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Demand for cereal grains in Asia: the effect of urbanization

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ABSTRACT

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This paper analyzes the effects of urbanization on demand for cereal grains – rice, wheat, and coarse grains – in nine Asian countries. A complete demand system (Almost Ideal Demand System in linear form) is estimated in two stages based on aggregate time series data from 1960 to 1988.

In the high-income countries, i.e. Japan and South Korea, urbanization was observed to significantly reduce demand for cereal grains. In the lower-income countries, demand for cereal grains either increased or remained the same with urbanization.

Among cereal grains, urbanization has had negative effects on demand for rice and coarse grains, but consistently positive effects on demand for wheat. Only Japan and Thailand among the countries studied have negative income elasticities of demand for total cereal grains and for rice in particular. Hence, rice remains a necessity and a normal good in most Asian countries.

Previous estimates of income elasticities of rice based on time-series aggregate data tend to be lower than those based on cross-section household level data. When urbanization is explicitly specified in the demand model, the estimates of income elasticities from time-series data turn out to be consistent with those from cross-section data.

INTRODUCTION

Cereal grains account for two-thirds of the calorie intake in the average Asian diet. Except in Pakistan, where wheat is the staple food, rice continues to be the dominant staple grain, contributing 40–75% of total calorie intake in most Asian countries. Significant quantities of wheat are

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consumed in northern parts of China and India, while coarse grains such as corn, barley and sorghum are important staples only in relatively small parts of the Philippines, South Korea and Indonesia. Not only is rice the major staple food, more than half of the rural labor force is engaged in rice production and thus it is also the major source of livelihood in rural Asia (Barker and Herdt, 1985). Because of the political importance of food self-sufficiency and cheap food in Asia, the nature of future demand for cereal grains, particularly of rice, is of major concern for policy formulation.

Although numerous studies of demand for cereal grains in Asia have been undertaken, estimates of income elasticities have varied widely depending on the type of data used and the specification of the demand model. For example, Table 1 shows that income elasticities of rice estimated from cross-section household data tend to be higher than those based on aggregate time-series data. Indeed, the study by Ito, Peterson and Grant (1989) using cross-country, time-series data in Asia indicates rela-

TABLE 1

Income elasticities for rice in Asia estimated by previous studies

Country	Cross-section			Time-series [a]	
	Authors	Survey year	Elasticity	IPG	HDD
Bangladesh	Bouis (1989)	1973	0.34/0.83 [b]	−0.04	0.08
China	FAO (1971)	1971	0.40	0.25	0.33
India	Bouis (1989)	1977	0.05/0.85 [b]	0.14	0.24
	Swamy and Binswanger (1983)	1956-75	0.942	0.15	0.25
Indonesia	Timmer and Alderman (1979)	1976	0.28/1.16 [b]	0.19	0.54
	Bouis (1989)	1981	0.04/0.40 [b]	0.12	0.47
Japan	FAO (1991)	1971	−0.10	−0.56	−0.45
S. Korea	FAO (1971)	1971	0.30	0.06	0.17
	Ingco (1990) [c]	1965	0.28	0.08	0.16
		1978	0.03	0.03	0.17
Pakistan	FAO (1991)	1971	0.30		
	Bouis (1989)	1984	0.26/0.73 [b]		
Philippines	Bouis (1989)	1978	−0.20/0.20 [b]	0.11	0.32
	Ingco (1991) [c]	1984/85	0.29	0.13	0.32
Thailand	Bouis (1989)	1975	−0.14/0.20 [b]	−0.25	−0.17

[a] Refers to estimates by Ito, Peterson and Grant (IPG) and Huang, David and Duff (HDD) pertaining to the same expenditure survey year except for the second line for India which refers to income elasticity in 1974.

[b] The range relates to income (high/low).

[c] Based on time-series data.

tively low and declining income elasticities over time, leading to the conclusion that rice is becoming an inferior good. While these results have been modified by Huang, David and Duff (1991) by correcting the methodological problems, there are at least two weaknesses with currently available estimates. First, the model specification ignores the theoretical restrictions of demand relationship, and secondly, the effect of structural changes in the economy such as urbanization has not been explicitly specified.

In this paper, we examine whether and to what extent the rate of urbanization affected the patterns of cereal grains consumption in Asia. We estimate a complete demand system based on time-series (1960–1988) aggregate data from nine major rice growing countries. These are Bangladesh, China, India, Indonesia, Philippines, Thailand, Japan, South Korea and Pakistan, which together account for about 85% of the world's rice consumption and production.

