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An econometric analysis of rice consumption in the People's Republic of China

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ABSTRACT

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Rice is the most important staple food in the People's Republic of China (PRC). In many Asian countries rice appears to have become an inferior good, with income increases leading to declines in per capita consumption as other food products are substituted for rice. In this study, human rice consumption is analyzed with a model that allows income elasticities to vary with income levels. An additional equation accounting for rice disappearance as seed, livestock feed, industrial uses and exports is also estimated. The results of the analysis indicate that rice has become an inferior good in China and per capita consumption is likely to decline in the future. Population growth and the growing use of rice for other purposes means that total rice disappearance will continue to increase although at a rate that is slower than has historically been the case. The predicted changes in rice consumption will create pressures to adjust production and trade patterns for rice as well as other agricultural products.

INTRODUCTION

Almost 80% of the rice produced and consumed in the world is accounted for by six Asian nations, including the People's Republic of China (PRC), India, Indonesia, Bangladesh, Vietnam and Japan (Ito, 1988). Of these countries, the PRC is by far the largest producer and consumer of rice. From 1986 to 1989, average annual rice production in the PRC was about 120 MMT * (throughout this paper, figures cited for rice consumption or production are on a milled basis) compared with about 63 MMT for the

* MMT, million metric tonne = 10^6 t = 10^9 kg.

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TABLE 1

Average annual rice production and trade (1986–1989) for selected countries

Country	Production, P (MMT) [% of World Total]	Net Exports, X (MMT)	Net Imports M (MMT)	$\frac{100X}{P}$ (%)	$\frac{100M}{P}$ (%)
PRC	119.7 [37.4]	0.8		0.7	
Thailand	12.9 [4.0]	4.9		38.0	
Burma	7.4 [2.3]	0.5		6.8	
U.S.	4.4 [1.4]	2.5		56.8	
Pakistan	3.2 [1.0]	1.0		31.3	
India	62.9 [19.6]	0.0		0.0	
Indonesia	27.5 [8.6]		0.0		0.0
Bangladesh	15.3 [4.8]		0.4		2.6
Brazil	7.3 [2.3]		0.4		5.5
EC-12	1.3 [0.4]		0.2		15.4
Others	58.5 [18.3]	3.4	12.1	–	–
World total	320.4	13.1		4.1	
Total wheat	508.4	94.5		18.6	
Total maize	450.5	58.1		12.9	

Source: USDA, 1990.

same period in India, the second largest producer (USDA, 1990). Most of the rice produced in the PRC is consumed by households as a staple food. In recent years, the use of rice for livestock feed has increased. In 1986, rice fed to livestock made up about 17% of total disappearance compared with about 13% in the mid 1960's. Human consumption accounts for about 79% of total disappearance with the remainder made up of seed, and exports (USDA, 1986).

Recent information on the international rice market is presented in Table 1. The figures for production, exports and imports are averages for the 4-year period 1986 to 1989. The figures in the table illustrate two striking features of the world rice market. First, only about 4% of total rice production is traded compared with over 18% of total wheat production and almost 13% of maize production. Four countries (PRC, Thailand, Pakistan and the U.S.) account for more than two-thirds of total rice trade and in three (Thailand, Pakistan and the U.S.), a large share (31.3% to 56.8%) of national production is exported. The second feature shown by the figures in Table 1 is the importance of the PRC in world rice production. Because exports account for less than one percent of production and the PRC holds virtually no stocks, internal rice utilization is

approximately equal to production with both amounting to about 37% of the corresponding world totals. Clearly, relatively small changes in production or consumption in the PRC could have an important effect on the world market. For example, a 1% fall in internal utilization coupled with a 1% increase in production could add more than 2 MMT of rice (more than 15% of current exports) to the present level of Chinese exports. A change of this magnitude would have important repercussions for producers in such exporting nations as Thailand or the United States.

The purpose of this study is to examine the likely evolution of rice consumption in the PRC. Total rice disappearance can be divided into human consumption and consumption for other purposes including livestock feed, seed, industrial uses and exports. Although human rice consumption accounts for most of the total disappearance, the amount of rice consumed for other purposes is substantial and has been growing in recent years. Consequently, it is necessary to account for both of these elements in assessing the likely evolution of rice consumption in the PRC. In the next section, models of per capita human rice consumption and consumption of rice for other purposes are described and estimated. These models are then used to project Chinese rice consumption to the year 2000. In the concluding section, the results of the analysis and their implications for world trade in rice are summarized.

