Translating and Scaling of Budget Shares: An Empirical Analysis of Chinese Urban Household Demand for Meat

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Abstract

The importance of incorporating demographic effects into a demand system is demonstrated using Lewbel's unified functions. In this study, the empirical analysis of meat demand in urban China shows the benefit of utilizing the translation and scaling of budget shares.

Keywords: unified functions; demographic effects; micro data; meat demand; urban China

JEL Classification: D12

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1. Introduction

A household survey usually provides detailed information of demographic characteristics a relatively larger sample size than a time series. These advantages make it popular to utilize micro household data in recent food demand studies; in addition, micro household data enables one to investigate heterogeneous consumption patterns. This study attempts to provide an in-depth understanding of heterogeneous consumer buying patterns by incorporating the demographic effects into a quadratic almost ideal demand system (QAIDS).

There are two reasons to incorporate demographic effects into a demand system (Muellbuaer, 1977). One is to estimate the equivalence scales and the other is to improve estimation. This study, with an emphasis on how to achieve better estimates of meat demand elasticities, focuses more on how to incorporate demographic effects to enhance a demand analysis. Estimation using pooled data without incorporation of demographic variables implicitly assumes identical tastes (or preferences) among households. This is not consistent with the observed facts in household data; hence, in order to achieve better estimates, several techniques for incorporating demographic effects have been developed and are further discussed in the literature (see Pollak and Wales (1992) for more details).

Lewbel (1985) introduced a unified approach– a modifying function procedure, which nested five procedures suggested by Pollak and Wales (1981) as special cases. Unfortunately, Lewbel's procedure is too general to apply empirically, and thus, there are very few empirical studies using his unified approach. To our knowledge, only Bollino, Perali, and Rossi (2000) applied Lewbel's procedure to extend the Gorman specification (1976). A critical shortcoming of their study is that they demonstrated their approach with incorporation of only one demographic variable indicating a handicap "to capture the vast amount of behavioral heterogeneity present in the data" (Bollino et al., 2000, p. 276). Chung (2001) utilized Lewbel's modifying function procedure to show a more general procedure than Lewbel's with no empirical evidence. Hence, this study attempts to estimate a QAIDS model using Lewbel's unified approach to demonstrate its applicability in empirical demand analysis.

Lewbel's unified approach has several important characteristics. First, the demand system, with incorporation of demographic variables using the unified approach, still satisfies the demand properties such as adding-up, homogeneity, and symmetry conditions. Second, the budget share can be divided into two parts. Part one consists of the traditional functional form with its prices and expenditure modified by demographic effects. This part contains original price and income effects. Part two contains demographic effects only without dealing with the conventional price and income effects. Therefore, the budget share can be explained by using ordinary budget share scaling and translation (OBSSAT) to analyze these two parts. Third, modified prices create price variety when cross-sectional data are used. These modified prices provide a solution to the identification problem and allow calculating price elasticities with cross-sectional data.

This study focuses on two major tasks: (1) to develop an economic model considering heterogeneous consumption patterns across households; and (2) to estimate an econometric model of a QAIDS using Chinese urban household meat consumption data.

The remainder of the paper is organized as follows. In the next section, an economic model is developed and an econometric model is specified. In section 3, the Chinese urban household data are described, showing intriguing findings on Chinese meat consumption. Section 4 shows the empirical results and important implications from the analysis are discussed. A summary is provided in the last section.

2. The Model

As mentioned earlier, Lewbel (1985) proposed unified approaches to incorporating demographic or other effects into demand systems. For our empirical analysis in this study, following Lewbel (1985, pp. 9-11), the modifying functions can be specified and called as 'ordinary budget share scaling and translation' (OBSSAT, in theorem 8). Specifically, the modifying functions are expressed as:

$$X = f[X^*, p, r] = \beta(r) \cdot (X^*)^{[s(r)/\alpha(r)]} \widetilde{P}(p,r), \tag{1}$$