CEREAL GRAIN CONSUMPTION IN ASIA

Table 2 summarizes the annual per-capita consumption of rice, wheat and coarse grains in nine selected Asian countries over the past three decades. Whereas rice consumption per capita decreased significantly in three countries – Bangladesh, Japan and Thailand, wheat consumption per capita increased significantly in nearly all countries. In fact, it was only in China and Indonesia, and to a lesser extent the Philippines, where significant increases in per-capita rice consumption were experienced. In India, South Korea and Pakistan, rice consumption per capita remained essen-

TABLE 2

Annual per-capita cereal grains consumption (kg) in Asia, 5-year average

Country	Rice			Wheat			Coarse grains		
	1960–64	1984–88	Change	1960–64	1984–88	Change	1960–64	1984–88	Change
Bangladesh	183	155	−28	1	29	28	–	–	–
China	68	115	46	33	92	59	48	36	−12
India	79	79	0	33	60	27	53	34	−19
Indonesia	110	160	50	1	9	8	27	21	−6
Japan	125	81	−44	43	50	7	23	49	26
South Korea	132	136	4	9	30	21	47	37	−10
Pakistan	23	22	−1	123	134	11	25	14	−11
Philippines	91	105	13	14	16	3	30	39	9
Thailand	194	161	−33	1	4	3	0	1	1

Sources: USDA and IMF (various issues).

tially the same. While declining trends for Japan and even Thailand may be expected because of relatively high per-capita income, this is somewhat unexpected for Bangladesh, which has one of the lowest per-capita incomes in Asia. On the other hand, consumption of per-capita coarse grains decreased in most countries. The only exceptions are in Japan and the Philippines, but this may be likely due to difficulties in identifying the use of coarse grains between food and feed. Overall, Table 2 indicates that over time, consumption of wheat increases relative to rice, and especially coarse grains, where consumption per capita generally declined in absolute terms. The increase in per-capita consumption of wheat was more substantial in China, Bangladesh, India and South Korea.

There is a common belief that wheat is substituted for rice as income grows. However, cross-section household survey data (Table 3) indicate that per-capita rice consumption is larger at higher-income levels in both the urban and rural areas. On the other hand, per-capita rice consumption in the urban sector is significantly lower than in the rural sector. This pattern may have two explanations. First, demand for more conveniently consumed food is greater in the urban areas where both spouses typically work outside the home, travel time between work and home are large, and cost of household help is higher than in the rural areas. Because wheat is typically consumed in the form of commercially supplied bread and instant noodles which can be easily purchased and consumed, it offers substantial time savings for the household. Secondly, agricultural labor requires more physical energy and thus calorie inputs than industrial work. At a given income, rural consumers will have a greater demand for the cheaper food per calorie, such as cereal grains, or even roots and tubers to maintain the calorie requirements for subsistence. [1] Evidently, changes in the rate of urbanization together with changes in relative prices and income will affect consumption patterns of cereal grains in Asia.

MODEL AND DATA

Conceptual model

The Almost Ideal Demand System (Deaton and Muellbauer, 1980) in linear form (LA/AIDS) has been used as a basic model and extended to

[1] Consumption and price data for the roots, tubers, animal products and vegetables are not available for most countries studied. Therefore, the substitution effects between these commodities and cereal grains are not examined explicitly in this study.

TABLE 3

Comparison of annual per-capita cereal grains consumption (kg per capita) by income group, by regions in selected Asian countries

Country	Income group [a]	Urban			Rural		
		Rice	Wheat	Coarse grains	Rice	Wheat	Coarse grains
Bangladesh	I	108	30	–	103	24	–
	II	120	32	–	123	20	–
	III	133	31	–	159	18	–
	IV	138	31	–	181	17	–
	all	132	31	–	147	20	–
India	I	56	46	25	59	26	57
	II	70	59	18	87	42	54
	III	71	66	14	100	54	53
	IV	71	70	10	103	81	56
Indonesia	I	95	2	2	92	2	18
	II	110	3	2	133	2	8
	III	116	6	2	155	5	7
Pakistan	I	8	110	–	11	129	–
	II	10	110	–	17	132	–
	III	13	104	–	16	148	–
	IV	15	102	–	19	160	–
Philippines	all	95	13	5	116	4	17
Thailand [b]	I	113	19	–	152	5	–
	II	113	25	–	163	13	–
	III	113	29	–	156	22	–
	IV	116	32	–	151	28	–

[a] Income levels from the lowest I to the highest IV. [b] The figures under wheat are all other cereal grains except rice.

Sources: Bangladesh data are from Dey (1988, table 9), Philippines from Quisumbing et al. (1988, table 56), and others from Bouis (1989, tables 55, 56, 58).

include urbanization rate as an explanatory variable. The LA/AIDS model can be expressed as:

$$w_i = \alpha_i^* + \sum_j \gamma_{ij} \ln p_j + \beta_i^* \ln(Y/P) \qquad \text{for} \quad i, j = 1, \ldots, n \tag{1}$$

where w is the budget share, Y is expenditure or income, p_j is commodity price, i and j are commodity indices, α_i^*, β_i^* and γ_j are parameters to be estimated, and P is the price index defined as $\ln P = \Sigma_i\, w_i \ln p_i$.