RICE CONSUMPTION IN THE PRC

In a study of rice consumption in 14 Asian countries, Ito et al. (1989) found that income elasticities of demand have declined in recent years in many of these countries and, in several, have become negative. Their results for the PRC indicate that rice is still a normal good although the income elasticity of demand appears to have declined in recent years. Other analysts have pointed to apparent changes in Chinese food consumption patterns (Sicular, 1985; Crook, 1987; Tuan, 1987). As in most Asian countries, rice consumption in the PRC is quite high compared with other regions of the world, and it is likely that most Chinese households will allocate any additional income earned to foods other than rice, notably meat and dairy products.

If the income elasticity of demand for rice in the PRC has become negative, it is likely that per capita rice consumption will decline in the future as incomes continue to grow. China has experienced rapid economic growth since economic reforms were initiated in the late 1970's. The World Bank has projected average annual growth in per capita income of between 3.5% and 5.5% over the next 10–15 years (World Bank, 1985). Increases of this nature coupled with negative income elasticities mean significant

declines in per capita rice consumption. Whether these declines lead to large exportable surpluses of rice depends on the way in which rice production and total population evolve. If population growth is high enough, the fall in per capita consumption may be offset and total rice consumption may actually increase. In addition, adjustments in production or increased use of rice as livestock feed could reduce the amounts available for export.

To account for these various influences on rice disappearance, it is useful to estimate separate equations for human consumption and for rice used for other purposes. In addition, human rice consumption should be estimated on a per capita basis to allow an assessment of the potentially conflicting effects of population and income growth. Finally, on the basis of previous results, it is important to model human demand in a manner that allows the income elasticities to vary with the level of income. The log-inverse-log model used by Ito et al. (1989) is an appropriate representation of the relationships to be analyzed:

$$X = \exp(a - bY^{-1})Y^{-c} \tag{1}$$

where X is per capita consumption, Y is real per capita income, and a, b and c are coefficients to be estimated. This can also be written as;

$$\log X = a - bY^{-1} - c \log Y \tag{2}$$

The first derivative of X with respect to Y is $(b/Y^2 - c/Y)X$. This derivative is positive if b/Y is larger than c and negative if b/Y is smaller than c.The income elasticity of demand derived from equations (1) or (2) is:

$$N = b/Y - c$$

As required for this study, this income elasticity varies with the level of income and becomes negative when incomes increase to the point where the expression b/Y is less than c. Ito et al. (1989) used cross-section, time-series analysis to estimate income elasticities of demand for the PRC and 13 other Asian countries. Their results indicated that the income elasticity of demand in the PRC declined from 0.42 in 1961 to 0.13 in 1984. In this study, time-series data are used to analyze the relationship and different price variables from the ones used by Ito et al. (1989) are included. In addition, human consumption is used as the dependent variable rather than total disappearance as in the study by Ito et al. (1989).

Aside from human consumption, the principal use of rice is for livestock feed. Over 90% of the meat consumed in the PRC is pork although poultry and dairy production are also significant livestock enterprises (World Bank, 1987). Industrial livestock production based on scientifically compounded

feeds is fairly limited but large quantities of locally produced grains and grain by-products are fed to barnyard animals in traditional husbandry systems. Southern China, the main rice producing region, is also a leading hog production area (World Bank, 1987). The amount of rice used for feed is influenced by livestock populations, notably those of hogs and poultry, and the intensity of feeding. Another variable that may influence the use of rice as feed is the price of maize, the main substitute for rice in livestock rations. Thus, a measure of livestock numbers and maize prices are important explanatory variables in accounting for the consumption of rice for purposes other than direct human consumption. The model estimated for this study also includes rice acreage because the amount of rice used for seed depends on acreage and seed use is included in the dependent variable. The final specification, thus, includes rice acreage, total consumption of pork and poultry as a proxy for livestock numbers, and real maize prices as explanatory variables.

Most of the data used in this study are from the *Statistical Yearbook of China* and cover the period 1960–1986. National income, defined in the PRC as the value of production excluding the government sector, the Chinese general index of retail prices (1950 = 100) used to deflate the income and some of the price variables, retail pork prices, producer prices for maize, rice acreage, and population are all taken from this source. In the absence of reliable data on retail wheat and rice prices, world prices as reported by the IMF are used. Data on rice consumption are from USDA (1986). The equation for per capita human consumption also includes a dummy variable for the years 1978–1986 to test the hypothesis that the agricultural reforms begun in 1978 have had an effect on rice consumption patterns. The equation was estimated with ordinary least squares and is shown below with the t-ratios in parentheses.

$$\begin{aligned}\log \text{RC} = {} & 1.085 - 1.142(\text{PCY})^{-1} - 0.436 \log \text{PCY} \\ & (2.470)\ (4.630) \qquad\qquad (2.474) \\ & + 0.748 \log \text{PM} - 0.036 \log \text{RWR} + 0.061 D \\ & (3.663) \qquad\quad (0.801) \qquad\quad (1.925)\end{aligned} \tag{3}$$

$$R^2 = 0.96 \qquad D.W. = 1.88$$

where RC is per capita rice consumption (kg), PCY real per capita income (yuan), PM real price of pork (yuan), RWR ratio of world rice to world wheat prices, and D is a dummy variable for the reform years 1978–86.

