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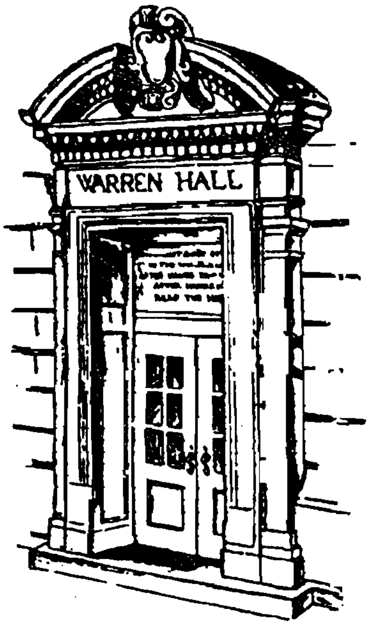

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Food Demand in China:

Lessons from Guangdong Province

By

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Food Demand in China: Lessons of Guangdong Province

Abstract

There is a substantial controversy in the economic 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. A 20-year forecast of China's food grain and feed grain consumption, based on the estimated demand system, demonstrates that the demand for feed grain will grow faster than for food grain, as expected, and that consumption will be higher than most other published forecasts.

I. Introduction

China has been one of the fastest growing countries 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 food grains. One consequence of these changes was the rapid rise in grain prices. By the end of 1994 and early 1995, China's grain price increased by 60 percent over the previous year (Brown, 1995). China's net grain imports also reached 19.6 millions tons in 1995 (China Custom Statistics, 1993-1995), a dramatic shift from 1993 and 1994 when China was a net exporter of 2 and 6 millions tons of grain, respectively. In an integrated world market, China's increasing dependence on imports would affect grain markets in the United States, currently the world's largest grain exporter, and throughout the world. Research is needed to determine if this dramatic change in China's net export position is due to short-term production shortages or a longer-term outward shift in the demand for grain.

The literature on Chinese food demand can be put into three categories: a) an analogy approach; b) a single-equation approach; and c) a complete demand system approach. There are two studies adopting the analogy approach. Gamaut and Ma (1992) investigated Taiwan's food demand patterns in the 1960's and 1970's when there were rapid increases in output, demand, and trade similar to that experienced by China in the 1980's. They argued that the dietary habits and preferences in China and Taiwan were very similar, and consequently, the changes in the pattern of food in Taiwan could be used as a paradigm for China. Price effects were not mentioned in this study.

In his popular book *Who Will Feed China?*, Brown (1995) looked at the industrialization processes in Japan, South Korea and Taiwan. He hypothesized that in a densely populated county or region, industrialization raises income and shrinks cropland area, and that the demand increases due to income will outstrip the production capacity in the country, leading inevitably to large increases in imports. By analogy, he argued that China will face the same problems in food demand as Japan, Korea, and Taiwan because China is densely populated and is industrializing. However, no models were specified in his book. It is not clear what income elasticities were used in forecasting food demand and the price effects were not considered at all.

The single equation approach was used mostly prior to 1991 (World Bank, 1991; FAO, 1991; Peterson et al., 1991), because comprehensive cross-section expenditure data were not available to researchers during this period. All three studies reported negative expenditure elasticities for grain, implying that food grain is an inferior good. If these results are correct, the per capita grain demand will decline as income increases and grain imports in the future will not be significantly higher than they are currently. The single equation approach is subject to many criticisms. To use Peterson et al., (1991) as an example, this paper used a log-inverse-log model to estimate the income elasticity of rice in China with time-series data aggregated at the national level over the period 1960-1986. The dependent variable is the log of per capita rice consumption. The regressors on the right-hand side are the log and inverse of real per capita income, the log of the real price of pork and the log of the ratio of world rice to world wheat prices. During most of the period 1960-1986, China was an isolated country. "Food self-sufficiency" was a national priority in Mao's era, and it is unlikely that the world wheat and rice prices played major role on China's food production and demand. Hence, it is not surprising to find that the coefficient of the log of the world price ratio was not significant (t-ratio is 0.801). Since the domestic rice and wheat prices were not included in the model, the changes of rice consumption attributed to income are biased. The conclusion that rice in China became an inferior good (expenditure elasticity -0.16 in 1986) during 1980's is certainly suspect.