When using time-series data, equation (1) may be misspecified due to omission of the effects of urbanization on consumption patterns between total cereal grains and all other commodities, and among cereal grains. To simplify the analysis, the parameters α^* and β^* in equation (1) are assumed to be linear functions of Z, where Z is a variable representing urbanization.[2] This means that expansion of the urban sector in the economy shifts the intercept and the slope of real income over time.

The impact of Z can then be specified with respect to equation (1) as:

$$w_i = \alpha_i + \alpha_i' Z + \Sigma_j \gamma_{ij} \ln p_j + (\beta_i + \beta_i' Z) \ln(Y/P) \quad (2)$$

where α, α', β, β' and γ are unknown parameters to be estimated. Existence of shifts in parameters caused by urbanization may be tested by examining whether or not $\alpha_i' = 0$ and $\beta_i' = 0$. Adding-up requires $\Sigma\ \alpha_i' = 0$ and $\Sigma\ \beta_i' = 0$.

To calculate the elasticities of income or expenditure (e_{iy}), price (e_{ij}), and urbanization (e_{iz}), the following formulas are used:[3]

$$e_{iy} = 1 + (\beta_i + \beta_i' Z)/w_i - (\beta_i + \beta_i' Z)/w_i\left[\Sigma w_k \ln p_k(e_{ky} - 1)\right] \quad (3)$$

$$e_{ij} = -\delta_{ij} + \gamma_{ij}/w_i - (\beta_i + \beta_i' Z)/w_i\left[w_j + \Sigma w_k \ln p_k(e_{kj} + \delta_{kj})\right] \quad (4)$$

$$e_{iz} = Z/w_i\left[\alpha_i' + \beta_i' \ln(Y/P) - \beta_i' \Sigma w_k \ln p_k e_{kz}\right] \quad (5)$$

where δ_{ij} is the Kronecker delta. The income and price elasticities for the standard model, i.e. equation (1) without urbanization variables, can be obtained by imposing $\beta_i' = 0$ in equations (3) and (4), respectively. Similar to the property of income elasticities or Engel Aggregation condition, the sum of weighted urbanization elasticities for related commodities will be zero, i.e., $\Sigma_i\ w_i e_{iz} = 0$.

Estimation procedure and data

For empirical estimation, the following stochastic structure of equation (2) is specified:

$$w_{it} = \alpha_i + \alpha_i' Z_t + (\beta_i + \beta_i' Z_t) \ln(Y_t/P_t) + \Sigma_j \gamma_{ij} \ln p_{jt} + u_{it} \quad (6)$$

where t indexes time, and u_{it} is the error term.

Considering the problem of data availability and the number of parameters to be estimated, the demand system was estimated in two stages. In the first stage, commodities have been grouped broadly into two, namely cereal grains, and non-cereal goods which include all other commodities besides

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[2] We assume that only α_i^* and β_i^* but not γ_{ij} are affected by the urbanization variable Z to avoid some econometric problems. However, this specification should not be considered as too restrictive an assumption, since change in β_i^* can reflect both changes in income and price elasticities as we will see from the elasticity formulas presented later.

[3] The elasticity formulas for LA/AIDS model are derived based on the studies by Green and Alston (1990) and Huang and David (1991).

cereal grains. Because the demand system expressed in budget share form is singular, only one equation (total cereal grain demand) is estimated. If serial correlation in the error terms is observed, the first-order autoregressive model or first-difference equation is used to estimate the total cereal grain demand function for each country.

In the second stage, the model consists only of cereal grains disaggregated into rice, wheat and coarse grains. The composition of coarse grains which included corn, barley, sorghum, rye, millet and other mixed grains differed by country. The error term u_{it} in equation (6) is a random variable satisfying the following conditions:

$$\begin{aligned} &E(u_{it}) = 0 \\ &E(u_{it}u_{it'}) = \Omega_{ij} \quad \text{for} \quad t = t' \\ &E(u_{it}u_{it'}) = 0 \quad \text{for} \quad t \neq t' \end{aligned} \tag{7}$$

If the Durbin–Watson test showed that the error terms in most of the equations are serially correlated, the first-difference equation is estimated. Iterative Seemingly Unrelated Regressions (SUR) or Iterative Zellner Estimation procedures (IZE) (Zellner, 1962, 1963) are used directly or after the variables have been transformed by the first difference. Several authors including Kmenta and Gilbert (1968) and Christensen and Manser (1977) have noted that the IZE procedure is equivalent to maximum likelihood estimations of linear equations systems. [4]