The results reported in equation (3) show a strong relationship between income and consumption. Both income coefficients are significant and of the expected sign. The price of pork is also significant suggesting a cross-price demand elasticity of 0.75. This result supports the argument

that high quality food products such as meat are being substituted for rice. The coefficient of the price ratio for grain is not significantly different from zero. This is not surprising given the extensive government control of these markets in China. Guaranteed rations of staple foods have historically been available to all consumers, and prices have been strictly controlled by the government. It is interesting to note that the dummy variable is significantly different from zero. This suggests that there has been a change in the relationships as a result of the economic reforms launched in 1978. In general, the model performs very well in predicting the historical level of per capita rice consumption as can be seen in Table 1. Overall, equation (3) appears to be a reliable representation of the determinants of per capita rice demand.

Equation (3) can be used to chart the evolution of income elasticities in the PRC. These historical elasticities are shown in Table 2. The results indicate that income elasticities declined throughout the 1960's and 1970's, turning negative in the early 1980's. By 1986, the estimated elasticity had fallen to -0.15.

The equation accounting for other uses of rice was also estimated with ordinary least squares:

$$\begin{array}{lllll} \text{OU} = -9124.83 + 0.38\ \text{MU} + 53.42\ \text{RM} + 78630.90\ \text{PCO} & & & & \\ \qquad\quad (1.72)\ \ (2.42) \qquad (6.89) \qquad\quad (1.13) & & & & (4) \end{array}$$

$$R^2 = 0.95$$

$$\rho = -0.395(1.97)$$

where OU is rice consumed as feed, seed, exports and industrial usages (1000 metric tonnes); MU rice area (1000 hectares); RM pork and poultry consumption (100 million jin *); and PCO real producer price for corn in the PRC (yuan/jin *). Equation (4) has been corrected for first-order autocorrelation ($\rho = -0.395$). The signs of all coefficients are as expected and significantly different from zero at the 5% level of confidence with the exception of the coefficient for real corn prices.

A more sophisticated model of the Chinese rice market would include simultaneous equations for supply, demand and trade. The relatively simple model presented above can be justified by noting the nature of the market. Historically, the state has exercised almost complete control over production, prices and distribution of rice (Ash, 1988). Although the agricultural reforms have allowed some private trade, government intervention is still pervasive. Under these conditions, it is reasonable to model

* 1 jin is approximately equal to one half kg.

TABLE 2

Per capita rice consumption in China (actual and predicted), estimated income elasticities, and total rice for other uses (actual and predicted)

Year	Per Capita consumption (kg)		Estimated income elasticity of demand	Total other rice use	
	Actual	Predicted		Actual	Predicted
1968	65.9	62.9	0.396	12755	13131
1969	65.0	66.0	0.305	13358	12985
1970	68.8	69.2	0.203	15095	13970
1971	71.0	70.9	0.167	17225	16042
1972	70.4	71.0	0.164	15818	16797
1973	69.8	69.9	0.133	17973	16973
1974	73.0	69.9	0.140	17302	17286
1975	72.6	71.0	0.166	18066	17457
1976	73.2	70.1	0.143	17975	17498
1977	72.7	70.1	0.115	18530	17100
1978	73.5	70.2	0.057	19088	17049
1979	78.6	79.7	0.021	19858	19842
1980	84.9	83.5	0.010	17681	21480
1981	87.2	84.3	−0.002	18350	21215
1982	87.8	84.8	−0.002	21161	21959
1983	88.9	85.7	−0.053	22566	22768
1984	91.5	85.9	−0.102	25224	23602
1985	94.4	91.7	−0.133	26638	25773
1986	93.0	93.0	−0.150	–	–

Source: USDA (1986) and authors' estimates.

consumption separately from production, trade and stocks. In addition, the quality of the data available may be such that more complicated specifications would add little to the explanatory power of the model. The two equations estimated for this study predict the historical evolution of the two dependent variables quite accurately (Table 2) and appear to represent the relationships of interest reasonably well. In the next section they are used to project rice disappearance to the year 2000.