There are several applications to Chinese food demand which use a complete demand system. These studies based on cross-sectional or province aggregate data have all estimated positive income elasticities for food grain. For instance, Halbrendt et al., (1994) obtained a rural expenditure elasticity of 0.57 with Guangdong Rural Household Sample Survey for 1990 using a Linear Almost Demand System (LD-M). Huang and Rozelle (1995) estimated a D-M model in which a market development index was incorporated using Hebei Province rural survey data in 1990. The expenditure elasticities for food grain, vegetables and other food in their analysis are high, at 0.51, 1.4 and 2.1, respectively.

There are two studies based on aggregate data at the province-level. Lewis and Andrews (1989) used a Linear Expenditure System (LES) model with aggregate panel data at the provincial level. They concluded that the expenditure elasticities for grain and fish were 0.22 and 3.56, respectively. The LES is very-restrictive (Deaton and Muellbauer, 1993) because it assumes that all goods are normal, gross complements and net substitutes[1]. In order to overcome the restrictions of LES, Fan et al., (1995) combined LES and D-M models using a panel data set for 1982-1990 at the provincial level. The expenditure elasticities were derived at the grand sample mean. The elasticities for grain, meat and other food were 0.5, 0.9 and 2.1, respectively.

The studies based on complete demand systems 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 grains. Nevertheless, the uncertainty over income elasticities results in uncertainty over forecasts for China's food demand. For example, based on a negative expenditure elasticity for grain , the USDA predicted that China's grain demand will reach 468 MMT by 2010. In contrast, Huang et al.' the forecast by Huang et al., (1995) is 513 MMT using a non-negative elasticity. Hence, the forecasts range from an increase of 25% above the level of 375 MMT in 1995 to an increase of 37%.

[1] Gross complement means the cross price effect is negative; net substitute means the cross price effect is positive, given a constant utility level.

In summary, although the analogy approach lacks formal analysis, it provides some insight into food demand in China through comparisons with the experiences of similar countries or regions. The single equation approach generally relies on time-series data and tends to underestimate the income effect due to the lack of substitution effects among different goods, 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[2].

One way to resolve the paradox over the income elasticity for grain is to estimate the demand system based on panel (pooled time-series of cross-sections) data set at the micro 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 for our study. This study is the first on China's food demand to use a panel data at the county level.

In Section II of this paper, there is a brief introduction to the background of Guangdong Province and data used in this study. An econometric model is constructed and elasticity properties are explored in Section III. Section IV provides the estimated results. Finally, a national forecast of the consumption of food and feed grain to 2020 is presented and the policy implications are discussed in Section V.

[2] Similar paradoxes have also been observed in the energy demand literature (Berndt, p. 455).

II. Background and Data

Guangdong Province is the fastest growing region in China, and thus it is perhaps the best example of how market reforms may affect China's future. In 1980, rural Guangdong had the same income level as the national average, but by 1994 incomes in Guangdong exceeded the national average by 79 percent (China Statistics Yearbook, 1995). The growth rate of rural net income (gross income less production cost) was two percent per year higher than the national average during this period. Based on the foreign exchange rate of 8.62 yuan to one dollar, the per capita net income[3] in rural Guangdong was 253 US dollars, compared with 142 US dollars for all rural China. The growing difference in income between Guangdong and China as a whole is largely due to the special economic polices and the large amount of foreign investment flowing into Gunagdong (Yeung and Chu, 1994).

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.*

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.

[3] In this study we mainly use living expenditures. Living expenditures are about 90 percent of net income. Expenditures on savings and gifts are not included in living expenditures (Guangdong Rural Household Sample Survey).