Data on consumption (availability) of cereal grains were obtained from the United States Department of Agriculture (USDA) which is based on supply-utilization balance sheets in each country. [5] Because government stocks and feed use of cereal grains are not reported for many countries in the USDA data base, data on consumption of coarse grains are likely overstated, which should be kept in mind when interpreting the results. The ratio of urban to total population is from the United Nations. Data on

[4] With both symmetry restrictions and iterative procedure, the estimation converges to full information maximum likelihood methods. Because the former requires the use of information across equations, the variance and covariance play important roles in estimation, and the latter converges to maximum likelihood method as stated above. Otherwise, the Zellner's estimation procedure reduces to single equation ordinary least squares (OLS).

[5] The alternative international source of cereal grain consumption data is the Food and Agriculture Organization of the United Nations (FAO). Both are mostly based on official supply-utilization balance sheets from respective governments, but the U.S. Department of Agriculture has made more modifications on official country statistics when these are deemed unreliable or historically inconsistent (Paulino and Tseng, 1980). Although consumption data for the nine selected Asian countries are quite consistent between FAO and USDA, we used the USDA data because FAO's published data refer to 3-year averages.

TABLE 4

Estimated parameters in cereal grains demand system models

Country	Commodity	Intercept	Z	ln Y/P *	Z ln Y/P *	ln PR	ln PW	ln PC	R^2 [a]	DW
Bangladesh	Rice	0.252	0.827	0.164	−0.173	−0.058	0.058	–	0.94	1.37
		(0.25) [b]	(1.24)	(0.86)	(−1.35)	(−3.24)	(3.24)			
	Wheat	0.748	−0.827	−0.164	0.173	0.058	−0.058	–	0.94	1.37
		(0.76)	(−1.24)	(−0.86)	(1.35)	(3.24)	(−3.24)			
China [c]	Rice	–	–	0.018	–	0.303	−0.131	−0.173	0.75	1.72
				(0.22)		(8.68)	(−2.92)	(−4.42)		
	Wheat	–	–	0.070	–	−0.131	0.164	−0.034	0.21	1.69
				(0.70)		(−2.92)	(2.00)	(−0.55)		
	Coarse grains	–	–	−0.088	–	−0.173	−0.034	0.207	0.39	1.61
				(−0.64)		(−4.42)	(−0.55)	(2.88)		
India	Rice	0.473	−0.480	0.015	0.073	0.334	−0.180	−0.155	0.69	1.69
		(0.12)	(−0.15)	(0.02)	(0.11)	(5.60)	(−3.96)	(−4.89)		
	Wheat	−3.328	3.619	0.638	−0.648	−0.180	0.180	−0.000	0.84	1.23
		(−0.98)	(1.30)	(0.96)	(−1.19)	(−3.96)	(3.73)	(−0.01)		
	Coarse grains	3.855	−3.139	−0.653	0.575	−0.155	−0.000	0.155	0.94	2.15
		(1.45)	(−1.44)	(−1.26)	(1.35)	(−4.89)	(−0.01)	(5.27)		
Indonesia	Rice	3.019	−1.411	−0.429	0.277	0.050	−0.012	−0.039	0.87	2.03
		(6.51)	(−3.95)	(−4.66)	(3.99)	(8.76)	(−3.38)	(−8.31)		
	Wheat	−2.154	1.722	0.412	−0.322	−0.012	0.007	0.005	0.88	2.23
		(−5.18)	(5.43)	(4.99)	(−5.23)	(−3.38)	(2.04)	(1.44)		
	Coarse grains	0.136	−0.311	0.017	0.045	−0.039	0.005	0.034	0.68	1.82
		(0.23)	(−0.68)	(0.15)	(0.51)	(−8.31)	(1.44)	(6.00)		
Japan	Rice	–	−4.319	−0.726	0.785	0.203	−0.165	−0.038	0.89	1.57
			(−1.40)	(−1.05)	(1.32)	(15.57)	(−20.58)	(−4.25)		
	Wheat	–	−2.630	−0.837	0.558	−0.165	0.159	0.006	0.95	1.83
			(−1.57)	(−2.23)	(1.73)	(−20.58)	(18.77)	(1.22)		

