between demand for the commodity and the income level of consumers holding everything else constant. The term does not imply that rice is nutritionally inferior or that consumers do not like the taste.

[3] Barker, Herdt, and Rose estimated income elasticities for total cereal using a functional form: $\ln Q = a + b \ln Y + c (\ln Y)^2$, where Q is grain consumption, Y is per capita gross domestic product transformed to US$, and a, b, and c are estimated coefficients. The dependent variable includes all grain consumption; therefore, the estimated elasticities may be under- or overestimated for rice (p. 167).

Table 3. Previously Estimated Income Elasticities for Rice in Asian Countries

	FAO (1971)	Others	IWG (1985)[a]
Bangladesh			−.218
Burma	.10		
PRC	.40		−.079
India	.40		.308
Indonesia	.70	.319 (Mears)	−.189
Japan	−.10		
Kampuchea	.40		
South Korea[b]	.30	.124 urban, .329 rural (Moon)	.102
		−.245 urban, .263 rural (KREI)	
Laos	.40		
Malaysia	.20		
Nepal	.30		
Pakistan	.30		−.534
Philippines	.20		.243
Singapore	.10		
Sri Lanka	.40		
Thailand	.20	.0559 (Wong)	−.131
		−.024 (Mann)	
Taiwan	.30	−.44 (Chen)	−.081
South Vietnam	.40	.25 to .35 nation	
		−.1 to −.15 rural (Daly et al.)	

[a] Ito, Wailes, and Grant.
[b] KREI stands for Korea Rural Economics Institute.

holds, the commodity is a normal good; if equation (4) holds, it is an inferior good.

The second derivative of equation (1) is

$$(5)\quad \partial^2 Q/\partial Y^2 = \mathrm{EXP}(a - bY^{-1})Y^{-2-c}[b^2Y^{-2} - (bc + c + 2)bY^{-1} + (1 + c)c].$$

The right-hand side of equation (5) is positive if the bracketed term $[\cdot]$ is positive. Multiplying the term in the brackets by Y^2 produces the following relationship:

$$(6)\quad b^2 - (bc + c + 2)bY + (1 + c)cY^2 > /=/ < 0.$$

The left-hand side of equation (6) changes from positive to negative and back to positive as Y increases. This indicates that once Q has reached its maximum it falls at a decreasing rate as income continues to increase. Thus, the results of equation (1a) can be plotted as shown in figure 1a.[4]

An income elasticity, E_Y, the percentage change in consumption due to a 1% change in income, is derived from equation (1) as follows:

$$(7)\quad E_Y = \partial Q/\partial Y * Y/Q = b/Y - c.$$

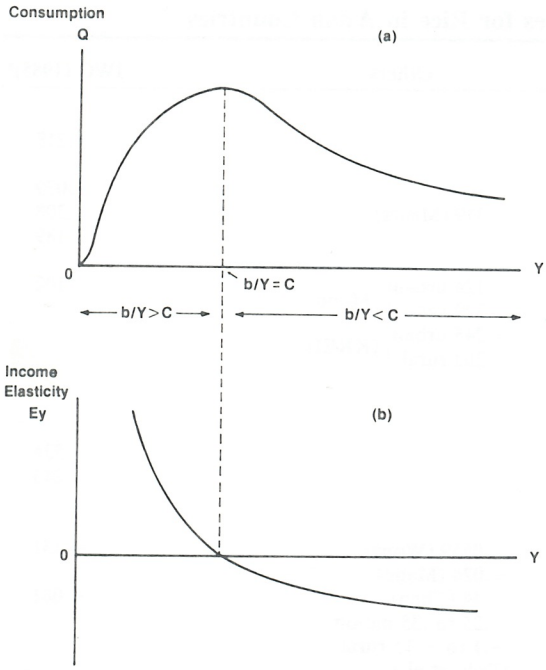
The plotted curve of equation (7) is shown in figure 1b. Income elasticities from this model decrease continuously intersecting the income axis at $b/Y = c$ and turning negative at higher incomes. The equation, therefore, indicates that the commodity becomes an inferior good as income levels rise above a certain point.[5]

The location of point $b/Y = c$ depends on the magnitude of coefficients b and c and the level of Y. These coefficients reflect the consumption pattern for the commodity in each country. Consumption patterns vary to a certain degree from one country to another. Because this analysis is based on pooled cross-sectional and time-series data for fourteen countries, the slope and/or intercept coefficients for each country must be adjusted to reflect the different national consumption patterns.