Meat consumption, for example, increased more rapidly in Guangdong than in China as a whole. Before 1981, rural residents in Guangdong consumed less meat than the national average. By 1994, per capita rural meat consumption in Guangdong reached 18kg, 60 percent higher than the national average. Grain consumption declined substantially from 1978 to 1885 and thereafter decreased slightly, while for China as a whole, the demand for grain increased slightly. Both Guangdong and China experienced a very fast increase in fish consumption. As Guangdong has more rivers and fish ponds than most other provinces, consumption there was much higher than 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 percent in 1986 to 29 percent in 1995[4]. 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.

It is hoped that the use of panel data in Guangdong, the most dynamic province, will provide a clearer understanding of the changing pattern of food demand and a vehicle to reconcile the differences in grain expenditure elasticities in the literature. The remainder of this section is devoted to the description of the data.

The Household Survey

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 for rural households. However, only data at the provincial level are published in the *Guangdong Province Statistical*

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

Yearbook. Thanks to cooperation from the China Development Institute, we were able to obtain the county-level data from the "Guangdong Province Rural Household Sample Survey 1982-1995". The availability of these new survey data makes it possible to assess the implications of income and price changes on grain demand in the various regions throughout the province.

The Statistical Bureau applies a three-stage stratified sampling method to select households for the survey. In the first stage, two to five counties are selected on the basis of size from each of the ten major rural prefectures. For instance, the Shaoguan prefecture has eight counties; four counties are chosen. 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 is identified, and households whose income fit in the midpoints of each interval are selected (Fan et al., 1995).

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 Statistical Bureau aggregates the survey data and publishes the data at the provincial level in the *Guangdong Province Statistical Yearbook.*

There have been two major adjustments in terms of sampling subjects and scope. Between 1982 and 1985, the survey included 36 counties out of nearly one hundred counties. In 1986, 18 counties in the sample were replaced by 19 new counties. In the same year, Hainan Island, a region belonging to Guangdong

Province, was established as a separate province. As a result, since 1987 five Hainan counties were no longer listed in the survey. In order to keep the panel data set consistent for this study, 31 counties over the period of 1986 -1993 are included in our data set.

The Data Set

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 percent 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. As a result, the important prices for Meat, Vegetables and Fish could not be derived from the data set. This was a major obstacle for modeling demand at the county level.

Whenever implicit prices for individual commodities can be derived from the quantity and expenditure data, there are potential problems. Deaton (1988) found that using the derived price from expenditures and quantity in a cross-section household survey led to bias because of quality effects and measurement errors.

The problem of bias in our case, however, should be minimal for several reasons. First, the data set used in our study 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. Further, as Deaton points out, the problem is more serious when the households are geographically clustered together. In *Guandong Province Household Sample*

Survey, 60-100 households in every county are sampled from different villages, implying that the problem of clustering is not that serious.

Second, since rice is the dominate staple in Guangdong, the derived grain price can be regarded as a proxy for the market price of rice. Therefore, this procedure should not lead to serious measurement problems for grain prices. Based on these arguments, the use of implicit prices where possible seems justified.

Since the prices for Meat, Fish and Vegetables could not be derived from the data set at the county level, 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 prefectures[5] (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 counties, it is assumed that all counties in the same prefecture share the same price index. Any problems arising from this assumption should 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 need to be derived from 10 prefecture price indices, only two or three counties share the same price indices.

Deriving implicit prices and using price indices from prefecture 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

[5] 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.

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[6] (Deaton and Muellabuer, 1980) using available price and expenditure data for all commodities.

III. Econometric Modeling

Econometric Modeling

The model used in this study is a D-M model with fixed regional effects and Vector Auto-Regression (VAR) structure of the residuals. It can be written as:

$$w_{it}=\alpha_i+\sum_{j}^{6} r_{ij}\ln p_{jt}+\beta_i\ln(x_t/P)+d_{i1}D_1+d_{i2}D_2+u_{it} \qquad (1)$$

where w_{it} and p_{it} are the share and price of the *ith* good at time t, respectively; P is a price index defined by

$$\ln P_t=\alpha_0+\sum_{j}^{6}(\alpha_j+d_{j1}D_1+d_{j2}D_2)\ln p_{jt}+\frac{1}{2}\sum_{i}^{n}\sum_{j}^{n} r_{ij}\ln p_{it}\ln p_{jt} \qquad (2)$$

i=1, ..., 6 represents Grain, Meat, Vegetables, Fish, Other-food and Non-food. In order to investigate whether the observed differences in demand patterns of the