	Coarse grains	–	6.949	1.563	−1.344	−0.038	0.006	0.032	0.59	1.55
			(2.82)	(2.84)	(−2.82)	(−4.25)	(1.22)	(4.14)		
S. Korea	Rice	3.479	−1.459	−0.539	0.282	0.095	−0.038	−0.057	0.75	1.70
		(1.37)	(−1.02)	(−1.14)	(1.06)	(1.34)	(−0.96)	(−1.32)		
	Wheat	−3.842	2.098	0.742	−0.390	−0.038	0.052	−0.014	0.45	2.25
		(2.44)	(2.37)	(2.51)	(−2.36)	(−0.96)	(1.87)	(−0.66)		
	Coarse grains	1.363	−0.640	−0.203	0.108	−0.057	−0.014	0.071	0.82	1.29
		(0.83)	(−0.69)	(−0.68)	(0.63)	(−1.32)	(−0.66)	(2.15)		
Pakistan	Rice	6.444	−6.690	−1.222	1.292	0.243	−0.222	−0.021	0.58	1.38
		(1.33)	(−1.57)	(−1.29)	(1.55)	(5.43)	(−5.94)	(−0.89)		
	Wheat	−12.700	12.596	2.575	−2.409	−0.222	0.326	−0.104	0.72	1.85
		(−2.83)	(3.15)	(2.93)	(−3.09)	(−5.94)	(7.93)	(−4.28)		
	Coarse grains	7.257	−5.905	−1.352	1.117	−0.021	−0.104	0.125	0.80	1.53
		(2.54)	(−2.32)	(−2.42)	(2.25)	(−0.89)	(−4.28)	(5.03)		
Philippines [c]	Rice	–	–	0.179	–	0.161	−0.058	−0.104	0.68	1.71
				(3.36)		(7.04)	(−3.23)	(−5.91)		
	Wheat	–	–	−0.097	–	−0.058	0.074	−0.016	0.37	1.18
				(−1.61)		(−3.23)	(3.34)	(−1.02)		
	Coarse grains	–	–	−0.082	–	−0.104	−0.016	0.120	0.51	1.60
				(−1.72)		(−5.91)	(−1.02)	(5.85)		
Thailand	Rice	–	−1.553	−0.272	0.298	0.030	−0.025	−0.005	0.63	1.94
			(−2.04)	(−1.68)	(1.97)	(3.07)	(−4.05)	(−0.63)		
	Wheat	–	1.249	0.214	−0.235	−0.025	0.026	−0.001	0.74	1.68
			(2.39)	(1.93)	(−2.27)	(−4.05)	(3.64)	(−0.17)		
	Coarse grains	–	0.304	0.058	−0.063	−0.005	−0.001	0.006	0.08	2.92
			(0.51)	(0.46)	(−0.53)	(−0.63)	(−0.17)	(0.67)		

[a] System R^2 for India, Indonesia, Korea and Pakistan are 0.98, 0.97, 0.89 and 0.93, respectively. In China, Japan, the Philippines and Thailand where estimations are based on first-difference forms, the system R^2s are not reported. [b] *t*-values in parentheses. [c] Models for China and the Philippines are estimated from equation (1), since the original model is not rejected.

population and private consumption expenditures (PCE) are mainly from the International Monetary Fund (IMF, various issues), Asian Development Bank (ADB, various issues) and World Bank (World Tables, various issues), except for China which are taken from Beijing Review Press (1990). To derive the aggregated price index of all cereal grains, the geometric mean is calculated, using the consumer price index as proxy for the price of non-cereal commodities. All price data are from various official country sources including: Bangladesh Statistical Yearbook, India Directorate of Economics and Statistics, Statistical Yearbook of Indonesia, Statistical Yearbook of the Ministry of Agriculture (Japan), Economic Statistics Yearbook of Korea, Yearbook of Agriculture and Forestry Statistics (Seoul), 25 years of Pakistan in 1947–72 and Pakistan Statistical Yearbook, Bureau of Agricultural Statistics and Central Bank of the Philippines, and China State Statistical Bureau.

RESULTS

Demand systems are estimated with the imposition of homogeneity and symmetry conditions suggested by demand theory. Tests of demand restrictions are satisfied when urbanization effects are specified but generally rejected in the standard model where urbanization is omitted. The estimation results of the first-stage model as well as the implied demand elasticities of total cereal grains are reported and discussed briefly in Appendix 1.

Table 4 shows the estimation results of the second-stage cereal grain demand model. [6] The statistical results are remarkably good with most of the coefficients having the expected signs and reasonable magnitudes. The goodness of fit measured by R^2 is generally high except for wheat in China. The low R^2 for China may be due to the prevalence of quantitative rationing so that income, prices and urbanization alone do not fully explain consumption levels of these commodities.

The coefficients of rice price tend to be more statistically significant than those for wheat and coarse grains. Given the predominant role of rice in the Asian diet, changes in the price of rice will significantly affect the budget shares of all cereal grains. The generally insignificant coefficients of real cereal expenditure indicate that the budget share of individual cereal grains is not sensitive to changes in the total cereal expenditures, but

[6] To obtain all the relevant statistical information for all three equations without encountering singularity problem, two alternative pair-wise demand equations are estimated, i.e. rice/wheat and then rice/coarse grains. The results show that estimations are invariant to the equation that is dropped. To simplify Table 4, only rice and wheat demand equations are reported.