Adding the cross-sectional factors and own- and cross-price variables, equation (1b) is modified as follows:

[4] If coefficients b and c are negative in equation 1a, the shape of the curve would be reversed.

[5] If $-c$ turns out positive with $-b < 0$ in equation (1b), the sign of equation (7) does not become negative. But it still meets the assumption that the income elasticity is becoming smaller. In this case, Q increases at a decelerating rate as income increases. The calculated income elasticity geometrically decreases as the income level increases, although the elasticity stays positive. See equation (7).



Consumption level, Q, peaks at $b/Y = c$ and decreases gradually after that point.

Figure 1(*a*). Plot of equation (1); $Q = \text{EXP}(a - bY^{-1})Y^{-c}$

Income elasticity decreases descendingly from positive to negative intersecting the Y-axis at $b/y = c$.

Figure 1(*b*). Income elasticity corresponding to equation (1)

$$(8)\quad \ln Q_{it} = a_i - b_i Y_{it}^{-1} - c_i \ln Y_{it} + d_{si} \ln P_{sit} + e_{it},\ (b > 0,\ c > 0),$$

$$i = 1, 2, \ldots, m \text{ (countries)}$$
$$s = 1, 2, \ldots, n \text{ (own and substitute commodities)}$$
$$t = 1, 2, \ldots, T \text{ (years)},$$

where a, b, c, Q, and Y are defined as for equation (1b), and P_s are own/substitute commodity price variables, and d_s, the estimated coefficients for $\ln P_s$. The adjusted coefficients can be obtained by using intercept and slope dummies for all independent variables in the form of a generalized covariance model (Judge et al., pp. 515–45).

Multicollinearity diagnostics, as developed by Belsley, Kuh, and Welsch, indicated that variables Y^{-1} and $\ln Y$ are collinear. In order to solve this problem, the ridge regression method (Hoerl and Kennard 1970a, b) was employed. In the ridge regression analysis, the fourteen countries were divided into three groups based on changes in per capita rice consumption levels during the period studied, 1961 through 1985 (table 1). Group I includes countries where per capita rice consumption decreased more than 10%: Japan, Malaysia, Nepal, Singapore, Thailand, and Taiwan. Group II includes those where rice consumption changed within ±10%: Bangladesh, India, South Korea, and Sri Lanka. Finally, Group III includes those where rice consumption increased by more than 10%: Burma, the PRC, Indonesia, and the Philippines. A ridge regression model was employed with a specific k-value for each group. Choice of the k-values for the particular models was based on the ridge trace suggested by Hoerl and Kennard (1970a, b).

Wheat is the major substitute for rice in Asia. Therefore, the price of wheat was included in the equation. The price variable used was the ratio of the prices of rice to the prices of wheat. Rice prices at Bangkok and wheat prices at U.S. Gulf ports were used to represent world prices and the price coefficients were also adjusted for each country by employing dummy variables.

Data for rice consumption are from USDA (1983, 1986), which is based on supply-disappearance balance sheets in each country. The USDA data are mostly based on "official statistics released by the respective government" (USDA 1986, p. 2). According to Barker, Herdt, and Rose (p. 160), the stock data are suspect. In addition, data from 1961 to 1965 for the PRC and Nepal may not be reliable (Barker). These data limitations should be kept in mind when interpreting the results. Data on GDP, populations, and exchange rates are from the IMF. In this analysis, per capita GDP in real terms was used to represent income.[6] World prices are also from the IMF. The time period of the data was 1961 through 1985.

