Analysis of Food Consumption Patterns in China: Nonparametric and Parametric Approaches

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ABSTRACT: This study analyzes consumption patterns of seven major categories of food for Chinese urban households using both nonparametric and parametric approaches. Nonparametric analysis was conducted to ensure that the data were consistent with the underlying theory. For the parametric part, a flexible demand system that nests the "Almost Ideal Demand System" (AIDS) and the Translog demand system proposed by Lewbel (1989) was estimated, and the expenditure and price elasticities for several food categories were analyzed. Chinese provincial data from the Income and Expenditure Survey of Chinese Urban Households showed that Chinese consumers' consumption behavior is consistent with the microeconomic utility maximization assumptions. The parametric analysis shows that in China from 1985 to 1990, meats, fruits, and eggs had very high expenditure elasticities. Grains were a necessity for low-income provinces but were an inferior good for high-income provinces. The results are useful in understanding and predicting food consumption patterns in China and have implications for economic policy decision making.

KEY WORDS: China, food demand.

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Introduction

China, with its changing economic system and its huge market, is of great interest to many policy makers and businessmen all over the world. Many changes have taken place in China since economic reforms began in 1979. Household income has grown substantially in recent years. In 1978, the per capita annual consumption expenditure was only 175 RMB yuan, whereas in 1990, it was 714 RMB yuan, representing an average growth rate of 12.43% per year during this period (Chern & Wang, 1994). Together with the growth in income, the food consumption patterns of Chinese households experienced significant structural changes. For example, using total food expenditure as a base, the average budget share for meats increased from 29% in 1985 to 34% in 1990, while the budget share for grains decreased from 22% to 16% during the same period.

Because understanding consumption behavior is important for making economic policy decisions involving pricing, production, and marketing, the purpose of this article is to explore consumption patterns of Chinese urban households for seven major categories of food using both nonparametric and parametric approaches. Food grouping was based on a nonparametric test, taking the consumption traditions of Chinese households into consideration. The demand elasticities were estimated and analyzed for seven categories of food: meats, grains, vegetables, fruits, nonstaples, eggs, and drinks. Provinces were further divided into high and low income. Demand systems were estimated separately for these two groups, and a comparative analysis was conducted.

Review of Literature

There have been several empirical studies of consumer behavior in China. In 1984, Van der Gaag estimated a Linear Expenditure System for food, clothing, housing, and services using pooled provincial household budget data for rural Hebei province and urban Beijing residents in 1981 and 1982. Chow (1988) estimated a logarithmic Engel curve for food, clothing, housing, and all other items using rural household budget data. Wang and Chern (1992) investigated the impacts of housing, fuel, and food grain rationing on consumption behavior of Chinese urban households by estimating four versions of the Almost Ideal Demand System (AIDS) with different rationed goods using pooled time series data for 1981–1987 and cross-sectional data by income groups from household expenditure surveys. Their results suggested that among unrationed commodities, articles for daily use, cultural life, and recreation (mostly durables) had the highest price and expenditure elasticities, whereas nonstaple food had the lowest elasticities. The comparative statistics (i.e., the response of an economic variable to changes in its environment) for changes in ration level revealed that increases in the rationed quantities of housing, grain, and fuel would simultaneously push up both the prices of and the demand for nonstaple food and durables.

Chern and Wang (1994) estimated and analyzed Engel functions for various aggregate food groups using linear and quadratic expenditure systems for ten major foods in China based on data from 1981 to 1990. Their results showed that the income elasticity for food was about 0.42 during that period, and the demand for pork, beef, eggs, and fish had high own-price elasticities.

Whereas these studies focused on parametric demand analysis and used less generalizable demand systems by assuming underlying rational consumer behavior, this study built its parametric analysis on the results of a nonparametric test and used a more flexible demand system, the Lewbel system, which nests both the AIDS and the Translog models.

Theoretical Considerations and Methods

Revealed Preference, Data Consistency, and the Nonparametric Test

Economists often devote less attention to selecting appropriate data series than to choosing econometric techniques with demand analysis (i.e., the study of consumer demand for commodities and services), although data and methods are equally important to the results (Manchester, 1977). After all, the rationality of consumer behavior is the basic premise of the neoclassical theory. Only if this premise is used can a well-behaved utility function be formulated and a system of demand functions be derived from the utility maximization principle. Therefore, the data set used must be consistent with the maximization behavior when assessing the validity of the estimates of a demand system.

