The Demand for Food Grain in China: New Insights into a Controversy

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There is a substantial controversy in the economics literature over the magnitude of the expenditure elasticity for food grain in China that is caused, to a large extent, by whether time-series or cross-section data are used in the analysis. A set of reasonable elasticities for a complete demand system is estimated by using a panel of county level data in Guangdong Province for the last ten years. The results show that food grain has a small positive income elasticity, implying that food grain is not an inferior good in China. The reason that consumption per capita has not increased during a period of rapid economic growth in income is that the relative prices of the food and non-food substitutes for food grain have decreased.

China has been one of the fastest growing economies in the world for at least the past two decades. Population growth, combined with rapidly rising incomes, has brought about an even more rapid increase in demand for food and other products but only a modest increase in demand for food grain. In 1995, China's grain price increased by 60% over the previous year (Brown 1995). In addition, China's net grain imports reached 19.6 million tons in 1995 (China Custom Statistics 1994–1996), a dramatic shift from 1993 and 1994 when China was a net exporter of 2 and 6 millions tons of grain, respectively. Because China's increasing dependence on imports would affect grain markets in the United States and throughout the world, research is needed to determine if this dramatic change is due to short-term production shortages or a longer-term outward shift in the demand for grain.

Previous literature on Chinese food demand is not clear on this point. By analogy, Garnaut and Ma (1992) argued that China in the 1980s would mirror Taiwan's rapid increases in food output, demand, and trade of the 1960s and 1970s. Similarly, Brown (1995) argued that in a densely populated country, industrialization raises income and shrinks cropland area, and that food demand increases due to higher incomes will outstrip the production capacity, leading inevitably to large increases in imports. Thus, he argued that China would face problems in food demand similar to those already experienced by Japan, Korea, and Taiwan.

More formal estimates of food demand prior to 1991 were based on single equations using time-series data (FAO 1991; Peterson et al. 1991; World Bank 1991). The three studies reported near zero or even negative expenditure elasticities for food grain. This suggests that the concerns of Garnaut and Ma and of Brown are not justified because demand will not grow in the future.

There are also several studies on Chinese food demand based on complete demand systems estimated from cross-sectional or province-level aggregate data that report relatively large positive income elasticities for food grain (Lewis and Andrews 1989; Halbrendt et al. 1994; Fan et al. 1995; Huang and Rozelle 1995). These studies undoubtedly show a more problematic picture for China's grain demand in the future, because coupling the rapid increase in income with a positive income elasticity leads to a higher demand for grain.

The wide variation in the estimates of income elasticity for grain makes it difficult to formulate meaningful forecasts for China's food demand. For example, based on a negative expenditure elasticity

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Table 1. Consumption Patterns in Rural Guangdong and Rural China

	Guangdong				China			
Year	Grain	Red Meat	Vegetables	Fish	Grain	Red Meat	Vegetables	Fish
1978–80	294.2	5.8	116.1	4.2	253.8	6.7	133.3	0.9
1981–83	273.8	10.1	127.7	6.3	258.7	9.2	129.0	1.4
1984–86	263.4	13.2	127.0	8.7	261.0	11.1	135.0	1.8
1987–89	258.6	14.8	117.2	9.3	260.3	11.1	131.0	2.0
1990–92	254.5	16.0	108.9	9.6	256.0	11.8	130.4	2.2
1993–95	253.1	18.3	107.8	10.7	261.8	11.9	106.6	2.8

Note: 1. The unit of consumption is kg/capita/year.
2. Grains are unhusked; 90 percent of grain consumption is rice in Guangdong.
3. Data source: various issues of *China Statistical Yearbook* and *Guangdong Province Statistical Yearbook.*

for grain, the USDA (1996) predicted that China's grain demand would reach 443 MMT by 2010. In contrast, the forecast by Huang et al., (1995) is 513 MMT using a positive elasticity estimated for rural residents. Hence, the forecasts range from an increase of 18% above the level of 375 MMT in 1995 to an increase of 37%.