Results

The results of the selected k-value, R^2, F-value, and number of observations in the

[6] The PRC is the only exception. The IMF does not report GDP for this country; therefore, national income, the variable reported by the IMF, was used. Data for Taiwan are from *Taiwan Statistical Data Book 1985*, published by Republic of China, 1985.

Table 4. Results of Ridge Regression Analyses

	k-Value	R^2	F-Value	Number of Observations	D.F.
Group I	.000002	.889	41.0	142	118
Group II	.05	.939	72.1	86	70
Group III	.1	.855	26.7	84	68

ridge regressions are reported in table 4. The selected k-value and R^2 are .000002 and .889, .05 and .939, and .1 and .855 for Groups I, II, and III, respectively. The high F-values indicate that the models for all groups are significant at the 1% level.

The estimated coefficients of the income variables are reported in table 5. Base countries are Taiwan in Group I, India in Group II, and Burma in Group III. The coefficients of the income variables for these countries were all significant except for the coefficient of the log of income variable for Burma. Coefficients of slope dummies for the inverse income variables (Y^{-1}) were mostly significant, implying that demand responses to income levels in these countries are different from the respective base countries except for Thailand and South Korea. The coefficients of the slope dummies for the log of income variables were not significant in Group I but were significant in Group II and III except for Indonesia. In all countries studied, except for Bangladesh and Sri Lanka, the inverse income variables had negative total coefficients.[7] This suggests that income elasticities are generally decreasing as incomes increase.

Estimated income elasticities are reported in table 6. For countries in Group I, income elasticities of demand had become negative by the late 1960s. Several of these countries had high rates of income growth during the estimation period (table 2). By the 1980s, income elasticities in these countries had taken on large negative values. In Japan, for example, the income elasticity had fallen to −.708 in 1984 following a long period of high income growth. Malaysia, the fourth wealthiest country with per capita income at US$2,237 in the mid-1980s, showed negative income elasticities since 1969, the year when the Malaysian economy entered a period of accelerated growth. The income elasticity in Malaysia changed the most among the nations studied, from .328 in 1961 to −.671 in 1984. Although Nepal has the lowest income level among the countries studied at US$138 per capita, it is one of the traditional rice exporters. The estimated income elasticity in Nepal fluctuated because of volatility of the economy but remained at around −.3 during the whole period. Because incomes in Nepal are lower than the other countries studied, the negative income elasticity is somewhat surprising. However, whether an income elasticity is negative or positive does not depend entirely on income level. This is evidenced by the negative income elasticities estimated by Daly et al. for rural South Vietnam. The availability of a commodity in the country (or region) may have a greater effect on the sign of the income elasticity than the level of income.

In Singapore, per capita income was at US$7,206 in the mid-1980s, the second highest after Japan. Although rice is the staple food, Singapore is the only country studied that does not produce rice domestically. Domestic rice demand is met entirely by imports. Per capita consumption was over 100 kg in the early 1960s but decreased to around 70 kg in the 1980s. Income elasticities in the country ranged from .211 in 1961 to −.599 in 1984.

Thailand, the world's largest rice exporter, has the fifth highest per capita income level (US$752) among the fourteen countries in Asia. The Thai per capita rice consumption level was relatively high at 159 kg in 1985. However, the consumption level has decreased over time. The estimated income elasticity was .237 in 1961 decreasing to −.437 by 1985. Taiwan, also a rice exporter, has experienced rapid economic growth; her per capita GDP at US$3,033 was the third highest after Japan and Singapore. Taiwanese income elasticities ranged from .015 in 1961 to −.594 in 1984.

Income elasticities in Group II countries were very inelastic. Bangladesh, which became independent in 1971, had a very low per

[7] A total coefficient for a dummy-country is the sum of the base-country coefficient and the slope-dummy coefficient. For example, the total coefficient of the inverse income variable (Y^{-1}) for Malaysia is −2496 (= −21815 + 19319). For a base country, on the other hand, only the base-country coefficient is applied.