One approach to assure data consistency is to use a nonparametric test that stems from revealed preference theory. The revealed preference conditions provide a complete list of restrictions imposed by rational behavior. Varian (1982) adopted the theorem developed by Afriat (1967) and derived the Generalized Axiom of Revealed Preference (GARP). Given a vector of commodities

X with price vector P, by denoting the i-th observation as X^i, with a price of P^i, the data set satisfies GARP if, whenever X^i is revealed to be preferred to X^j ($P^i X^i \geq P^i X^j$), X^j is not strictly revealed preferred to X^i($P^j X^j \leq P^j X^i$) (Varian, 1982, 1992). Varian proved that if a data set satisfies GARP, then there exists a well-behaved utility function that rationalizes this data set. That is, the data set can be generated from utility-maximizing consumers. Only after confirming that a data set can be rationalized under certain utility maximization behavior will the parameter estimates from demand systems using the data set be valid.

Parametric Demand Analysis: A Flexible Demand System

The exactly aggregable Translog and AIDS are among the most frequently estimated demand systems used in empirical demand analysis during the past decade. Both systems are known to have desirable properties in demand system modeling (Deaton & Muellbauer, 1980; Jorgenson, Lau, & Stoker, 1982). In 1989, Lewbel proposed a general demand system that nests AIDS and Translog as two special cases. In particular, for a commodity bundle with n goods, with price vector P, and total expenditure M, if we denote w_i as the budget share for commodity i, $V_i = \mathrm{Log}(P_i)$, and $Z = \mathrm{Log}(M)$, the indirect utility function is specified as follows:

$$Log(U(V,Z)) = b'V + Log(d + a'V + 0.5V'cV - (a'l + V'cl)Z) \quad (1)$$

where d is a scale parameter, a and b are vectors satisfying $a'l = 1$, $b'l = 0$ with l being a vector of ones, and c is a symmetric matrix satisfying $l'cl = 0$. These parameter restrictions can also be written as

$$\sum_{i=1}^{n} a_i = 1, \sum_{i=1}^{n} b_i = 0, \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij} = 0, c_{ij} = c_{ji} \quad (2)$$

for all i and j.

By Roy's identity (Varian, 1992), the demand system in expenditure share form can be derived as

$$w_i = \frac{a_i + c_i'V + b_i(d + a'V + 0.5V'cV) - (c_i'l + b_i(1 + V'cl))Z}{1 + V'cl} \quad (3)$$

for $i = 1, \ldots, n$.

Together, these restrictions (equation 2) imply adding up, homogeneity, and symmetry of the demand system (equation 3). One convenient aspect of this demand system is that the restriction $b_i = 0$ for all i reduces the system to the Translog, whereas the restriction

$$\sum_{j=1}^{n} c_{ij} = 0 \tag{4}$$

for all i leads to the AIDS. These restrictions can be tested to examine the acceptability and relative explanatory power of the AIDS and the Translog.

If we further denote the expenditure elasticity as e_i, the price elasticities as e_{ij} (own-price elasticity when $i = j$), the elasticities for the Lewbel demand system take the following forms:

$$e_i = 1 - \frac{c_i'l + b_i(1+V'cV)}{w_i(1+V'cV)} \tag{5}$$

$$e_{ij} = \frac{c_{ij} + b_i(a_j + c_j'V) - b_i c_j'Z}{w_i(1+V'c_i)} - \frac{c_{ij} + b_i(a_j + c_j'V) - b_i c_j'Z}{w_i(1+V'c_i)^2} - \delta_{ij} \tag{6}$$

where $\delta_{ij} = 1$ for $i = j$, $\delta_{ij} = 0$ otherwise.