In summary, these differences in estimated elasticities are in large measure due to the type of data used. The single equation approach generally relies on time-series data and tends to underestimate the value because substitution effects among different goods are missing, usually leading to the conclusion that grain is an inferior good in China. In contrast, a complete demand system model with cross-section data tends to bias estimates of the expenditure elasticities upward. The results are consistent with empirical findings from other research on food demand in developing countries. According to Bouis (1995, p. 98), in many developing countries the cross-sectional grain expenditure elasticities are significantly higher than those based on time-series data.[1]

One way to resolve the inconsistencies over the income elasticity for grain is to estimate the demand system based on a panel (pooled time-series of cross-sections) data set at the county level. However, as Lyons (1997) pointed out, few studies in China have made a systematic use of county-level data, mainly because price or expenditure information is usually absent in publications. Fortunately, a high quality rural household survey data set at the county level in Guangdong Province for the period 1986–1995 is available, and this study is the first on China's food demand to use panel data at the county level.

In the next section of this paper, there is a brief introduction to the background of Guangdong Province. An econometric model is constructed and elasticity properties are explored in the section that follows next. The data used in this study are described in the data appendix. The pentultimate section provides the estimated results. The policy implications are discussed in the last section.

Background

Guangdong Province is the fastest growing region in China, making it perhaps the best example of how market reforms may affect China's future. By 1995 rural incomes in Guangdong exceeded the national average by 79% (China Statistics Yearbook 1996). The growth rate of rural net income (gross income less production cost) was two percentage points per year higher than the national average between 1980 and 1995. The widening income gap between Guangdong and China as a whole is largely due to the special economic polices and the large amount of foreign investment flowing into Guangdong (Yeung and Chu 1994) from neighboring Hong Kong.

The food demand patterns in Guangdong have changed substantially in response to rapid economic growth. Table 1 presents a comparison of the consumption patterns between rural Guangdong and rural China as a whole. Meat consumption, for example, increased more rapidly in Guangdong than China as a whole. Before 1981, rural residents in Guangdong consumed less meat than the national average. By 1995, per capita rural meat consumption in rural Guangdong reached 18kg, 60% higher than the national average. Grain consumption declined substantially from 1978 to 1985 and thereafter decreased slightly, while for

[1] Similar inconsistencies have also been observed in the energy demand literature (Berndt 1990, p. 455). Hsiao (1986) offers an explanation for this phenomenon. He argues that cross-sectional data are likely to reflect inter-individual difference inherent in comparison of different people, therefore tend to give higher estimate values than time-series data, which reflect historical change for an individual.

China as a whole, the demand for grain increased slightly. Both Guangdong and China experienced a rapid increase in fish consumption. Since Guangdong has more rivers and fishponds than most other provinces, consumption there was much higher than the national average. Regarding vegetable consumption, Guangdong and China exhibited similar patterns: first increasing and then decreasing. Since more meat and fish consumption implies more demand for feed grain, the ratio of feed grain to total grain in Guangdong increased from 23% in 1986 to 29% in 1995.[2] Following Guangdong's lead, this suggests a further outward-shift of demand for meat and fish in China as incomes increase. The implications for food grain are less obvious given the observed reduction in consumption in Guangdong.

A panel of county-level data from the "Guangdong Province Rural Household Sample Survey 1986–1995" is used in this paper. The use of panel data for Guangdong should provide a clearer understanding of the changing pattern of food demand due to the rapid growth of the economy and a vehicle to reconcile the differences in grain expenditure elasticities in the literature (See Zhang (1998) and the data appendix for a complete discussion of the data).

Econometric Modeling

The model used in this study is an Almost Ideal Demand System proposed by Deaton and Muellbauer (D-M) with a Vector Auto-Regression (VAR) structure of the residuals. It can be written as:

$$(1) \quad w_{it} = \alpha_i + \sum_j^6 r_{ij} \ln p_{jt} + \beta_i \ln(x_t/P_t) + u_{it}$$

where w_{it} and p_{it} are the expenditure share and price of the *ith* good in year t, respectively; x_t is nominal total household expenditure in year t; P_t is a price index defined by:

$$(2) \quad \ln P_t = \alpha_0 + \sum_j^6 \alpha_j \ln p_{jt} + \frac{1}{2}\sum_i^n \sum_j^n r_{ij} \ln p_{it} \ln p_{jt}$$

$i = 1, \ldots, 6$ represents Grain, Meat, Vegetables, Fish, Other-food and Non-food.