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

different regions within Guangdong Province (see Zhang, 1998 for details) are due to regional effects or income and price effects, two dummy variables D_1 and D_2 are incorporated into the D-M model to test the effects of regions. D_1 is the dummy variable for the mountain counties. D_2 is the dummy variable for the Pearl River delta area, the first special economic zone in China and the richest area in Guangdong. The rest of the area refers to the flat area that is not in the delta and the mountain areas.

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

$$u_t=\Phi u_{t-1}+v_t \; ; \qquad t=1986,\ldots,1995 \tag{3}$$

$$u_t' = [u_{1t}, u_{2t}, \ldots, u_{6t}]$$

$$v_t \in N(0,\Sigma) \text{ and } v'_t = [v_{1t}, v_{2t}, \ldots, v_{6t}]$$

$$\Phi_t = \{\theta_{ij}\}, \quad i, j=1, \ldots, 6;$$

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 6x6 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:

$$\sum_{i=1}^{6} (\alpha_i+d_{i1}D_1+d_{i2}D_2)=1; \quad \sum_{i=1}^{n} r_{ij}=0; \quad \sum_{i=1}^{n} \beta_i=0; \text{ for any j.} \tag{4}$$

Homogeneity (w_i unchanged by a proportional change of all prices and income) is defined as $\sum_{j=1}^{n} r_{ij}=0$; for any i. (5)

Symmetry of the Hicksian cross price effects are

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

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:

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

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, 1991). Buse (1994) shows that for most estimators the LD-M is inconsistent for the correct D-M. So it is better to estimate D-M instead of LD-M if the sample and the model are not too large. 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) is used in D-M without leading to major difficulties in computation.

Price and income (expenditure) elasticities are 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 one percent 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 price elasticity is:

$$\eta_{ij} = -\delta_{ij} + [r_{ij} - \beta_i (a_i + d_{i1} D_1 + d_{i2} D_2 + \sum_j r_{ij} \ln p_j)] / w_i \tag{8}$$

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):

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

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 become 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 changes in income and prices result in 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 price effects can be computed. According to Buse (1995), the elements of the Hessian matrix can be written as:

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

$S_t=\{s_{ijt}\}$ 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. Checking 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.

IV. Estimation Results and Empirical Analysis

Estimation Results

Since the adding up structure is inherent in the D-M model, the full system of six equations is singular. Following a standard convention (p. 782, Buse, 1994), the last Non-food equation is omitted for estimation in order to overcome the singularity problem. 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 (p. 474, Berndt, 1990).

Table 2 Statistics for the Estimated Equations

	Root MSE	R-squared	Adj R-squared	D-W
Grain	0.022	0.818	0.812	2.176
Meat	0.018	0.702	0.691	2.185
Vegetables	0.017	0.742	0.733	2.108
Fish	0.013	0.820	0.814	2.161
Other-food	0.027	0.477	0.458	2.227

Note: 1. Root MSE is the square root of the Mean Square Error.