Data

Data used for this study were drawn from the 1985–1990 Income and Expenditure Survey of Chinese Urban Households. These data include average price and quantity information on 23 food groups for 28 provinces each year, for a sample size of 168 observations. Foods for Chinese main meals include grains, edible oil, fresh vegetables, dried vegetables, pork, beef, poultry, eggs, fish, fresh fruits other than melons, cake and related foods, milk, and canned food. Other related categories are sugar, cigarettes, tobacco, rice wine, beer, other wine, tea, fresh melon, dried fruits, and candy. In China, tobacco is included as a food-related expenditure item in the government agricultural statistics. Many missing values were found in the price and quantity information on tobacco, which caused some difficulties in both nonparametric and parametric analysis. Therefore, this commodity was deleted before doing further analysis.

Several attempts were made to estimate the demand system containing these 22 categories of food, but no convergence could be reached because of the size of the system. To reduce commodity groups, two alternative strategies may be used. The first is to assume separability, which reduces the dimensionality of the estimation problem. A second approach is to use the composite commodity theorem, which is based on the behavior of exogenous variables such as price rather than on the form of the utility function. Both approaches make some restrictive assumptions. In an early stage of this study, Varian's separability test was employed to determine whether the separability approach could be used. After numerous commodity combinations, no subset of commodities was found that satisfied the separability conditions. Thus the composite commodity approach was used to reduce the number of food categories. Food grouping was first based on Chinese food consumption traditions. A nonparametric test was then performed on the regrouped data set to test their consistency, and certain adjustments[1] were made to guarantee the creation of a well-behaved data set. Seven food categories were finally constructed: meats (pork, beef, poultry, fish), vegetables (fresh and dry), grains, fruits (fresh and dry, fresh melon), eggs, drinks (beer, wine, tea, milk), and other nonstaple food (edible oil, sugar, candy and related foods, and others).

Because the model we used was highly nonlinear, we were not able to follow the conventional procedure of using the error component model to deal with the pooling nature of the data. Also, the dummy variable approach was not used because of the degree of freedom issue. To identify possible differences in the error structure between provinces and to compare and analyze the differences in food consumption behavior for high-income and low-income provinces, we divided the observations into two subsets: provinces with higher-than-average income as the high-income group and other provinces as the low-income group, using mean income as the criterion.[2] Twelve provinces and cities were classified as high-income (Beijing, Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Hunan, Fujian, Guangdong, Guangxi, Sichuan, and Yunnan), and the other 16 provinces were classified as low-income (Shanxi, Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Guizhou, Gansu, Qinghai, Ningxia, Xingjiang, Hebei, Shangdong, Hubei, and Shaanxi).

Results of Nonparametric Analysis

The nonparametric analysis was employed to examine whether this data set was consistent with the utility-maximization hypothesis. The tests were conducted using a computer software program developed and provided by Hal Varian (1982). The software was limited in that it could not accommodate more than 75 observations. Because the sample exceeded this limit, six subsets were constructed for the tests, with every two consecutive years in one subset.

Although in theory the nonparametric test is very straightforward, in practice the analysis becomes extremely time-consuming when large numbers of observations are involved. Simply stated, an acceptable commodity grouping must satisfy GARP (or at least have only small numbers of violations) in all six independent tests, and numerous possible commodity groupings could be constructed for a data set containing 22 goods. Although this data set involved consumption paths over time, the dominant feature was still cross sectional, the budget lines of different provinces were very likely to cross each other, and possible irrational behaviors were easy to detect. This feature of the data set can improve the power of the nonparametric test, but in practice, the test was difficult to perform.

The first step of the nonparametric test was to test the consistency of the whole data set with 22 commodities. In all six tests, only one violation was detected. Because the number of violations was very small in terms of probability (1 out of 18,816 chances), the whole data set was considered to be essentially consistent.

Initially, a weak separability test was used in an attempt to find a separable subset with fewer commodities, but after numerous tries to find possible commodity subsets, none was found. Therefore, the composite commodity approach was applied with the assumption that the prices in the same commodity group moved in parallel (Hicks, 1939).

Several possible methods of grouping the commodities were tested using the nonparametric procedure. The results indicated that the one described in the data section had the best performance (least violations). As a result, this method was chosen for the parametric analysis.

Descriptive statistics for the seven composite commodities are provided in Table 1. The nonparametric test results indicate that the selected commodity groups essentially satisfied GARP, and an underlying well-behaved utility function based on rational behavior could be assumed. This result provides theoretical justification for performing further parametric demand system analysis and improves the validity of the empirical estimations of parameters and elasticities.