A Vector Auto Regression (VAR) is embedded into a D-M model to eliminate the serial autocorrelation problems inherent in the model. It is defined as follows:

$$(3) \quad \begin{aligned} &u_t = \Phi u_{t-1} + v_t; \quad t = 1986, \ldots, 1995 \\ &u_t' = [u_{1t}, u_{2t}, \ldots, u_{6t}] \\ &v_t \in N(0, \Sigma) \text{ and } v_t' = [v_{1t}, v_{2t}, \ldots, v_{6t}] \\ &\Phi_t = \{\theta_{ij}\}, \quad i, j = 1, \ldots, 6; \end{aligned}$$

The vector of errors u_t in (3) is a first order autoregressive system, v_t is a random white noise vector and Φ_t is a symmetric 6×6 matrix of unknown parameters.

The properties from neoclassical demand theory can be imposed on this system by putting restrictions on the parameters.

Adding up conditions ($\Sigma w_i = 1$) are given by:

$$(4) \quad \sum_{i=1}^6 \alpha_i = 1; \sum_{i=1}^n r_{ij} = 0; \text{ for any j. } \sum_{i=1}^n \beta_i = 0;$$

Homogeneity (w_i unchanged by a proportional change of all prices and income) is defined as

$$(5) \quad \sum_{j=1}^n r_{ij} = 0; \quad \text{for any } i.$$

Symmetry of the Hicksian cross price effects implies

$$(6) \quad r_{ij} = r_{ji} \quad \text{for any } i \text{ and } j.$$

This model is intrinsically nonlinear because P, defined in (2), is a function of the unknown parameters. The linear version of D-M (LD-M) is widely used to simplify the estimating process with the Stone price index replacing the nonlinear price index in the D-M model. That is, the price index in (2) is replaced by:

$$(7) \quad \ln P_t^* = \sum_{i=1}^n w_i ln(p_i),$$

The implicit assumption for this simplification is that prices are relatively collinear in the sense that $\ln P^*$ is approximately proportional to the correct price index $\ln(P)$.

The use of LD-M results in an undesirable complication in the estimation of expenditure and price elasticities (Green and Alston 1990). Buse (1994) shows that for most estimators the LD-M is inconsistent for the correct D-M. Consequently, it is better to estimate D-M instead of LD-M if the sample and the model are small enough to avoid computational problems. The data set used in this study includes thirty-one counties over a period of ten years to give a total 310 observations. With six commodities, the sample and the model are tractable and the nonlinear price index in (2) can be used in D-M without leading to major difficulties in computation.

Price and income (expenditure) elasticities are

[2] Calculated by authors; see Zhang (1998) for details.

important parameters for demand forecasting. There are two different theoretical forms of price elasticity: the Marshallian price (uncompensated price elasticity), and the Hicksian price elasticity (compensated price elasticity). The Marshallian price elasticity is defined as the percentage change in the quantity of a good demanded that results from a 1% change in a price holding other prices and income constant. The Hicksian price elasticity is similar except that the utility is held constant instead of income. In the empirical literature of demand analysis, the Marshallian elasticity is more widely used than Hicksian elasticity because income levels rather than utility levels are observed. Here, the focus is on the Marshallian elasticity, as the Hicksian elasticity can be easily derived from the Slutsky equation. For our specific model, the Marshallian price elasticity is:

$$(8) \qquad \eta_{ij} = -\delta_{ij} + [r_{ij} - \beta_i(a_i \sum_j r_{ij} \ln p_j)]/w_i$$

Where δ_{ij} is a Kronecker delta (1 if $i = j$ and 0 otherwise).

By following similar steps, the expenditure elasticity of the D-M model can be written (Green and Alston 1990):

$$(9) \qquad \eta_{ix} = \frac{\partial \ln q_i}{\partial \ln x} = 1 + \frac{\partial \ln w_i}{\partial \ln x} = 1 + \frac{\beta_i}{w_i}$$

When β_i is positive/negative, the good i is income elastic/inelastic. One would expect most food items to be income inelastic; hence β_i for these goods would be negative. Consequently, from (1) it can be shown easily that expenditure shares for these goods will decrease if expenditure increases and all the price levels are held constant. The Marshallian own-price elasticity (8) will be inelastic, as expected for food, if the numerator in the second term of (8) is positive. In this case, given a decrease in the expenditure share w_i, the income elasticity (9) and own-price elasticity (8) will both become more inelastic. In our data set, since numerous changes in income and prices determine the observed changes in shares, the corresponding changes in elasticities are more difficult to interpret than simple constant elasticity models.

Since shares appear as denominators of the elasticity formulae (8) and (9), it is possible to get a negative income elasticity and a positive own-price elasticity when shares are very small for a commodity that is both price and income inelastic. Therefore, the D-M model may give rise to elasticities which violate theory when expenditure shares are very small. This is an undesirable feature of the D-M model that should be checked.