2. D-W is the Durbin-Watson statistic.

Table 3 Estimated Parameters of the D-M Model

	α_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	β_i	d_{i1}	d_{i2}
Grain	0.997*	0.006	-0.052*	-0.041*	-0.007	-0.011	-0.110*	0.026*	-0.001
	(15.13)	(0.33)	(-6.29)	(-6.66)	(-1.26)	(-1.07)	(-10.65)	(2.11)	(-1.29)
Meat	0.302*	-0.052*	0.081*	-0.034*	0.007	-0.017*	-0.051*	0.017*	0.01
	(5.08)	(-6.29)	(7.37)	(-6.38)	(1.02)	(-3.01)	(-5.86)	(2.92)	(1.14)
Veget-able	0.406*	-0.041*	-0.034*	0.032*	0.001	0.015*	-0.040*	0.003	0.001
	(8.75)	(-6.66)	(-6.38)	(6.15)	(0.31)	(3.47)	(-5.72)	(0.50)	(0.20)
Fish	0.062	-0.007	0.007	0.001	0.007	-0.01*	-0.003	-0.004	0.008
	(1.60)	(-1.26)	(1.02)	(0.31)	(1.04)	(-2.03)	(-1.54)	(-0.28)	(1.63)
Other-food	0.048	-0.011	-0.017*	0.015*	-0.040*	-0.003	0.020	-0.022*	0.010
	(0.60)	(-1.07)	(-3.01)	(3.47)	(-5.72)	(-1.54)	(1.64)	(-2.08)	(1.01)

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

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 4055. 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, 0.82, 0.70, 0.74 and 0.82 which are relatively high. The R^2 for Other-food of 0.48 is lower perhaps because there are measurement errors in the Other-food category when price and expenditure data are derived.

Table 3 gives the estimated parameters of the D-M model. Most of the parameters have relatively high t-ratios (| t | >2). The only coefficients for the regional effects that are significantly different from zero are for Grain, Meat and Other-food in the Mountain region. The Mountain areas are marked by poor transportation conditions and have less access to markets, which affect consumption patterns. 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 percent level.

Table 4 The Concavity of the D-M Model in Three Regions

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Delta	yes	yes	no	no	yes	yes	no	no	no	no
Mountain	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
Flat	yes	yes	yes	yes	yes	yes	yes	yes	yes	no

Note: The concavity of the Hessian matrix is evaluated at the mean county level for the three regions in Guangdong province for the period of 1986-1995. The consistency and violation of the concavity are marked by 'yes' and 'no', respectively.

Even though the elastiticties implied by the coefficients in Table 3 appear plausible, the D-M model does not satisfy the property of global concavity for all sample observations. According to Rothman, Hong and Mount (1994), the D-M model tends to perform undesirably when expenditure shares differ significantly from the overall sample mean values, particularly when some shares are close to zero. In order to check if our D-M model is well behaved, the Eigen values of the Hessian matrix (10) are calculated for the county means of the three regions for each year. A positive Eigen value implies a violation of concavity. Table 4 lists the results for the D-M model, and 8 out of 30 points violate concavity. Since the expenditure shares in the early years of the Delta area, most years of the Mountain and Flat area are close to the overall sample means, the model tends to be well behaved for these years. From 1988 to 1989 and 1994 to 1995, China experienced serious inflation. Grain prices in 1989 doubled from the 1988 level, declined in 1990 and then increased by 60 percent from 1994 to 1995. High inflation may distort the relative price structure and send wrong signals to farmers, causing them to make seemingly irrational economic decisions which are inconsistent with conventional utility maximization theory. As a consequence, the expenditure shares in the years of high inflation are far from the sample means, resulting in the violations of concavity. The lack of global concavity of the D-M model using estimated D-Ms could be a reason why previous studies based on the D-M model only report elasticities evaluated at the overall sample mean.

Model Simplification

In the previous section, the estimation results for the D-M model with regional dummies were discussed. However, it is not clear whether the regional demand differences were mainly caused by income and price differences or by other factors captured by the regional dummy variables. When forecasting for Guangdong Province or China as a whole, it is important to know whether the regional dummies should be incorporated in the model. In this section, some model selection criteria are applied to shed light on this question.

Two versions of the D-M model are estimated. One has regional dummies and the other does not. To test whether the restricted model (no regional dummies included) is statistically equivalent to the un-restricted model (with ten regional dummies), the likelihood ratio (LR) test for the null hypothesis that the ten regional effects are zero is 33.9. Since the value is significant at the one percent level, the null hypotheses should be rejected. It is not surprising because some of the coefficients have relatively large t-ratios. However, the LR test tends to favor the unrestricted model by ignoring the effect of the degrees of freedom on the values of the likelihood function (Judge et al., 1988). In order to overcome the problem, the AIC and SBC criteria have been proposed in the literature for selecting one of the two models.