Results of Parametric Demand Analysis

For the Lewbel demand system to be estimable, the adding-up restriction requires that one commodity group be dropped. The selected

TABLE 1

Selected Mean Statistics

	1985			1988			1990		
Commodity	P	Q	W	P	Q	W	P	Q	W
Meats	2.97	235.74	0.29	5.06	254.43	0.33	5.85	279.69	0.34
Grains	0.46	1108.14	0.22	0.57	1137.65	0.17	0.67	1090.27	0.16
Vegetables	0.30	1132.67	0.14	0.57	1215.59	0.17	0.69	1137.20	0.16
Fruits	0.72	325.34	0.09	1.13	366.39	0.10	1.33	398.42	0.10
Nonstaples	2.26	122.85	0.12	2.99	131.90	0.10	3.95	118.70	0.11
Eggs	2.60	60.78	0.07	4.07	59.96	0.06	4.86	60.95	0.06
Drinks	1.72	108.34	0.07	2.32	125.95	0.07	2.77	128.69	0.07

Note. P = price, Q = quantity, W = budget share.

group was drinks, which had a mean food budget share of about 7%. Estimated elasticities at sample mean level from the Lewbel demand system for all China, high-income group, and low-income group are summarized in Tables 2–4.[3] The results of the parameter estimation that generated the estimated elasticities are reported in the Appendix.

The Lewbel demand model had a fairly good fit. About half of the estimated parameters were significant. Except for the food group eggs, the adjusted R-squares were acceptable, and the R-square was especially high for grains (over 0.80).

These results suggest that in China, during 1985–1990, meats, fruits, and eggs had strong income effects, with mean expenditure elasticities greater than one. It is somewhat surprising that eggs had such a high expenditure elasticity for both the high-income and the low-income groups because some previous studies found that eggs were necessities (Chern & Wang, 1994). The reason for this contradiction may be that the budget share equation for eggs in this demand system had very low explanatory power so the elasticity estimates may not be very accurate. This result, however, may have other implications related to Chinese dietary habits. Further research is needed to explore this apparent contradiction.

Although the budget share for vegetables demonstrated an upward trend in the early years and held relatively constant in the later years of the sample period, it had an expenditure elasticity of less than one, which suggests that vegetables were considered a necessity in China during this period.

An interesting phenomenon was found when the expenditure elasticity of grains was considered. For all the China data, the mean expenditure elasticity was 0.27, indicating that grains were a necessity. But though still positive for the low-income group, grains had a negative income elasticity (-0.13) for the high-income group. This suggests that grains were becoming an inferior good for the high-income provinces. Such a finding has clear policy implications because if income continues to increase and if supply remains the same or increases, ending grain rationing should not dramatically affect the real market price of grains. The own-price elasticities were all negative, indicating no particular food was a Giffen good (i.e., a decrease in its price leads to a decrease in its demand). The cross-price elasticities were more varied, and no particular pattern could be identified.

TABLE 2

Estimated Mean Elasticities: All China

Commodity	Expenditure elasticity	Price elasticities							Adj. R^2
		Meats	Grains	Vegetables	Fruits	Nonstaples	Eggs	Drinks	
Meats	1.06	−0.57	−0.05	0.02	0.01	−0.07	−0.17	0.29	0.32
Grains	0.27	−0.09	−0.26	0.01	−0.14	0.01	0.08	0.26	0.87
Vegetables	0.72	0.04	0.01	−0.71	0.03	−0.05	0.09	0.28	0.21
Fruits	1.60	0.07	−0.19	0.05	−1.07	−0.24	−0.02	0.14	0.21
Nonstaple	1.06	−0.19	0.01	−0.07	−0.25	−0.14	−0.30	0.18	0.56
Eggs	1.85	−0.86	0.19	0.22	−0.03	−0.50	−0.83	0.22	0.04
Drinks	−0.46	−0.47	0.21	−0.06	−0.10	−0.03	0.05	−0.78	—

Note. Because the Lewbel demand system is a constraint system, only six equations were estimated. The demand equation for drinks was not directly estimated and therefore no R^2 value is reported.