TABLE 5

Tests of urbanization effects within cereal grains demand system

Country	Wald-statistics		
	Intercept df = 2 [a]	ln Y/P slope df = 2 [a]	Both df = 4 [b]
Bangladesh	1.55	1.82	182.30 **
China	2.767	2.83	2.97
India	3.24	2.78	167.31 **
Indonesia	41.46 **	39.53 **	59.67 **
Japan	11.16 **	11.75 **	27.58 **
S. Korea	7.30 *	7.10 *	14.85 **
Pakistan	12.85 **	12.25 **	92.79 **
Philippines	2.31	2.24	3.35
Thailand	6.16 *	5.62	9.60 *

[a] df = 1 for Bangladesh. [b] df = 2 for Bangladesh. * Significant at 5% level. ** Significant at 1% level.

consumption may be significantly affected by those changes. This is because of the simultaneous effects of total cereal expenditure and price on the relative budget share ($w_i = p_i q_i / Y$). For example, holding price constant, the consumption level (q_i) will increase (decrease) by the same proportion as income (Y), leaving the budget share (w_i) unchanged.

To examine the existence of urbanization effect, Table 5 reports the results of the Wald chi-square tests which showed that urbanization shifted the intercepts in five out of nine Asian countries at the 5% significance level, i.e., Indonesia, Japan, South Korea, Pakistan and Thailand. Except in Thailand, the slopes of real total cereal expenditure have also significantly changed in these countries. The overall Wald tests indicate that urbanization has had a significant impact in seven (i.e. Bangladesh, India, Indonesia, Japan, South Korea, Pakistan and Thailand) out of nine countries. The insignificant result in China may be due firstly to the slow rate of urbanization over the period of study as interregional migration was highly restricted; and secondly, to the system of grain rationing that limited consumer choices. In the Philippine case, the insignificant coefficient of the urbanization ratio may be due to the relatively higher correlation between the real income and urbanization which increased the variances of estimates more than in other countries.

Price and expenditure elasticities

Table 6 summarizes the elasticities of demand for cereal grains computed at the sample mean based on the estimated parameters reported in

TABLE 6

Summary of mean budget share and estimated elasticities at sample mean

Country	Commodity	Mean budget share	Elasticities			
			Own price	Cereal expenditure	Total expenditure [a]	Urbanization [c]
Bangladesh	Rice	0.95	−0.92	0.85	0.38	−0.15
	Wheat	0.05	−2.48	4.07	1.82	2.95
China	Rice	0.46	−0.35	1.04	0.43	
	Wheat	0.33	−0.58	1.20	0.49	
	Coarse [b]	0.21	0.04	0.60	0.25	
India	Rice	0.55	−0.52	1.18	0.53	−0.24
	Wheat	0.25	−0.16	0.44	0.20	1.56
	Coarse	0.20	−0.26	1.18	0.53	−1.24
Indonesia	Rice	0.86	−0.88	0.93	0.47	−0.09
	Wheat	0.05	−0.83	0.47	0.24	4.54
	Coarse	0.09	−0.71	1.87	0.94	−1.30
Japan	Rice	0.78	−0.94	1.21	−0.21	−0.34
	Wheat	0.18	−0.06	0.06	−0.01	1.83
	Coarse	0.04	−0.25	1.13	−0.20	−1.40
S. Korea	Rice	0.75	−0.81	0.92	0.46	0.11
	Wheat	0.10	−0.55	1.80	0.90	0.27
	Coarse	0.15	−0.50	0.87	0.43	−0.72
Pakistan	Rice	0.24	−0.40	2.12	0.49	−0.11
	Wheat	0.65	−0.31	0.62	0.14	0.29
	Coarse	0.11	0.18	0.82	0.19	−1.45
Philippines	Rice	0.69	−0.96	1.25	0.25	
	Wheat	0.14	−0.35	0.31	0.06	
	Coarse	0.17	−0.24	0.52	0.10	
Thailand	Rice	0.95	−1.07	1.11	−0.14	−0.04
	Wheat	0.04	−0.27	−0.96	0.12	1.22
	Coarse	0.01	−0.15	−2.28	0.28	−2.96

[a] Total expenditure elasticities of rice, wheat and coarse grains are the product of total cereal expenditure elasticity obtained from stage I and cereal expenditure elasticity from stage II. IFPRI's estimates (1976) on total cereal expenditure elasticities are used for Bangladesh (0.48), India (0.47), and Pakistan (0.23).
[b] Coarse grains.
[c] Elasticities are calculated for those countries where the estimated parameters are statistically significant.