The Akaike Information Criterion (AIC) is defined as:

$AIC=-(2/T)(\log L-n)$.

The Schwarz Bayesian Criterion (SBC) is defined as:

$SBC=-(2/T)(\log L-0.5*n*(\ln T))$.

Where T is the total number of observations, L represents the computed value of the likelihood of the estimated demand system associated with each case, and n is the number of parameters estimated including the autoregressive coefficients. For both the AIC and SBC, a small value is preferred. Table 5 lists the values of these criteria for the two versions of the D-M model. Both the AIC and SBC criteria suggest that the restricted model without regional dummies is the best one. Accordingly, the model without dummies will be used to evaluate food demand in Guangdong Province.

Table 5 The Tests for Model Selection

Model	Log Likelihood	AIC	SBC
Restricted	-3988.165	26.053	26.655
Unrestricted	-4005.129	26.227	26.950

Empirical Analysis of Guangdong Province

Similar to the unrestricted model, the concavity of the restricted model is calculated for the province mean for each year in order to check whether the restricted model is well-behaved. It is found that the Hessian matrices (S matrix) for most years' mean values are negative semi-definite except in 1989 and 1995 when serious inflation occurred. In light of its concavity at most sample points, the restricted model seems to be robust for evaluating Guangdong's food demand.

Using the restricted model without dummies, the expenditure elasticity and price elasticity can be evaluated at the provincial means over the period of 1986-1995. As a first step, the expenditure elasticities evaluated at the means for the whole province over the period 1986-1995 are reported in Table 6.

Table 6 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

Note: The results are from the D-M model without regional dummies.

First notice that the expenditure elasticity for Non-food is greater than 1.3, implying it is income elastic. Expenditure elasticities for Grain, Meat, Vegetables and Fish are below one, implying that these foods are income inelastic. The expenditure elasticity for Other-food is slightly greater than one. 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 increase in income if prices are constant. As a result, the total food expenditure share in food tends to decrease as Engel's Law predicted.

The Grain expenditure elasticities were positive except in 1989, implying that Grain was not an inferior good in Guangong Province, even though the income levels are 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 primarily to the increasing availability of inexpensive food substitute for grain.

The expenditure elasticity for Vegetables declined from 0.53 in 1986 to 0.16 in 1995. The main reason for the decline in the expenditure elasticities for Vegetables is due to the decrease in the expenditure share. As rural residents became richer, the share of income used for vegetable consumption decreased, and Vegetables became more expenditure inelastic.

Generally speaking, Meat and Fish were more expenditure elastic than Grain and Vegetables. Therefore, it is likely that the demand for feed grain will increase much faster than for food grains as a result of rising income.

Turning to the price elasticities, the own-price elasiticties at the means for the entire province for each year are presented in Table 7. A major finding is that Fish is more price-elastic than Grain, Meat and Vegetables. The high expenditure and price elasticities for Fish illustrate that both income and price will play important roles for aquatic food consumption. If the prevailing price structure continues, 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 fish ponds, which will lead to a rapid price rise for fresh aquatic products, and may prevent consumption from going up further.

Table 7 Own-Price Elasticities for Guangdong Province

Year	Grain	Meat	Vegetables	Fish	Other-food	Non-food
1986	-0.36	-0.28	-0.46	-0.84	-1.07	-0.87
1987	-0.28	-0.23	-0.48	-0.84	-1.07	-0.88
1988	-0.16	-0.27	-0.44	-0.84	-1.07	-0.88
1989	0.07	-0.32	-0.27	-0.84	-1.06	-0.87
1990	-0.27	-0.34	-0.27	-0.85	-1.07	-0.87
1991	-0.25	-0.33	-0.24	-0.84	-1.07	-0.87
1992	-0.18	-0.30	-0.28	-0.84	-1.07	-0.87
1993	-0.15	-0.25	-0.23	-0.84	-1.06	-0.88
1994	-0.31	-0.28	-0.16	-0.84	-1.07	-0.89
1995	-0.26	-0.31	-0.05	-0.85	-1.07	-0.89

Note: The results are from the D-M model without regional dummies.