To check if the system is well behaved, the Hessian matrix of second-order price effects can be computed. According to Buse (1995), the elements of the Hessian matrix can be written as:

$$(10) \qquad s_{ijt} = [w_{it}w_{jt} - \delta_{ij}w_{it} + r_{ij} + \beta_i\beta_j \ln(x_t/P_t)]\frac{x_t}{p_i p_j}, \quad \text{for time } t$$

$S_t = \{s_{ijt}\}$ is the Hessian matrix for the demand system. For a well-behaved model, the expenditure function should be concave and therefore S should be negative semi-definite. Showing that the signs of the eigen values of S are non-positive corresponds to checking the second order conditions for maximizing utility, implying that the model is well behaved.

Empirical Results

Estimation Results

Since the adding up structure for a complete set of expenditure shares is inherent in the D-M model ($\Sigma_i w_{it} = 1$ for any t), the full system of six equations is singular. Following a standard convention (Buse 1994, p. 782), the last Non-food equation is omitted for estimation. The coefficients for Non-food can be retrieved from the other equations using the properties of adding up, homogeneity and symmetry. Dropping the last Non-food equation will not affect the estimation results because all parameters, log likelihood values, and estimated standard errors are invariant to the choice of the equations that are estimated as long as the Maximum Likelihood (ML) procedure is used (Berndt 1990, p. 474).

The Full Information ML algorithms in the Model Procedure in SAS were used to estimate the model. The model converged at the 0.001 level, and the log likelihood was 3988. Some standard statistics for the equations in the system are reported in table 2. The R^2s for Grain, Meat, Fish and Vegetables are, respectively, 0.81, 0.69, 0.74 and 0.81 which are relatively high. The R^2 for Other-food of 0.44 is lower perhaps because there are measurement errors in the Other-food category for which price and expenditure data are derived.

Table 3 gives the estimated parameters of the D-M model.[3] Most of the parameters (20 out of 35)

[3] A model with fixed regional effects is also estimated in Zhang et al. (1998) to test against the D-M model without regional dummies. Based on two model selection criteria—Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC), the simplified model is preferred and thus is used in this paper.

Table 2. Statistics for the Estimated Equations

	Root MSE	R-Squared	Adj R-Squared	D-W
Grain	0.022	0.810	0.805	2.176
Meat	0.018	0.697	0.688	2.185
Vegetables	0.017	0.742	0.734	2.108
Fish	0.013	0.818	0.813	2.161
Other-food	0.028	0.457	0.441	2.227

Note: 1. Root MSE is the square root of the Mean Squared Error.
2. D-W is the Durbin-Watson statistic.

reported in table 3 have relatively high t-ratios ($|t| > 2$). Although the coefficients of the autoregressive residuals are not reported in table 3, all the coefficients fall in range from 0.5 to 0.9 and are significant at the 1% level.

In order to check if the D-M model is well behaved, the eigen values of the Hessian matrix (10) are calculated using predicted expenditure shares for the provincial means for each year. A positive Eigen value implies a violation of concavity. It is found that the Hessian matrices (S matrix) for most years are negative semi-definite except in 1989 and 1995 when serious inflation occurred. High inflation may distort the relative price structure and send wrong signals to consumers, causing them to make seemingly irrational economic decisions (for example, expectations about future prices affected decisions to purchase durables). As a consequence, the predicted expenditure shares in the years of high inflation are far from the sample means, resulting in the violations of concavity. This finding is consistent with the findings by Rothman, Hong and Mount (1994) who show that the D-M model tends to perform poorly when expenditure shares differ significantly from the overall sample mean values, particularly when some shares are close to zero. In light of its concavity at most sample points, the model seems to be robust for evaluating Guangdong's food demand.[4] The lack of global concavity of the D-M model could be a reason why previous studies based on the D-M model only report elasticities evaluated at the overall sample mean.

Analysis of Guangdong Province

Using the estimated D-M model, the expenditure and price elasticities can be evaluated for the sample observations over the period of 1986-1995. As a first step, the expenditure elasticities evaluated at the annual means for the whole province are reported in table 4 for the period 1986-1995.