Table 4. Except for coarse grains in China and Pakistan, all the own-price elasticities have the correct signs. The generally higher absolute values of uncompensated own-price elasticities for rice compared to wheat and coarse grains would largely reflect the greater income effects of a price

change in rice which dominates total cereal expenditure in most of the countries.

Several patterns may be observed with respect to the total expenditure elasticities for individual grains. The total expenditure elasticity for rice remains positive ranging from 0.25 (Philippines) to 0.53 (India) in seven out of the nine Asian countries. The negative total expenditure elasticity of demand for rice in Japan, which has one of the world's highest per-capita incomes, is to be expected. The negative elasticity for Thailand is also plausible as the country now has the highest per-capita income among South and Southeast Asia. The relatively high elasticity for South Korea is due partly to the fact that shifts in consumption from barley to rice have occurred as income increased and partly to the overestimate of total expenditure elasticity of demand for total cereal grains in the first stage of this study.

The total expenditure elasticities for wheat are positive in all countries except for Japan. However, wheat does not appear to be preferred over rice as evidenced by the lower total expenditure elasticity for wheat compared to rice in India, Indonesia, Pakistan and the Philippines. Japan is the only country where all cereal grains are regarded as inferior goods, but the absolute values of the expenditure elasticities are relatively low.

It should be noted that estimated total expenditure elasticities of demand for coarse grains may be overstated because of underestimation of feed use, which lead to overestimation of food consumption in the data used.

Urbanization elasticities

The elasticity of urbanization is defined as the percentage change in demand due to a percentage change in the ratio of urban to total population. Consistent with expectations, urbanization has generally negative effects on consumption of rice and coarse grains, but positive effects on wheat consumption.

Japan has the most negative urbanization elasticity (−0.34) of demand for rice, which implies that omission of urbanization variable in the specification of cereal grain demand models for Japan will lead to a downward bias in estimated income or expenditure elasticity. The highly negative urbanization elasticity (−0.24) in India, which is next only to Japan, can partly explain why per-capita rice consumption in India remained relatively unchanged over the last three decades. Likewise, the decrease in per-capita rice consumption by 28 kg in Bangladesh despite the relatively high expenditure elasticity during the last three decades may partly be explained by the negative effects of urbanization on rice demand in this country. [7] The urbanization elasticity of rice in Pakistan is also negative but small in magnitude because rice is not a staple food in this country. Moreover, unlike in other Asian countries, wheat is not generally consumed as commercial breads, and therefore is not necessarily more convenient to consume than rice. Thailand also has a negative elasticity, but the magnitude is unexpectedly low. The positive urbanization elasticities in South Korea is unexpected and may imply that the substitution of rice for barley occurred not only because of higher income but also because of the higher rate of urbanization.

In contrast to rice and coarse grains, urbanization elasticities for wheat are all positive with relatively high absolute values. Therefore, observed growth in wheat consumption over time in all countries is due not only to increases in income but also to the growing urbanization. Because wheat is the staple food in Pakistan, the urbanization elasticity is relatively small (0.29). The low elasticity obtained for South Korea (0.27) is explained by the different nature of substitution among cereal grains in this country. Whereas wheat is typically substituted for rice as urbanization increases, the substitution of rice for barley was also important in this country during this period. In general, countries with small initial budget shares of wheat have higher urbanization elasticities.

For coarse grains, urbanization had negative effects on consumption in all countries studied. The negative signs are due to the fact that wheat as well as rice are generally more accessible and convenient to consume than coarse grains. Omission of urbanization variables in the analysis of demand for rice, wheat and coarse grains may therefore tend to underestimate income or expenditure elasticities for rice and coarse grains while overestimating them for wheat.

As shown in Table 1, estimates of income elasticities based on cross-section data are generally significantly higher than those based on time-series aggregate data. Even when the estimation problems in IPG's time-series analysis which lead to downward bias in estimated income elasticity have been corrected by HDD, estimates in the last column are still below those from cross-section data. All of these time-series estimates, however, are based on single equation models that specify only income and relative prices as independent variables. When urbanization and interdependence of rice and all other commodities in the economy are accounted for in the

[7] Aside from the effects of urbanization, production shifts from rice to wheat may have increased home consumption of wheat grains over the last three decades in Bangladesh. This follows from Bouis (1990) hypothesis that greater commercialization of a cereal grain will tend to reduce its consumption.

analysis as done in this paper, estimates of income elasticities based on time series become remarkably consistent with estimates from cross section data. For example, our expenditure elasticity of demand for rice in Bangladesh is 0.38, which is close to the cross-section estimate by Bouis (0.34–0.83) and much higher than time-series estimates by IPG (−0.04) and HDD (0.08). Similarly, time-series estimates of expenditure elasticities of demand for rice in this study are quite comparable with those estimated by cross-section data in China, India, Indonesia, Japan, South Korea, Pakistan, Philippines and Thailand. The omission of urbanization variable which is typically positively correlated with income, therefore, leads to underestimation of income elasticity in time-series analysis.