$$p_i^* = h_i(p,r) = \gamma(r) \cdot p_i^{\alpha(r)}, \tag{2}$$

where X and p are total expenditure and prices, respectively; $\widetilde{P}(p,r) = \prod_{i=1}^{n} p_i^{r_i}$; p_i^* is i^{th} modified price; X^* is a modified expenditure; r is a function of demographic characters A; and $\alpha(r)$, $\beta(r)$, $\gamma(r)$, and $s(r)$ are some specific functions of r, which will be specified later. According to theorem 4 (Lewbel, 1985, pp. 4-5), the demand system in share form can be derived as:

$$w_i(X,p,r) = \frac{\partial f[.]}{\partial X^*} \frac{X^*}{X} \sum_{j=1}^{n^*} \frac{\partial h_j(.)}{\partial p_i} \frac{p_i}{p_j^*} w_j^*(X^*, p^*) + \frac{\partial f[.]}{\partial p_i} \frac{p_i}{X}, \tag{3}$$

where $\dfrac{\partial f[.]}{\partial X^*} = \beta(r) \cdot \dfrac{s(r)}{\alpha(r)} \cdot (X^*)^{[s(r)/\alpha(r)]-1} \cdot \widetilde{P}(p,r) = \dfrac{s(r)}{\alpha(r)} \cdot \dfrac{X}{X^*}$,

$\dfrac{\partial f[.]}{\partial p_i} = \beta(r) \cdot (X^*)^{[s(r)/\alpha(r)]} \cdot \dfrac{r_i}{p_i} \widetilde{P}(p,r)$, and

$$\frac{\partial h_j(.)}{\partial p_i} = \begin{cases} \gamma(r) \cdot \dfrac{\alpha(r)}{p_i} \cdot p_i^{\alpha(r)} = \dfrac{\alpha(r)}{p_i} \cdot h_i(p,r) & \forall i = j \\ 0 & \forall i \neq j \end{cases}.$$

Hence equation (3) becomes:

$$\begin{aligned} w_i(X,p,r) = {} & \frac{s(r)}{\alpha(r)} \frac{X}{X^*} \frac{X^*}{X} \frac{\alpha(r)}{p_i} h_i(p,r) \frac{p_i}{p_i^*} w_i^*(X^*, p^*) \\ & + \beta(r) \cdot (X^*)^{[s(r)/\alpha(r)]} \cdot \frac{r_i}{p_i} \widetilde{P}(p,r) \frac{p_i}{X} \end{aligned},$$

and thus,

$$w_i(X,p,r) = s(r)\cdot w_i^*(X^*,p^*) + r_i, \qquad (4)$$

which is equation (20) in Lewbel (1985, p.10), where $s(r) = 1-\sum_{j=1}^{n} r_j$, $r_i \geq 0\ \forall i$, $0 < s(r) \leq 1$.[1,2] This budget share is a function which is *independent* from $w_j^*\ \forall j \neq i$ and the modifying function $p_i^* = h_i(.)$ is *independent* from p_j for all $j \neq i$.[3]

If we specify $\alpha(r) = s(r) = a$ and $\gamma(r) = \beta(r) = 1$, as indicated in Lewbel (1985, p.10), then equation (4) can be simplified as:

$$w_i(X,p,r) = a\cdot w_i^*(X^*,p^*) + r_i, \qquad (5)$$

where $a = 1-\sum_{j=1}^{n} r_j$, $X^* = X/\widetilde{P}$, $\widetilde{P}(p,r) = \prod_{i=1}^{n} p_i^{r_i}$, $p_i^* = p_i^a$, and $r_i = \sum_{k=1}^{K} \delta_{ik} A_k$.

Therefore, for an empirical analysis, a demand system with incorporation of demographic variables, i.e., equation (5), can be estimated as long as $w_i^*(X^*,p^*)$ is specified. In this study, the QAIDS model with demographic variables can be expressed as:

$$w_i(X,p,r) = a\cdot w_i^*(X^*,p^*) + r_i, \qquad (6)$$

where $$w_i^*(X^*,p^*) = \alpha_i + \sum_k \gamma_{ik} \ln p_k^* + \beta_i \ln\left(\frac{X^*}{a(p^*)}\right) + \frac{\lambda_i}{b(p^*)}\cdot\left[\ln\left(\frac{X^*}{a(p^*)}\right)\right]^2,$$

$$\ln a(p^*) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i^* + 1/2 \sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln p_i^* \ln p_j^*,$$

$$b(p^*) = \prod_k (p_k^*)^{\beta_k}, \text{ and}$$

$$\ln X^* = \ln(X/\widetilde{P}) = \ln X - \ln \widetilde{P} = \ln X - \sum_{j=1}^{n} r_j \ln p_j.$$