Table 5. Estimated Coefficients of Inverse Income, Log of Income and Price Variables in Each Country

	Inverse of Income		Log of Income		Price	
	Base Country	Slope Dummies	Base Country	Slope Dummies	Base Country	Slope Dummies
Group I						
Taiwan	−21815 (7334)[a]		−.769 (.141)		.079 (.113)	
Japan		−1055022 (487589)		−.425 (.363)		−.151 (.157)
Malaysia		19319 (7244)		−.497 (.469)		−.271 (.161)
Nepal		20775 (7001)		−.205 (.211)		.029 (.150)
Singapore		18633 (7337)		−.072 (.294)		−.587 (.171)
Thailand		14563 (8066)		−.119 (.497)		−.218 (.156)
Group II						
India	−187 (50.9)		.028 (.002)		−.050 (.041)	
Bangladesh		343 (72.9)		.023 (.002)		.039 (.003)
South Korea		−9896 (8469)		.009 (.001)		.024 (.003)
Sri Lanka		217 (79.4)		.009 (.001)		.013 (.002)
Group III						
Burma	−32.0 (9.91)		.002 (.003)		−.134 (.059)	
PRC		−42.6 (7.9)		−.018 (.004)		−.025 (.003)
Indonesia		−37540 (8612)		−.001 (.001)		−.008 (.003)
Philippines		−649 (146)		−.016 (.002)		−.029 (.003)

[a] Standard errors are in parentheses.

capita income level at US$144 in the mid-1980s. The estimated income elasticities were negative but very inelastic throughout the period. Because the estimated coefficient for the inverse income variable was negative, the negative income elasticities moved in a positive direction as income rose over the period. In India, with an income level of US$252 per capita, rice consumption decreased by 2.6% while per capita GDP increased by 31% between the early 1960s and 1980s. The estimated income elasticities declined from .163 in 1961 to .125 in 1984.

The economy in South Korea, where per capita GDP was the fourth largest at US$2,052 in the mid-1980s, grew by a remarkable 417% during the period studied. This dramatic increase is above that of any other nation. The estimated income elasticities in South Korea were very inelastic. The magnitude decreased from .095 in 1961 to .046 in 1984. These estimates can be compared with Moon's estimates of .124 for urban consumers and .329 for rural consumers or those of Korean Rural Economic Institute, which range from −.245 in urban areas to .263 in rural zones. Because urban people account for approximately three-quarters of the national population, the income elasticity in the urban area should dominate the elasticity in the rural area. Thus, the national aggregate income elasticities would be slightly greater than .124 based on Moon's estimates or somewhere close to −.2 based on the KREI estimates. Given, however, that per capita national income grew by more than 400% and rice consumption in-