CONCLUSIONS

Urbanization has significantly affected patterns of Asian cereal grains consumption. Its effects on total cereal grains may differ by country according to income levels. In high-income countries, it has been observed that urbanization significantly increased the consumption of other non-cereal goods and decreased cereal grains consumption, whereas urbanization increased cereal grain consumption in low-income countries.

Among cereal grains, urbanization has had negative effects on consumption of rice and coarse grains but positive effects on wheat consumption. The positive effects of urbanization on demand for wheat are consistently observed for all countries because of the greater convenience of consuming wheat products. Therefore, continuing increases in wheat consumption over time are due not only to increases in income, but also due to those urbanization effects. Among the countries studied, only Japan and Thailand have negative income elasticities of demand for total cereal grains. Rice remains a necessity and a normal good in all countries except these countries.

A review of the existing studies of rice demand in Asia reveals that time-series data tend to generate lower estimates of rice income elasticities than cross-section data. This study has shown that when the effects of urbanization are taken into account, estimates of income elasticities for rice based on time-series data become consistent with those from cross-section data. In order to improve projections of future demand for cereal grains, therefore, changes in the rate of urbanization as well as income must be taken into account.

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APPENDIX TABLE 1

Estimated parameters and elasticities of demand for total cereal grains

Country	Demand parameters						R^2	DW	Elasticity	
	Intercept	Z	$\ln(X/P^*)$	$Z \ln(X/P^*)$	$\ln(P$ cereal)	$\ln(P$ other)			Expenditure [b]	Urbanization
China	−4.397	4.965	0.905	−0.986	0.238	−0.238	0.96	1/70	0.41	0.57
	(−1.90) [a]	(2.34)	(1.88)	(−2.33)	(12.98)	(−12.98)				
India	1.232	0.243	−0.176	−0.038	0.205	−0.205	0.96	1.96	0.22	0.12 [c]
	(0.88)	(0.22)	(−0.71)	(−0.20)	(5.64)	(−5.64)				
Indonesia	0.950	0.018	−0.089	−0.004	0.172	−0.172	0.97	2.20	0.51	−0.07 [c]
	(2.40)	(0.05)	(−1.93)	(−0.01)	(11.04)	(−11.04)				
Japan	–	−2.324	−0.294	0.187	0.047	−0.047	0.71	1.62	−0.18	−0.36
	–	(−2.32)	(−3.06)	(2.24)	(3.72)	(−3.72)				
S. Korea	2.725	−0.809	−0.233	0.067	0.198	−0.198	0.98	1.94	0.50	−0.93
	(13.29)	(−3.08)	(−9.63)	(3.04)	(8.09)	(−8.09)				
Philippines	1.095	−0.284	−0.172	0.059	0.130	−0.130	0.95	1.85	0.20	0.69
	(0.80)	(−0.23)	(−0.77)	(0.29)	(7.35)	(−7.35)				
Thailand	1.783	−0.466	−0.212	0.056	0.098	−0.098	0.92	1.85	−0.12	−0.09 [c]
	(1.94)	(−0.42)	(−1.93)	(0.45)	(4.66)	(−4.66)				

[a] *t*-values in the parentheses.

[b] The income elasticities for India, Indonesia and Thailand are derived from the original LA/AIDS model, since tests for urbanization effects on consumption showed that they are not statistically significant in the stage I.

[c] Elasticities derived from the parameters which are statistically insignificant.

APPENDIX 1

Appendix Table 1 presents the estimation results of the first-stage model as well as the implied demand elasticities for total cereal grains. Bangladesh and Pakistan as well as India have been excluded from the first-stage analysis because of unreliable data on private consumption expenditure in the 1960s when the former two countries were not yet separated, and lack of data for the latter. With the exception of Japan and Thailand, the total expenditure elasticities of demand for cereal grains are positive. Indonesia has the highest expenditure elasticities of total cereal grains (0.51), followed by South Korea (0.50) and China (0.41).

Urbanization effect is still in favor of cereal grains consumption in some low-income countries such as China and the Philippines. This may be due to the high substitutability of cereal grains for inferior root crops such as sweet potatoes and cassava. On the other hand, urbanization reduces cereal grains consumption in those countries where income levels are high such as Japan and South Korea. This suggests that urbanization induces substitution between cereals and other food such as animal products. The effects of urbanization on total cereal grain consumption are insignificant in India, Indonesia and Thailand.

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