PROJECTIONS OF CHINESE RICE CONSUMPTION

The first step in projecting human rice consumption in China is to develop predictions of the likely evolution of real income. Real per capita income has grown at an average annual rate of about 7% in the 1980's. These high rates of growth are not likely to be sustained in the 1990's. Rapid economic growth in recent years has led to inflationary pressures and the government is working to slow growth rates. For the purposes of

TABLE 3

Projected income, population and elasticities

Year	Real per capita income (high growth scenario)		Real per capita income (low growth scenario)		Population (millions)	
	Income (yuan)	Elasticity	Income (yuan)	Elasticity	Low	High
1990	523	−0.218	494	−0.205	1140	1147
1995	693	−0.271	607	−0.248	1236	1259
2000	873	−0.305	725	−0.278	1331	1376

Source: Authors' estimates.

this study, two income scenarios were adopted. Both reflect the expectation that income growth rates will decline. In the first, the current rate of 7% is maintained into the early 1990's, after which it falls to 5.5% from 1992–96 and 4.5% from 1997–2000. The low growth scenario uses rates of 5.0%, 4.0% and 3.5% for the same periods. The two income levels and the associated income elasticities of demand are shown for selected years in Table 3.

Population is the other variable affecting total human consumption. Because the population of China is very large, small differences in growth rates could lead to large differences in the absolute number of people. The World Bank has projected population in China to the year 2000. Their projections may underestimate population growth in China because individuals born in the baby boom of the 1960's are now entering the reproductive years. In addition, programs to control rural population growth have not been very effective and the new income streams resulting from the changes in agricultural policies make it easier for rural families to support additional children (Lan, 1989). For this study, two population growth paths are assumed. The first allows population to grow at 2.0% per year from 1987 to 1992 and at 1.8% from 1993 to 2000. This leads to a higher predicted population in the year 2000 than that predicted by the World Bank. The second population growth path is based on the assumption that population grows at 1.8% per year until 1992 with the annual growth rate falling to 1.5% thereafter. The two population projections are shown for 1990, 1995 and 2000 in Table 3. Both of them indicate that the Chinese population will surpass 1.3 billion by the year 2000.

The income and population projections give rise to four possible combinations. Only two of these, low population growth coupled with high income growth and high population growth along with low income growth, are reported in Table 4. The other combinations lead to results between the extremes generated by these two growth profiles (Lan, 1989). As shown

TABLE 4

Projected per capita and total human rice consumption

Year	Low population/High income		High population/Low income	
	Per capita (kg)	Total (MMT)	Per capita (kg)	Total (MMT)
1990	91.0	103.7	93.0	106.6
1991	89.6	103.9	92.0	107.7
1992	88.5	104.6	91.3	108.9
1993	87.3	104.7	90.5	110.0
1994	86.1	104.8	89.7	110.9
1995	84.9	104.9	88.8	111.8
1996	83.6	104.9	88.0	112.8
1997	82.6	105.2	87.2	113.8
1998	81.6	105.4	86.5	114.8
1999	80.5	105.6	85.7	115.8
2000	79.4	105.7	84.9	116.8

Source: Authors' estimates.

in Table 4, relatively rapid growth in real income leads to a fall of around 13% in annual per capita rice consumption from 91 kg in 1990 to just under 80 kg in 2000. Despite the decline in per capita consumption, population grows sufficiently, even on the basis of the low population growth projection, to induce a slight increase in total consumption over this period. Projected total consumption in 2000, however, is only 1.9% higher than the 1990 level because of the lower population growth assumptions. If the income growth assumptions are retained but even lower population growth rates are assumed, total consumption could even begin to decline. For example, if the average annual population growth rate is 1.5% for the entire period between 1988 and 2000, total population will just barely reach 1.3 billion in 2000 and total rice consumption (at 103.2 MMT) would be a fraction lower than the predicted level for 1990.

For the other scenario, high population growth rates are combined with low income growth. Annual per capita rice consumption falls less rapidly to about 85 kg in 2000 and the higher assumed population growth leads to an increase in total human consumption between 1990 and 2000 of 9.6%. The two scenarios shown in Table 4 can be taken to represent upper and lower bounds for total human rice consumption in the PRC. Other assumptions about income and population growth would generally fall between these two extremes. Based on these results it appears that total rice consumption by the human population will grow between 2% and 10% over the next decade. In contrast, if one assumes that the level of annual per capita rice consumption in 2000 remains at the 1986 figure of 93 kg, total human consumption would be between 124 and 128 MMT depending on the

TABLE 5

Projected rice acreage, pork and poultry consumption, rice consumption for other purposes, and total rice disappearance