First notice that the expenditure elasticities for Other-food and Non-food are greater than 1, implying they are income elastic. Expenditure elasticities for Grain, Meat, Vegetables and Fish are below one, implying that these foods are income inelastic. Since the demand for Non-food is more income elastic than for any of the food groups, the share of Non-food will expand with increases in income if prices are constant. As a result, the total expenditure for food tends to decrease as Engel's Law predicted. Most expenditure elasticities are rather stable during the sample period except that the elasticity for Vegetable declines significantly. This rapid decrease is primarily due to the small initial share for Vegetables combined with a low income elasticity. In 1986, the expenditure share for Vegetables is 8% compared to 18% for Grain. By 1995, the share for Vegetables is only 5% while all other shares increase slightly or remain constant. With a declining expenditure share, Vegetables become increasingly expenditure inelastic

[4] Following the practice by Banks, Blundell, and Lewbel (1997), a quadratic term of log(y/p) was added to the D-M model to improve the concavity. However, the quadratic D-M model had more concavity violations than the linear D-M model.

Table 3. Estimated Parameters of the D-M Model

	α_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	β_i
Grain	1.047*	−0.005	−0.054*	−0.043*	−0.007	0.017	−0.1170*
	(16.83)	(0.24)	(−6.53)	(−7.53)	(−1.21)	(1.69)	(−11.88)
Meat	0.293*	−0.054*	0.081*	−0.033*	0.008	−0.014*	−0.050*
	(5.11)	(−6.53)	(7.81)	(−6.67)	(1.25)	(−2.66)	(−5.85)
Vegetable	0.409*	−0.043*	−0.033*	0.032*	0.001	0.018*	−0.041*
	(9.82)	(−7.53)	(−6.67)	(7.00)	(0.39)	(4.03)	(−6.57)
Fish	0.059	−0.007	0.008	0.001	0.006	−0.03	−0.006
	(1.65)	(−1.21)	(1.25)	(0.39)	(0.90)	(−1.57)	(−1.18)
Other-food	−0.013	0.017	−0.014*	0.018*	−0.03	−0.012*	0.029*
	(−0.17)	(1.69)	(−2.66)	(4.03)	(−1.57)	(−2.50)	(2.44)

Note: t-statistics are given in parentheses and * represents |t| values bigger than 2.

Table 4. Expenditure Elasticities for Guangdong Province

Year	Grain	Meat	Vegetables	Fish	Other-Food	Non-Food
1986	0.35	0.66	0.53	0.85	1.21	1.45
1987	0.26	0.64	0.55	0.85	1.20	1.43
1988	0.14	0.66	0.52	0.85	1.20	1.41
1989	−0.08	0.69	0.38	0.85	1.19	1.39
1990	0.26	0.70	0.37	0.85	1.20	1.43
1991	0.24	0.69	0.34	0.85	1.20	1.42
1992	0.17	0.68	0.38	0.85	1.20	1.41
1993	0.14	0.65	0.33	0.85	1.19	1.40
1994	0.29	0.67	0.25	0.85	1.19	1.42
1995	0.23	0.68	0.16	0.85	1.19	1.41

(the elasticity is inversely related to the share, see (9)).

The Grain expenditure elasticities are positive except in 1989, one of the years that violated concavity, implying that Grain is not an inferior good in Guangong Province, even though the income levels are one of the highest in China. As a result, the observed lack of growth in per capita consumption during a period of high income growth is due to the increasing availability of inexpensive substitutes for Grain. Since Meat and Fish are substantially more expenditure elastic than Grain, it is likely that the demand for feed grain will increase much faster than for food grain as a result of rising income.

It is interesting to compare the elasticities in this study with other elasticities in the literature. For time-series estimates, the expenditure elasticities for grain are generally small. For instance, the rice expenditure elasticity in 1986 estimated by Peterson et al. (1991) is −0.15. USDA's estimates (1996) for rice and coarse grain elasticities range from −0.15 to 0.02 and from −0.25 to −0.1, respectively. Regarding cross-section studies, Lewis et al. (1989), Halbrendt et al. (1994), Fan et al. (1995), and Huang and Rozelle (1995) report much higher expenditure elasticities for grain of 0.22, 0.58, 0.5, and 0.51, respectively. Halbrendt et al.'s study is also for Guangdong Province. However, their model has some dubious properties because the own price elasticity for other food is positive. Although Lewis et al.'s result for the grain expenditure elasticity is similar to ours, their expenditure elasticity of 3.56 for Fish is unrealistically high and much higher than the value (0.85) in our study. Similarly, the expenditure elasticites for Vegetables and Other-food are high at 1.4 and 2.1, respectively, in Huang and Rozelle's study. It is reassuring that the value of the expenditure elasticity for Grain in our study falls between the estimates in the time-series and cross-section studies, and all the expenditure elasticites have reasonable magnitudes.