Table 6. Income Elasticities in Asian Countries, 1961–85

	Group I						Group II				Group III			
Year	Japan	Malaysia	Nepal	Singapore	Thailand	Taiwan	Bangladesh	India	South Korea	Sri Lanka	Burma	PRC	Indonesia	Philippines
1961	0.165	0.328		0.211	0.237	0.015		0.163	0.095	0.022	0.030	0.418		0.201
1962	0.125	0.290		0.172	0.221	−0.014		0.161	0.090	0.023	0.030	0.462		0.194
1963	0.049	0.283		0.121	0.176	−0.063		0.150	0.083	0.023	0.028	0.438		0.180
1964	−0.091	0.206	−0.331	0.182	0.127	−0.142		0.149	0.080	0.023	0.031	0.380		0.186
1965	−0.141	0.110	−0.335	0.128	0.042	−0.192		0.157	0.081	0.023	0.033	0.327		0.179
1966	−0.234	0.073	−0.369	0.054	−0.058	−0.224		0.156	0.077	0.023	0.043	0.292		0.176
1967	−0.332	0.113	−0.328	0.002	−0.053	−0.273		0.155	0.074	0.023	0.041	0.321		0.172
1968	−0.420	0.090	−0.377	−0.091	−0.075	−0.295		0.157	0.070	0.025	0.035	0.348	0.310	0.163
1969	−0.492	−0.060	−0.404	−0.188	−0.107	−0.322		0.150	0.066	0.025	0.033	0.311	0.284	0.155
1970	−0.546	−0.064	−0.352	−0.267	−0.123	−0.356		0.148	0.064	0.026	0.032	0.266	0.266	0.151
1971	−0.561	−0.086	−0.368	−0.333	−0.142	−0.394		0.145	0.062	0.025	0.033	0.253	0.259	0.151
1972	−0.608	−0.124	−0.397	−0.400	−0.182	−0.440		0.142	0.060	0.026	0.033	0.251	0.227	0.154
1973	−0.649	−0.281	−0.300	−0.387	−0.251	−0.490	−0.040	0.140	0.056	0.026	0.034	0.236	0.207	0.139
1974	−0.618	−0.290	−0.289	−0.381	−0.238	−0.456	−0.042	0.151	0.054	0.028	0.033	0.237	0.188	0.138
1975	−0.603	−0.200	−0.392	−0.392	−0.250	−0.455	−0.016	0.153	0.053	0.028	0.036	0.226	0.195	0.131
1976	−0.611	−0.367	−0.426	−0.432	−0.284	−0.496	−0.021	0.137	0.051	0.029	0.038	0.211	0.188	0.122
1977	−0.622	−0.429	−0.355	−0.448	−0.316	−0.515	−0.032	0.136	0.049	0.030	0.036	0.226	0.174	0.117
1978	−0.649	−0.497	−0.379	−0.468	−0.360	−0.540	−0.018	0.131	0.047	0.031	0.033	0.201	0.161	0.112
1979	−0.673	−0.589	−0.415	−0.500	−0.386	−0.556	−0.017	0.130	0.047	0.031	0.032	0.185	0.142	0.110
1980	−0.671	−0.625	−0.351	−0.525	−0.396	−0.562	−0.017	0.126	0.047	0.031	0.030	0.183	0.122	0.110
1981	−0.678	−0.599	−0.339	−0.548	−0.395	−0.563	−0.018	0.125	0.047	0.031	0.028	0.177	0.118	0.110
1982	−0.685	−0.598	−0.334	−0.565	−0.396	−0.564	−0.019	0.127	0.047	0.032	0.028	0.169	0.119	0.112
1983	−0.692	−0.630	−0.298	−0.584	−0.411	−0.577	−0.021	0.124	0.046	0.032	0.028	0.156	0.110	0.112
1984	−0.708	−0.671	−0.346	−0.599	−0.431	−0.594	−0.016	0.125	0.046	0.032	0.028	0.133	0.108	0.121
1985			−0.332		−0.437		−0.015			0.032				0.140

creased by only 5.4% during this period, it is probably safe to conclude that the aggregate income elasticity is quite inelastic. In Sri Lanka per capita GDP reached US$371 in the mid-1980s, and the economy grew by 162% during the period studied. Although the income elasticity increased slightly over time due to a positive coefficient for the inverse income variable, it remained very inelastic at around .03.

The results for countries in Group III varied considerably. In Burma, the estimated elasticities were consistently inelastic, while they declined substantially in the PRC and Indonesia. Burma, where per capita GDP decreased in the mid-1960s and 1970s, showed very inelastic income elasticities at around .03. In the PRC, on the other hand, per capita income increased by 140% and rice consumption increased by 33%. Meanwhile, the estimated income elasticities sharply decreased from .418 in 1961 to .133 in 1984. The estimated income elasticities in Indonesia, where the income level is much higher at US$519 than the PRC's US$222, were almost the same as in the PRC, declining from .310 in 1968 to .108 in 1984. In the Philippines, where the income level was at US$603, the estimated income elasticities decreased from .201 in 1961 to .110 by 1979. They turned slightly upward in the 1980s because of a decrease in income.