Under this specification, the expenditure elasticity is given by:

$$E_i = 1 + \frac{1}{w_i} \cdot \frac{\partial w_i}{\partial \ln X}, \tag{7}$$

where $\frac{\partial w_i}{\partial \ln X} = a \cdot \frac{\partial w_i^*}{\partial \ln X^*}$ and $\frac{\partial w_i^*}{\partial \ln X^*} = a \cdot [\beta_i + 2 \cdot \frac{\lambda_i}{b(p^*)} \cdot \ln\left(\frac{X^*}{a(p^*)}\right)]$.

The Marshallian price elasticities (E_{ij}^M) can be computed by:

$$E_{ij}^M = -\bar{\delta}_{ij} + \frac{1}{w_i} \cdot \frac{\partial w_i}{\partial \ln p_j}, \tag{8}$$

where $\bar{\delta}_{ij} = \begin{cases} 0, & if \quad i \neq j \\ 1, & if \quad i = j \end{cases}$, $\frac{\partial w_i}{\partial \ln p_j} = a \cdot [a \cdot \frac{\partial w_i^*}{\partial \ln p_j^*} - r_j \cdot \frac{\partial w_i^*}{\partial \ln X^*}]$, and

$$\frac{\partial w_i^*}{\partial \ln p_j^*} = \gamma_{ij} - \left(\alpha_j + \sum_k \gamma_{jk} \ln p_k^*\right) \cdot \left(\frac{\partial w_i^*}{\partial \ln X^*}\right) - \beta_j \cdot \frac{\lambda_i}{b(p^*)} \cdot \left[\ln\left(\frac{X^*}{a(p^*)}\right)\right]^2.$$

The Hicksian price elasticities (E_{ij}^H) can be calculated by using the Slutsky equation, i.e.,

$$E_{ij}^H = E_{ij}^M + w_j E_i. \tag{9}$$

The elasticities with respect to demographic variable A_k can be expressed as:

$$E_{A_k}^i = \frac{A_k}{w_i} \cdot \frac{\partial w_i}{\partial A_k}, \tag{10}$$

where $\frac{\partial w_i}{\partial A_k} = a \cdot \frac{\partial w_i^*}{\partial A_k} + w_i^* \frac{\partial a}{\partial A_k} + \frac{\partial r_i}{\partial A_k}$,

$\frac{\partial r_i}{\partial A_k} = \delta_{ik}$, $\frac{\partial a}{\partial A_k} = -\sum_{j=1}^n \frac{\partial r_j}{\partial A_k} = -\sum_{j=1}^n \delta_{jk}$,

$\frac{\partial w_i^*}{\partial A_k} = \frac{\partial w_i^*}{\partial \ln X^*} \cdot \frac{\partial \ln X^*}{\partial A_k} + \sum_{j=1}^n \frac{\partial w_i^*}{\partial \ln p_j^*} \cdot \frac{\partial \ln p_j^*}{\partial A_k}$,

$$\frac{\partial \ln X^*}{\partial A_k} = \sum_{j=1}^{n} \delta_{jk} \ln p_j \, , \quad \frac{\partial \ln p_j^*}{\partial A_k} = -\ln p_j \cdot (\sum_{l=1}^{n} \delta_{lk}) \text{, and}$$

$\frac{\partial w_i^*}{\partial \ln p_j^*}$ and $\frac{\partial w_i^*}{\partial \ln X^*}$ as discussed earlier.