TABLE 3

Estimated Mean Elasticities: High-Income Group

Commodity	Expenditure elasticity	Own-price elasticities							Adj. R^2
		Meats	Grains	Vegetables	Fruits	Nonstaples	Eggs	Drinks	
Meats	1.20	−0.81	−0.08	0.01	0.12	−0.05	−0.15	0.29	0.24
Grains	−0.13	−0.21	−0.15	0.06	−0.00	0.08	0.22	0.23	0.81
Vegetables	0.55	0.03	0.05	−0.66	0.05	−0.10	0.09	0.26	0.20
Fruits	1.43	0.41	−0.00	0.06	−1.17	−0.25	−0.22	0.15	0.18
Nonstaples	1.13	−0.17	0.11	−0.14	−0.28	−0.24	−0.36	0.19	0.58
Eggs	2.28	−0.91	0.41	0.20	−0.37	−0.56	−1.01	0.30	0.04
Drinks	−1.24	−0.43	0.11	0.16	−0.27	0.05	−0.06	−0.84	—

Note. Because the Lewbel demand system is a constraint system, only six equations were estimated. The demand equation for drinks was not directly estimated and therefore no R^2 value is reported.

TABLE 4

Estimated Mean Elasticities: Low-Income Group

Commodity	Expenditure elasticity	Price elasticities							Adj. R^2
		Meats	Grains	Vegetables	Fruits	Nonstaples	Eggs	Drinks	
Meats	1.19	−0.42	−0.07	0.01	0.07	−0.13	−0.22	0.25	0.27
Grains	0.31	−0.11	−0.33	0.04	−0.14	0.07	−0.01	0.24	0.82
Vegetables	0.64	−0.03	0.04	−0.66	0.06	0.06	0.05	0.28	0.22
Fruits	1.74	−0.17	−0.21	0.09	−1.05	−0.24	0.07	0.15	0.39
Nonstaples	0.84	−0.37	0.10	0.07	−0.24	−0.11	−0.22	0.18	0.56
Eggs	1.72	−1.08	−0.02	0.13	0.12	−0.37	−0.57	0.16	0.10
Drinks	−0.11	−0.44	0.35	−0.11	−0.09	−0.37	0.17	−0.75	—

Note. Because the Lewbel demand system is a constraint system, only six equations were estimated. The demand equation for drinks was not directly estimated and therefore no R^2 value is reported.

Conclusion, Implications, and Limitations

This article analyzed the consumption patterns of seven major categories of food for Chinese households during 1985–1990, using both nonparametric and parametric approaches. The nonparametric test results show that Chinese consumers' consumption behavior is generally consistent with microeconomic utility-maximization assumptions. The parametric analysis shows that in China, meats, fruits, and eggs had expenditure elasticities greater than one. Grains were considered a necessity in low-income provinces but were considered an inferior good in high-income provinces. These findings should be useful in understanding and predicting food consumption patterns in China and have clear implications in economic policy decision making such as price reform.

The study had several limitations. First, the composite commodity approach was used to aggregate 22 food items to seven major categories of food. This approach assumed that the prices in the same composite commodity group moved in parallel (Hicks, 1939). No formal tests were available to assess whether this assumption was satisfied. Second, aggregate data were used in this study. As Theil (1971) noted, aggregation bias can result when macro data are used to infer relationships between micro variables. Because micro data were not available, the size and direction of the aggregate bias are unknown. Results of the nonparametric test, however, suggest that the aggregate data are consistent with the demand theory based on individual behavior. Finally, during the analysis period, some commodities such as grains were still being rationed in China. This demand analysis did not impose the commodity rationing restriction. Further analysis of these data should take that into consideration.

Notes

1. Eggs were first included in the meats category because we thought many Chinese households treated eggs as a substitute for pork, chicken, and other meats. The consistency test showed that the data were more consistent when eggs were considered as a separate food category.
2. At first, Engel coefficients were considered as the criterion to differentiate the high-income group from the low-income group, but it turned out that Guangdong and Fujian provinces, which are generally considered to be high-income provinces, had much higher Engel coefficients than the overall mean and than Mongolia and Xinjiang, which are generally considered

to be low-income provinces. This may be caused by regional differences in food consumption traditions in China.