Coefficients for the ratio of world rice and wheat prices were also estimated with slope dummies (table 5). Because the dependent variable and the price variables are both in log forms, the estimated coefficients are the estimated elasticities. In most Asian countries, governments control the domestic rice economies attempting to insulate the domestic prices from world prices. This is accomplished through floor/ceiling prices, rationing, and export/import quotas, taxes, or subsidies. Thus, world price variations are not always transmitted to the domestic market. This situation may be reflected in the insignificant price coefficients estimated for high income countries such as Japan and Taiwan. The price dummy coefficient for Singapore, however, indicates a significant and relatively elastic price elasticity at $-.508$. This may reflect the nation's sensitivity to world prices due to the fact that Singapore imports all rice consumed domestically. On the other hand, many of the price coefficients in low income countries are significant but very inelastic indicating that although world prices may be transmitted to these markets, consumer responses to price changes are very small.

Implications

The results of the study indicate that rice is already an inferior good in economically advanced countries such as Japan, Taiwan, Malaysia, and Singapore and in rice-exporting countries such as Thailand and Nepal. Although rice is still a normal good in South Korea, India, Indonesia, the Philippines, and the PRC, income elasticities in these countries have been decreasing. The decreases in Indonesia and the PRC are substantial, suggesting that per capita rice consumption levels in these two countries may soon reach the maximum and begin to decrease. Despite the variations in the magnitudes of estimated changes in income elasticities for rice in these Asian nations, these results indicate that income elasticities in Asia have generally been declining over time.

Decreasing income elasticities mean either that the demand curve is shifting in or that it is shifting out by declining amounts. If supplies are not adjusted down, rice prices will tend to fall in Asia. What are the implications of this situation for Asia and the rest of the world? First, the quantities of rice in Asia available for export may increase and put downward pressure on world market prices. Given that Asian rice production is approximately 300 million metric tons and that only ten to eleven million metric tons of rice are currently traded in the world market, the potential increase in exports from Asia could put substantial pressure on world prices. Low prices would make rice more easily available for importing countries, rendering costly programs aimed at entirely satisfying internal demand from domestic production less tenable. In fact, the target of complete self-supply of rice has been removed from the primary policy agenda in Malaysia (Barker, Herdt, and Rose). Of course, self-supply might be achieved more easily if per capita consumption levels off or decreases. South Korea achieved 100% self-supply of rice in 1984 with some help from the leveling off of per capita rice consumption in the 1980s.

Second, because rice is such an important staple food crop in Asia, it has long been central to any development strategy. Some countries have implemented policies designed to

encourage increased output. The results of this study suggest, however, that it may be more important to shift some land from rice production to more profitable crops as demand begins to level off or decline. For rice-exporting countries in particular, maintaining and expanding market shares may become more difficult.

A third consideration is the volatility of world prices for rice. Because world trade in rice is thin relative to world production, a crop failure in major producing areas in Asia would lead to substantial increases in prices in world rice markets.[8] Although the projected changes in consumption patterns in Asia may lead to lower world prices in normal years, alone they will do nothing to increase the stability of world rice prices. If importing countries elect to abandon efforts to increase the degree of self-supply, they may benefit from the lower world prices but become more vulnerable to the effects of periodic shortfalls. In this context, effective storage programs may become indispensable.

Fourth, the results also have implications for other commodities. Production, consumption, and trade of substitute commodities such as wheat may be affected as consumers in these Asian nations gradually decrease rice consumption. In addition, consumers in Asia are likely to increase their consumption of meat and dairy products as incomes grow. Rice feed use may become more common, thus affecting markets for corn and other feed grains. Finally, it may be unreasonable to expect Asia to import large amounts of rice from non-Asian rice exporters such as the United States unless export prices are considerably subsidized or production costs are substantially cut.

This study has dealt primarily with per capita demand in the fourteen Asian countries studied. Some of the implications discussed above could be offset to a certain extent by growing populations in Asia. The full implications of changing consumption patterns in these countries can be ascertained only with more information on their production systems as well as the likely evolution of world markets. Nevertheless, because these countries dominate world rice production and consumption, changes in either of these variables will have a significant impact on rice economies in the rest of the world. There may be a need for rice exporters to develop new markets both domestically through new types of processed food using rice and internationally through promotion of rice consumption in non-Asian areas.