3. Data

The database used in this study is obtained from the National Bureau of Statistics (NBS) in China. This study employs data from three provinces, i.e., Shandong (near Beijing), Jiangsu (adjacent to Shanghai), and Guangdong (adjacent to Hong Kong), for 1998, which represents diverse patterns of food consumption in urban China. Five animal- protein food items are analyzed in this study, including pork, poultry, eggs, beef and mutton (BM), and aquatic products (AP). In total, there are 2,049 observations. In addition, several demographic effects are incorporated in this study, including household size, number of children in a household, income groups, ownership of refrigerators, and other characteristics of householders, such as age, gender, and education level.

The definitions and descriptive statistics of variables are presented in Table 1. The budget share for pork is the largest, accounting for more than 40%. Beef and mutton have the smallest share at only 6%. The other three animal food items (poultry, eggs, and aquatic products) have similar budget shares of slightly over 15%. Prices of these animal food items range from 6.5 Yuan/Kg for eggs to 16.5 Yuan/Kg for beef and mutton. In addition, the average expenditure on these five animal food items totaled 575 Yuan per capita in 1998.

4. Empirical Results

In order to focus on the demand for meats and related products in urban China, meat consumption is assumed to be weakly separable from other food or non-food items. An empirical analysis is conducted by estimating econometric models in a sequence of four steps: (1) an Engel curve analysis, (2) the QAIDS, (3) the QAIDS with demographic variables, and (4) the censored QAIDS with demographic variables. This sequential analysis allows us to examine the impact of the effects of each factor, such as income, prices, demographic variables, and zero consumption on the demand system.

4.1 An Engel Curve Analysis

Banks et al. (1997) showed that the QAIDS is a more suitable model than the AIDS to explain household consumption behavior. However, whether the QAIDS model properly applies to our food demand analysis in urban China requires further validation. In order to investigate whether the QAIDS is an appropriate model to explain Chinese household consumption, its nested model, the AIDS, is used as an alternative specification.[4] As indicated earlier, the QAIDS model has an additional quadratic term in the logarithm of expenditure (log income, in short); therefore, a nested test examining the quadratic term in log income is executed before price effects are considered.[5] This assessment of the consumption-expenditure (income) relationship is called an Engel curve analysis. Among several single-equation specifications, the Working-Leser form is chosen since it satisfies the adding-up property.

The Working-Leser form is augmented by incorporating demographic variables and can be expressed as:

$$w_i = \alpha_i + \sum_{k=1}^{K} \delta_{ki} A_k + \beta_i \ln X + \gamma_i (\ln X)^2 , \qquad (11)$$

where w_i = budget share of food i for i = 1,…,5,

A_k = k^{th} demographic variable for k = 1,…, K,

$\ln X$ = logarithm of total expenditure, and

α_i's, β_i's, γ_i's, and δ_{ki}'s are parameters to be estimated.

Following Deaton and Muellbauer (1980a, pp.19-24), each equation (11) is estimated independently utilizing the ordinary least squares estimator (OLS), which automatically satisfies the adding-up property.

Table 2 presents the estimation results.[6] Since the purpose of this exercise is to determine whether or not the demand system is quadratic in log income, more attention is paid to the coefficients γ_i's in this analysis. Specifically, we are interested in testing the hypothesis of $\gamma_i = 0$ against $\gamma_i \neq 0$, for i=1,…,5. Table 2 shows that at least one γ_i

coefficient for pork is significant at the 0.05 level. As a result, the QAIDS should be used in the remaining analysis including incorporation of demographic variables and censored demand systems. In addition, a hypothesis testing for the quadratic term will also be further implemented. The following three sections will present the empirical results by considering the original QAIDS model itself (Section 4.2) augmented by incorporation of demographic variables (Section 4.3) as well as censoring (Section 4.4).