The own-price elasticities behave similarly to the expenditure elasticities over time, with a rapid decrease in the price elasticity for Vegetables and relatively stable elasticities for other commodities. Estimates for a set of price elasticities for food groups in 1994 are summarized in table 5. A major finding is that Fish is more price-elastic than Grain, Meat and Vegetables. The high expenditure and price elasticity for Fish illustrate that both income and price will play important roles for aquatic food consumption. If the prevailing price structure stays constant, the demand for Fish will increase as a result of rising incomes. However, with rapid industrialization and urbanization, it is expected that a large amount of land will be diverted from fishponds. This will lead to a rapid price rise for fresh aquatic products, and may prevent consumption from going up further. The own-price elasticity for Other-food is price elastic. Since Other-food, which includes alcohol and tobacco, is also income elastic, this category of "food" will be the most responsive to market forces.

The cross price elasticities of Meat, Fish and Vegetables on Grain consumption are 0.031, 0.017 and −0.011 respectively, implying that food Grain is a complement with Vegetables but a substitute

Table 5. Marshallian Price Elasticities within Food Groups

	Grain	Meat	Vegetables	Fish	Other-Food
Food Grain	−0.307	0.031	−0.011	0.017	0.064
Meat	−0.027	−0.282	−0.103	0.080	−0.112
Vegetables	−0.037	−0.224	−0.156	0.082	0.279
Fish	−0.021	0.275	0.082	−0.844	−0.081
Other-food	−0.080	−0.188	0.048	−0.034	−1.066

Note: The elasticities are evaluated at the provincial means in 1994.

with Meat and Fish, which is consistent with the finding by Fan et al. (1995). Other-food is also a substitute with Grain. Since the cross-price effect of Meat on Fish is 0.275, Meat and Fish are close substitutes. Other-food is a close substitute with Vegetables but a complement for Meat and Fish.

In conclusion, the use of panel data at the county level for 1986–1995 in Guangdong Province provided a plausible set of elasticities for a complete demand system. The observed decline in the consumption of food grain could be explained in terms of price effects, and the estimated expenditure elasticity of around 0.2 falls between the typical estimates using time-series and cross-section data. In addition, the expenditure elasticities for Fish and Meat were higher than for Grain, implying that the demand for feed grain is likely to increase faster than the demand for food grain as income increases.

Conclusions and Policy Implications

A demand system for five food groups and one non-food group was estimated using a D-M model (Almost Ideal Demand System) based on a panel data from Guangdong Province for 1986–1995. A distinguishing feature of our model is that the estimated elasticities have reasonable values for all commodities in large measure because the model is derived from a new panel data set at the county level. Furthermore, since Guangdong Province is the most economically advanced province in China, the results for Guangdong can also provide some implications for China as a whole. The major conclusions follow.

First, the model shows that food grain is not an inferior good in Guangdong. The estimated expenditure elasticity of about 0.2 falls between the low, and sometimes negative values from time-series data and the relatively high values estimated from cross-section data. Forecasts of total grain consumption in China derived from our model are consistent with forecasts of demand in other studies (see Zhang, Mount and Boisvert 1998).

Second, the estimated expenditure elasticity for food grain is relatively low, compared to the elasticities for meat and fish. The forecast for China shows that the demand for feed grain will grow much faster than the demand for food grain and is likely to put additional pressure on the domestic grain supply. Unless significant steps are taken by the livestock and fishing industries, China may have to purchase a large amount of feed grain from the international market.

Third, since the expenditure elasticity for Other-food is greater than one, the share of expenditures on Other-foods will tend to increase as incomes rise. Alcohol (beer and liquor), tobacco, many processed foods and eating out are the major food items included in the Other-food category. Brown (1995) has warned that the demand for beer could take a substantial amount of grain. Since Other-food is price elastic, imposing a tax on alcohol and tobacco would be an effective way to reduce the growth of demand.

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Data Appendix

In 1982, Guangdong Province began a comprehensive rural household sampling survey administered by the Chinese State Statistical Bureau. The survey includes comprehensive annual production, investment, consumption quantity, and expenditure information. Only data at the provincial level are published in the *Guangdong Province Statistical Yearbook.* With cooperation from the China Development Institute, we were able to obtain the county level data set.