Year	Rice acreage (1000 ha)	Pork/Poultry consumption (100 million jin *)	Rice for other uses (MMT)	Total rice disappearance (MMT)	
				Low	High
1990	33625	288	24.7	128.4	131.3
1991	33707	299	25.3	129.2	133.0
1992	33787	309	25.9	130.5	134.8
1993	33871	320	26.5	131.2	136.5
1994	33953	330	27.1	131.9	138.0
1995	34034	341	27.1	131.9	138.0
1996	34116	332	28.3	133.2	141.1
1997	34198	362	28.9	134.1	142.7
1998	34280	373	29.5	134.9	144.3
1999	34362	383	30.1	135.7	145.9
2000	34443	394	30.7	136.4	147.5

Source: Authors' estimates.

assumptions on population growth compared with the range of 106–117 MMT projected for the year 2000 in this study.

To project the disappearance of rice for other uses, it is necessary to predict values for the explanatory variables. The projections for rice acreage and pork and poultry consumption are based on time trends while the real price of corn was held constant at its average value between 1981 and 1985. The projected explanatory variables are shown in Table 5 along with projections of rice consumption for other purposes and total rice disappearance. Total rice disappearance includes human consumption and other uses of rice. In the low population growth/high income growth scenario, total disappearance increases by 6.2% from an estimated volume of 128.4 MMT in 1990 to 136.4 MMT in the year 2000. In the scenario coupling high population growth with low income growth, total disappearance increases from 131.3 to 147.5 MMT, an increase of 12.3%. Again, using the 1986 figure for per capita consumption (93 kg) would lead to much higher predictions for total rice consumption, ranging from 155 to 159 MMT.

To understand the implications of these results, it is helpful to consider some independent projections of Chinese rice production. The World Bank, for example, has predicted annual increases of 1.8%. If these increases are realized over the coming decade, total milled production would reach about 155 MMT in the year 2000. On the basis of the results presented in this study, this production estimate implies an exportable

surplus ranging from 7 to 25 MMT. In another study, Noh (1983) predicted that milled production would reach 187.6 MMT by the year 2000. The exportable surplus would be even larger if this prediction is realized. Note that predictions based on relatively constant levels of per capita consumption would seriously underestimate the potential excess supply. Using the 1986 figure for per capita consumption, the World Bank production projections and the levels of rice disappearance for other uses predicted in this study, Chinese rice disappearance would be approximately equal to availability in 2000. This shows the importance of allowing income elasticities of demand to vary with the level of income.

CONCLUSION

The results set out above are not derived from a complete model with endogenous production and government policy. As the predicted slowing in the growth of total human rice consumption becomes apparent, producers and the Chinese government can be expected to react in some way to the changes in consumption patterns. Policies designed to increase rice production may need to be modified in light of these changes. As consumers allocate greater proportions of their growing budgets to high quality products such as meat and dairy products, demand for feed grains can be expected to grow. Given the size of the world rice market (see Table 1), strategies based on trading growing excess supplies of rice for imported feed grains do not appear promising. Any sustained increase in the level of rice exports by the PRC is likely to depress world rice prices quite substantially, worsening the PRC's terms of trade. A more promising strategy may be to adopt policies that encourage feed grain production at the expense of further increases in rice production. Alternatively some of the current rice acreage could be shifted to rice varieties particularly suitable for feeding livestock. Reactions of this nature are likely to result in lower production levels than predicted by the World Bank and actual exportable surpluses will almost certainly be much less than the quantities indicated in the previous section.

Other implications of the changing consumption patterns in the PRC are more difficult to detail. In a less regulated market, the slower growth in demand would cause rice prices to decline relative to the price of other goods, benefiting low-income consumers and providing the incentives to re-allocate resources from rice production to feed grain and livestock production. In the PRC, the effects may be to encourage production of livestock products, vegetables and other foods for the small free market instituted as part of the agricultural reform. Rice grown in the northern parts of the PRC on land more suited to wheat cultivation may be replaced

with that crop. Thus, the market for wheat, as well as those for feed grains and livestock products may be affected by the predicted changes. Much will depend on the response of the government to these changes and the types of price policies implemented.

Finally, slower growth in the demand for rice in the PRC will have an impact on world markets for rice, feed grains and, perhaps, livestock products and wheat. The PRC could potentially become the leading rice exporting country if falling consumption leads to increased exports. It could also become an important market for feed grains if land is not shifted from rice production to feed grain production. Because per capita consumption of rice is likely to fall as incomes increase, the future growth in total rice consumption is likely to be lower than what many planners had expected. This prediction is particularly important in a country where markets cannot be expected to guide the allocation of resources toward production of other crops and livestock products for which demand is likely to increase.

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