4.2 The Quadratic Almost Ideal Demand System

This section presents the empirical results of the QAIDS model without considering demographic or censoring effects. As discussed earlier, the QAIDS is used as a functional specification to examine the significance of the quadratic terms of log income. In addition, homogeneity and symmetry conditions are imposed to ensure regularity conditions hold.[7]

Table 3 shows the results of testing the quadratic term $\lambda_i = 0$ vs. $\lambda_i \neq 0$ by using the Wald test. This is actually a nested test of the AIDS versus the QAIDS. From the Wald test, the null hypothesis, $\lambda_i = 0$, is rejected for two meat items, including aquatic products, and beef and mutton. This indicates that the QAIDS model fits the urban Chinese household data better than the AIDS model. However, pork, poultry, and eggs do not reject $\lambda_i = 0$ at the 0.05 significant level. This finding is not consistent with that from the Engel curve analysis (Section 4.1) especially for pork when price effects are added. However, our findings reenforce the previous findings from Banks et al. (1997) that the QAIDS is a more suitable model than the AIDS to explain household consumption behavior. It should be noted that the demographic effects are not yet considered, and this conclusion may be altered in the later analysis.

The demand elasticities, including expenditure elasticities and Marshallian and Hicksian price elasticities are calculated, using equations (7)-(9), and presented in Table 4. All the expenditure and own-price elasticities have a correct sign. The expenditure elasticities range from 0.504 for eggs to 1.279 for aquatic products. Aquatic products and poultry have relatively high expenditure elasticities, which indicate that people will increase (decrease) consumption on these food items relative to other food items as total expenditure (affected by income) increases (decreases). The Marshallian own-price elasticities of pork, poultry, and beef and mutton are close to or lower than unity (-1); whereas those for eggs and aquatic products are -0.595 and -0.706, respectively, indicating that eggs and aquatic products are price inelastic. Most of the Hicksian cross-price elasticities are positive, which indicate that most meats and related items are net substitutes, as expected.

4.3 Incorporation of Demographic Variables

Following Lewbel's unified approach to incorporating demographic variables, the ordinary budget share scaling and translation (OBSSAT) is utilized to fit the QAIDS, equation (6), with the dataset from urban China. The five food items are estimated using the full information maximum likelihood estimator (FIML) in SAS.

Table 5 shows the parameter estimates in the QAIDS with demographic variables. In order to reduce the computational burden and to satisfy demand properties, homogeneity and symmetry are imposed in estimation. By doing so, the elasticities can be compared with those obtained in the previous section. With incorporation of demographic variables, only some α's in the QAIDS model are statistically different from zero at the 0.05 significant level. In addition, some parameter estimates corresponding to demographic variables are significant. In general, these selected demographic variables help explain consumption patterns in urban China since all the adjusted R^2's are improved dramatically. For example, the adjusted R^2 of poultry improves from 0.04 to 0.25. When interpreting these parameter estimates, it is necessary to be cautious since their impact on budget shares (the dependent variables) is compounded with other factors, e.g., prices. This is revealed from equation (10). However, the parameter estimates still reflect a direct impact of demographic variables on the budget share (from the $\partial r_i / \partial A_k$ term). Overall, the demographic variables such as age of the householder, ownership of a refrigerator, and region are the most important factors affecting meat consumption patterns. The most significant contribution of the demographic variables is from the provincial dummy variables. The results indicate that the differences among the three provinces are notable. Relative to Guangdong, people in Shandong spent significantly more on eggs whereas people in Jiangsu spent significantly smaller expenditure shares on beef and mutton, and poultry. Hence, regional differences are important factors affecting consumption choices in China.

With incorporation of demographic variables, the results of hypothesis testing of $\lambda_i = 0$ vs. $\lambda_i \neq 0$ can be obtained from the third column in Table 3. It is obvious that, with incorporation of demographic variables, the explanatory power of the QAIDS has been diluted since none of the five *λ's* is statistically different from zero according to the Wald test. We also find that the QAIDS can be reduced to the AIDS in two food items (beef and mutton, and aquatic products) since the *λ's* are not statistically important when incorporating demographic variables. This may be because the effect of demographic variables on budget share dominates the effect of the quadratic term in the model.