[*Received January 1988; final revision received June 1988.*]

[8] The PRC is particularly important in this context. Because of the possibility of unreliable data, the results reported in this study for the PRC should be interpreted with caution. The estimates presented here are not inconsistent with the 1971 FAO estimate, but further study is needed to improve our understanding of rice consumption in the PRC. With rice production and consumption in the PRC of over 100 million metric tons and world trade in rice of only about 11 million metric tons, even a 1% change in either production or consumption in this country could seriously disrupt world markets.

References

Barker, Randolph, Robert W. Herdt, with Beth Rose. *The Rice Economy of Asia*. Washington DC: Resources for the Future, 1985.

Barker, Randolph. Personal comments on an earlier draft of this paper, Cornell University, April 1988.

Belsley, D. A., E. Kuh, and R. E. Welsch. *Regression Diagnostics*. New York: John Wiley & Sons, 1980.

Chen, Wu-Hsiung. *An Economic Study on Government Rice Stock Operation in Taiwan*. Ph.D. thesis, University of Illinois, 1980.

Chen, H. Y., W. F. Hsu, and Y. K. Mao. "Rice Policies of Taiwan." *Food Res. Inst. Stud.* 14(1975):403–17.

Coyle, William T. *Japan's Rice Policy*. Washington DC: U.S. Department of Agriculture, Econ. Statist. Serv. FAE Rep. No. 164, 1981.

Daly, Rex F., R. G. Hoffman, F. Nelson, and H. Weingarten. *Agriculture in the Vietnam Economy: A System for Economic Analysis*. Washington DC: U.S. Department of Agriculture, Econ. Res. Serv., June 1973.

Food and Agriculture Organization of the United Nations (FAO). *Agricultural Commodity Projections, 1970–1980*, vol. 1, 2. Rome, 1971.

Hoerl, A. E., and R. W. Kennard. "Ridge Regression: Applications to Nonorthogonal Problems." *Technometrics* 12(1970):69–82.

———. "Ridge Regression: Biased Estimation for Nonorthogonal Problems." *Technometrics* 12(1970):55–67.

International Monetary Fund (IMF). *International Financial Statistics, 1986*. Washington DC, 1986.

Ito, Shoichi, Eric J. Wailes, and Warren R. Grant. "Asian Rice Elasticities." *Rice Outlook and Situation Report*, pp. 20–24. Washington DC: U.S. Department of Agriculture, Econ. Res. Serv. RS45, Mar. 1985.

Judge, George G., W. E. Griffiths, R. Carter Hill, Helmut Lutkepohl, and Tsoung-Chao Lee. *The Theory and Practice of Econometrics*, 2nd ed. New York: John Wiley & Sons, 1985.

Korea Rural Economics Institute. *Seoul-shi Migok Utong Gaesun Bang Hyang (Studies for Improving Rice*

Marketing in Seoul Area—Focusing on the Wholesale Market). Seoul, South Korea, 1984.

Mann, Jitendar S. *Food Demand Pattern in Thailand*. Washington DC: U.S. Department of Agriculture, Econ. Res. Serv. IED Staff Rep., 1982.

Mears, Leon A. *The New Rice Economy of Indonesia*. Indonesia: Gadjah Mada University Press, 1981.

Moon, Pal Yong. "The Evolution of Rice Policy in Korea." *Food Res. Inst. Stud.* 14(1975):381–402.

Phlips, L. *Applied Consumption Analysis*. Amsterdam: North-Holland Publishing Co., 1974.

Republic of China. *Taiwan Statistical Data Book 1985*. Council for Economic Planning and Development, Republic of China, 1985.

U.S. Department of Agriculture (USDA), For. Agr. Serv. *Foreign Agriculture Circular, Grains, FG-26-83, September 9, 1983*. Washington DC, Aug. 1986.

———. *Foreign Agriculture Circular, Grains, World Grain Situation and Outlook, 7, FG-8-86*. Washington DC, Aug. 1986.

Wong, Chung Ming. *A Model of the Rice Economy of Thailand*. Ph.D. thesis, University of Chicago, 1976.