The Statistical Bureau applies a three-stage stratified sampling method for the survey (Chen and Ravallion 1996). In the first stage, two to five counties are selected on the basis of size from each of the ten major rural prefectures. Next, sub-village groups are selected from the counties. Finally, households are selected from sub-village groups. In Guangdong Province in 1995, 31 of the 76 counties were chosen and the total sample size in Guangdong Province was 2400. The previous year's income is used as an indicator for ranking all households. Generally, 60 to 100 households are surveyed in every county. With cumulative population figures and the desired sample size, the sample interval for income is identified, and households whose income fit in the midpoints of each interval are selected. Every sample household is compensated with some cash for bookkeeping. The household is responsible for recording detailed consumption and production transactions. Every month, a survey specialist from the county rural survey team visits the households, inspecting and collecting the data. The county rural survey team aggregates and submits the survey data to the Provincial Statistical Bureau.

The main objective for the analysis is to estimate a complete demand system consisting of the following six expenditure groups: Grain (rice and wheat, 90% is rice), Meat (pork, mutton, beef and poultry), Vegetables, Fish (seafood and fresh aquatic products), Other-food (fruit, sweets, sugar, candy, tea, alcohol and tobaccos) and Non-food.

To estimate the demand system, the price and expenditure shares of the six goods must be known. However, complete price and expenditure data for the six goods are only available at the county level since 1993. Before 1993, only total expenditures, food expenditures, grain expenditures and non-staple expenditures were reported. The implicit grain price for each year can be derived from grain consumption quantity and expenditure.[5] Yet, the important prices for Meat, Vegetables and Fish before 1993 could not be derived from the data set at the county level. This was a major obstacle for modeling demand and there was a need to find another data source. Fortunately, the *Guangdong Province Statistical Yearbooks* publishes a cost of living index and price indices for food, staples, non-staples, meat, vegetables and fish for seven rural counties and thirteen prefec-

[5] Using derived prices from expenditures and quantity in a cross-section household survey (Deaton 1988) may lead to bias because of quality effects and measurement errors. The problem of bias in our case, however, should be minimal because the data set used is not at the household level. When households are aggregated at the county level, the derived price from the aggregate expenditures and quantities are likely to be close to the market price. Furthermore, since rice is the dominate staple in Guangdong, there is no need to divide grain into subgroups such as wheat, rice, and corn and the derived grain price can be regarded as a proxy for the market rice price.

tures[6] (our sample includes ten prefectures). Since the seven counties are represented in our data set, the price indices can be used directly. For the other 24 counties, it is assumed that all counties in the same prefecture share the same price index. Any problems arising from this assumption should also be minimal because prefectures are defined according to geological and social homogeneity. Counties in the same prefecture usually have similar incomes and price levels. The inter-prefecture differences are much more significant than differences within a prefecture. Since 24 county price indices are derived from 10 prefecture price indices, only two or three counties share the same price index.

By deriving implicit prices directly from quantity and expenditure data in 1993 and using price indices from prefecture and county data, price levels for Grain, Meat, Vegetables, and Fish can be determined for 1986–1995 at the county level. With price and quantity data, expenditures for Grain, Meat, Vegetables, and Fish can be subtracted from total food expenditure to obtain Other-food expenditures. Non-food expenditures are equal to the differences between food expenditures and total living expenditures.

The final step is to derive the Other-food and Non-food price indices. In our data set, food expenditures include grain expenditures and non-staple expenditures. Non-staples can be divided into Meat, Vegetables, Fish and Other-food. Since the price indices for Meat, Vegetables and Fish are available, only the Other-food price index in the non-staples category is unknown. Following the practice in the literature on Chinese food demand (Halbrendt et al. 1994; Fan et al. 1995; Huang and Rozelle 1995), the price of Other-food is used as a numeriare (price is one). Non-food prices are derived from a Stone Index[7] (Deaton and Muellabuer 1980) using available price and expenditure data for all commodities.

[6] In China, a prefecture is an administrative level below the province and above the county. There are two types of prefectures. The first type is an urban prefecture such as Shenzhen. It includes only urban districts and urban counties. The other type of prefecture mainly consists of two to eight subordinate counties and a few county-level municipalities. In our data set, only the second type of prefecture is included.

[7] Although other forms of the index can be used, the Stone Index is used here, for simplicity.