The own-price elasticities for Other-food were price elastic, in contrast to the Giffen food finding by Halbrendt et al. The demands for Grain and Vegetables become more price inelastic over time largely due to the decline in expenditure shares. With increasing income, the shares of Grain and Vegetables will continue decreasing, and the demand for Grain and Vegetables will become more price inelastic.

Table 8 Marshallian Price Elasticities within Food Groups

	Food 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 elastities are evaluated at the provincial means in 1994.

Table 8 is presented for examining substitute effects among different food groups in 1994. The price effects of Meat, Fish and Vegetables on food grain consumption are 0.031, 0.017 and -0.011, respectively, implying that food grain is a complement with Vegetables but a substitute with meat and fish, which is consistent with the finding by Fan et al. (1995). Since the price effect of Meat on Fish is 0.275, Meat and Fish are substitutes. Also, Vegetables are substitutes with Fish and Other-food.

In conclusion, during the sample period of 1986-1995 in Guangdong Province, Fish was one of the most expenditure and price elastic foods; Grain and Vegetables became increasingly expenditure and price inelastic. The expenditure elasticities for Fish and Meat were higher than for Grain and Vegetables, implying that the demand for feed grain increased faster than the demand for food grain.

V. National Grain Forecast and Conclusions

Our model has proven to be reasonably good at reconciling the controversy regarding the expenditure elasticities for food grain among different studies. Most other forecasts assume constant elasticity parameters taken from cross-section or time-series studies and used for predictions. The elasticities were often assumed to be constant over one or two decades. With the complete demand system based on a panel data set in hand, it is possible to do a prediction using the whole system rather than using constant elasticities evaluated at the sample means.

National Grain Forecasts and a Comparison with Other Studies

Before doing a forecast, it is important to specify the underlying assumptions. Due to the non-concavity of the D-M model in 1995, 1994 is used as a base year for prediction. Since Guaungdong Province is much more advanced economically than other provinces, the per capita expenditure and consumption in 1994 are regarded as representing the national average in 2000. From 1978 to 1994, the annual growth rate of real rural expenditure per capita in China was 2.8 percent while the growth rate for urban residents was 4.2 percent. Considering the fact that the rural population accounts for more than two-thirds of total population and economic growth is gradually slowing down, the annual growth rate of real expenditure is assumed to be 2.8 percent during the prediction period 2000-2020. The population growth rate is assumed to be 1.1 percent during 1995-2000, 0.74 during 2000-2010 and 0.65 during 2010-2020.[7]

Since forecasting prices is at least as difficult as forecasting consumption, the price levels in the forecast period will be assumed to be constant at the 1994 levels. Given the expenditures and prices for the prediction period, the consumption shares for the six goods can be predicted with the D-M model. The quantity consumed can be derived from the shares using the information about price and total expenditure. Meat and Fish are converted to feed grain using the ratio of 1:3 and 1:2 (see Fan and Somalia, 1997b, for the discussion of the conversion ratios). Table 9 reports the forecasts for the food grain, feed grain, total grain and the ratio of feed grain to total grain[8].

[7] The assumption is consistent with Huang and Rozelle (1996).

[8] The D-M model is concave for the first three years of forecast but not for the rest forecast period. The violations of concavity are not that serious considering that the positive Eigen Value in each year is small and the price and income effects fall in a reasonable range. As a consequence, using the estimated D-M model may provide better forecasts than just using constant elasticities in spite of the undesirable features of the D-M model.

Table 9 Projections of Grain Demand in China

Year	Food Grain	Feed Grain	Total Grain	Feed/Total
1995	270	105	375	0.28
2000	317	131	448	0.29
2005	339	149	489	0.31
2010	356	169	525	0.32
2015	369	191	559	0.34
2020	373	215	589	0.37

Note: 1. The units of grain are million metric tons (MMT).
2. The total grain consumption in 1995 is taken from Fan and Sombilla (1997a). Food grain and feed grain are estimated by specifying that the share of feed grain to total grain is 0.28.