3. The researchers did not derive the variance for the estimated elasticity and therefore cannot say anything about the significance of the estimated elasticities. The Bootstrap method can be used to compute the variance, but this model was highly nonlinear and it would be too complex to do it.

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APPENDIX TABLE A1

Parameter Estimates from the Lewbel Demand System

	All China		High-income group		Low-income group	
Parameter	Coefficient	T-value	Coefficient	T-value	Coefficient	T-value
a1	−0.1506	−0.67	−0.6072	−1.25	−0.2580	−0.96
a2	−0.2651	−1.05	−0.3947	−0.75	−0.5696*	−1.65
a3	2.4666***	5.27	2.2146***	3.12	1.8096***	2.79
a4	1.6616	1.23	−0.5276	−0.22	−0.2952	−0.18
a5	0.3588	1.37	−0.6048	−0.16	0.3130	0.62
a6	1.4218***	2.78	0.9905	1.30	0.8206	1.17
b1	−0.0061***	−5.22	−0.0090***	−4.48	−0.0033*	−1.69
b2	−0.0091***	−9.21	−0.0111***	−6.55	−0.0097***	−6.64
b3	−0.0192***	−20.45	−0.0155***	−11.86	−0.0208***	−12.67
b4	−0.0493***	−16.11	−0.0503***	−10.46	−0.0439***	−9.13
b5	−0.0102***	−13.06	−0.0085***	−7.73	−0.0158***	−10.55
b6	−0.0214***	−21.82	−0.0176***	−11.23	−0.0231***	−14.77
c11	0.0145	0.79	−0.0011	−0.04	0.0312	1.17
c12	−0.0003	−0.04	−0.0295*	−1.79	0.0088	0.85
c13	0.0231**	2.00	0.0412***	2.67	−0.0013	−0.08
c14	−0.0665***	−2.91	−0.0753*	−1.92	−0.0803***	−2.96
c15	−0.0398***	−3.51	−0.0453***	−3.04	−0.0287*	−1.79
c16	0.0240**	2.10	0.0172	0.95	0.0102	0.74
c17	−0.0188	−1.05	0.0008	0.02	0.0101	0.67
c22	−0.0069	−0.77	−0.0234	−1.22	−0.0052	−0.51
c23	−0.0267***	−3.21	−0.0007	−0.06	−0.0315***	−2.78
c24	0.0235	1.14	0.0547	1.29	−0.0224	−0.94
c25	−0.0317***	−4.58	−0.0362***	−3.13	−0.0315***	−3.48
c26	0.0129	1.48	0.0092	0.56	0.0119	1.13
c27	−0.0462*	−1.86	−0.0207	−0.38	−0.0114	−0.33
c33	0.2315***	13.11	0.2181***	9.57	0.2044***	8.57
c34	0.0043	0.15	−0.0484	−1.11	−0.0296	−0.79
c35	0.0080	0.80	0.0174	1.45	0.0174	1.08
c36	0.0152	1.17	0.0120	0.73	0.0104	0.61
c37	−0.0466	−0.91	0.0153	0.21	0.0324	0.46
c44	0.2753**	2.59	0.0712	0.43	0.2120*	1.82
c45	−0.0138	−0.73	−0.0241	−0.85	−0.0517*	−1.81
c46	0.0402	1.23	0.0015	0.03	−0.0063	−0.16
c47	−0.2110	−1.57	−0.0051	−0.02	−0.0362	−0.24
c55	0.1301***	8.51	0.0995***	5.87	0.1600***	6.56
c56	−0.0044	−0.45	−0.0212	−1.57	0.0109	0.75
c57	−0.0426	−1.51	0.0040	0.10	−0.0343	−0.62
c66	0.0823***	5.09	0.0810***	3.58	0.0684***	3.33
c67	−0.0799	−1.36	0.0216	0.24	−0.0076	−0.09
d	33.9069	1.44	−0.1195	−0.00	3.020	0.10

Note. Refer to equation 3 for *a*, *b*, and *c* notations.
$^{*}p < .10$. $^{**}p < .05$. $^{***}p < .01$.