It is clear that grain demand will increase as a result of the rise in income and population. The demand for feed grain is growing faster than for food grain. By 2020, feed grain demand will double compared with the 1995 level. Accordingly, the share of feed grain compared to total grain will increase to 0.37 in 2020 from 0.28 in 1995, which is consistent with the elasticity analysis made above.

Table 10 Alternative Predictions of Grain Demand in China

Year	Brown	IFPRI	USDA	World Bank	Huang et al.	Zhang et al.
1995	375	375	375	375	375	375
2000	405	403	387	420	450	448
2005	437	434	414	459	480	489
2010	472	468	443	502	513	525
2020	549	565	n.a.	n.a.	594	589

Note: 1. The table is taken from Fan and Sombilla (1997a), except that the last column is estimated by authors.
2. The units used in the table are MMT.

Given the forecast of national demand for grain, it is possible to make a comparison with other predictions of China's grain demand. Table 10 lists six projections for grain demand in China. According to Fan and Sombilla (1997a) the assumptions for elasticities, income (expenditure), population growth rates and price changes may all contribute to the differences in forecasts. Even though there are some differences in the underlying assumptions of these forecasts, projected levels of grain demand are generally similar in the models reviewed. In the five studies considered in Table 10, projected grain demand in 2020 ranges from 549 MMT to 594 MMT. It is interesting to note that the lowest forecast was made by Brown.

The predictions of the grain supply in China are the major source of controversy over grain forecast (see Fan and Sombilla, 1997a). Brown predicted that total grain supply in China will decrease to 294 MMT by 2020 from 355 MMT in 1995 and as a result, China will need to import about 250 MMT grain from international markets. In contrast, the other studies forecast that total supply will rise due to price effects, public investment and technological innovations. Considering the relatively close predictions of alternative studies on grain demand, the major disagreements about China's grain imports in the future arise mainly from the differences in supply side modeling. Further work is needed to explore the reasons for these differences.

Policy Implications and Conclusions

Six commodity expenditure share equations were estimated using D-M model (Almost Ideal Demand System) based on a panel data set in Guangdong Province. The commodities included in the model are Grain, Meat, Vegetables, Fish, Other-food and Non-food. The food demand patterns in three regions in the province are compared. Since Guangdong Province is the most advanced province in China, the results for Guangdong may provide important policy implications for China as a whole, and the major conclusions follow.

First, food grain has not become an inferior good in Guangdong, the richest province in China. The potential pressure for food grain demand from rising income should not be neglected even though the demand is income inelastic.

Second, the estimated expenditure elasticities for food grain and vegetables are relatively low, while the elasticities for meat and fish are relatively high. The forecast for China shows that the demand for feed grain will grow faster than the demand for food grain and is likely to put tremendous pressure on the domestic grain supply. The rapid change in the pattern of grain demand calls for attention by policy makers. Unless significant steps are taken by the livestock and fishing industries, China will have to import a large amount of feed grain from the international market. Given the limited arable land, the current strategy for exporting grains and livestock should be reevaluated. Tax incentives should be considered for technological innovation in the livestock and fishing industries to expand production capacity.

Third, since the expenditure elasticity for Other-food is greater than one, people will increase the share of expenditures on other-foods 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 huge potential demand for beer could take a substantial amount of grain. Since Other food is price elastic, imposing a higher tax on alcohol and tobacco may be an effective way to reduce the growth of demand.

Fourth, the forecasts of China's future grain demand assumed that the prevailing price structure will continue. However, prices will change in response to the market situation for the aggregate demand and supply in China and decision's about trading agricultural products. If the grain market is not open to the world market, the domestic grain price may well exceed the world price, which, to some extent, may prevent food demand from increasing rapidly. If China opens its grain market and imports a large amount of grain, the world price for grain may increase. Regardless of whether China opens its grain market to the world or not, domestic agricultural supply will play an important role for China's grain situation in the future. The supply side of food and the availability of land for agriculture are the real issues of contention.

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