The elasticities, including expenditure as well as Marshallian and Hicksian price elasticities, are presented in Table 6. These elasticities are calculated excluding demographic effects in order to make a comparison with those presented in Table 4. The expenditure elasticities still have an expected positive sign but the range narrowed from 0.839 (for eggs) to 1.105 (for aquatic products). Several of them are close to unity, such as pork, beef and mutton, and poultry. All the Marshallian own-price elasticities have a correct sign and range from -1.042 (for pork) to -0.884 (for aquatic products). Again, most of them are close to unity (-1.0). From the Hicksian price elasticities, meat items are substitutes except between beef and poultry as complements, which may be difficult to rationalize. A comparison of elasticities in Tables 4 and 6 shows that, with incorporation of demographic variables, most of the expenditure and own-price elasticities in Table 6 move towards unity (either 1.0 for expenditure elasticities or -1.0 for own-price elasticities) compared with those in Table 4 whereas cross-price elasticities move towards zero.

4.4 Censored Demand System

It is necessary to consider the zero-consumption problem since micro household data are employed in this study. As to meat consumption in urban China, the most serious zero consumption problems occurred in beef and mutton, as 20.7% of households with zero consumption. Hence, it is important to improve estimation by considering a censored demand system. The two-step estimation procedure proposed by Shonkwiler and Yen (1999) is adopted in this study.

Shonkwiler and Yen's procedure consists of two steps. In the first step, the Probit models in single equation are estimated using LIMDEP 7.0 econometric software in order to compute the probability and cumulative density values for beef and mutton with serious zero consumption problems.[8] In the second step, the censored QAIDS models are estimated. Using the seemingly unrelated regressor (SUR), the parameter estimates are summarized in Table 7.

From Table 7, the additional information from the probability values in the first step improves the fit of the QAIDS model to the Chinese urban household data. The corresponding parameter, $\varphi 2$, in BM equation is statistically different from zero at the 0.001 significance level, indicating an important improvement to the fitted models. Those parameter estimates corresponding to demographic variables are of significant interest to this study. Generally, the effects of demographic variables are similar with or without censoring. Age of household head, regional differences, and ownership of a refrigerator are the most influential factors. For example, the parameter estimates of age are significantly different from zero, including pork, beef and mutton, and eggs. The parameter estimates of the ownership of a refrigerator on beef and mutton (0.014) is significant. Among the demographic variables, the most notable impacts are regional differences. This conclusion is similar to the previous analysis. The food consumption patterns between Guangdong and Shandong are statistically different for poultry and the parameter estimates of the dummy variable for Jiangsu, which indicates the difference between Jiangsu and Guangdong, are statistically different from zero for poultry, and beef and mutton.

The last column of Table 3 presents the Wald tests of $\lambda_i = 0$ vs. $\lambda_i \neq 0$ in the censored QAIDS with incorporation of demographic variables. Again, the purpose is to investigate whether the quadratic term of log income is important. Not surprisingly, none of the parameter estimates is statistically different from zero using the Wald test. This finding shows that most of the budget shares are linear in log income.

The elasticity estimates are presented in Table 8. These elasticities with censoring are slightly different from those without censoring. It should be noted again that these elasticities are calculated without considering demographic effects, which are set to zero. Expenditure elasticities range from 0.81 (poultry) to 1.13 (aquatic products), which is slightly wider compared to those from Table 5.10. Most of the expenditure elasticities are close to unity. Own-price elasticities, either Marshallian or Hicksian, have a correct sign. In addition, most of the Marshallian own-price elasticities are close to unity, ranging from -0.838 (aquatic products) to -1.010 (beef and mutton). Hicksian own-price elasticities are below unity, ranging from -0.945 (beef and mutton) to -0.530 (pork). Cross-price elasticities, as expected, are smaller than own-price elasticities (in absolute values) and many of the cross-price elasticities are close to zero, meaning very small effects with respect to changes of other prices. In addition, the Hicksian cross-price elasticities indicate that these five meat items are net substitutes. This is slightly different compared with the results presented in Table 6.

5. Conclusion

This study attempts to capture heterogeneous consumption patterns using micro household data. The importance of incorporating demographic effects into a demand system is demonstrated using Lewbel's unified functions. Meat consumption data from urban China is employed to show the benefit of utilizing the translation and scaling of budget shares.

The empirical results show several interesting findings. The QAIDS is used to test the significance of the necessity of a quadratic term in log income. According to the Wald test results, the QAIDS is accepted as a preferable model to its linear counterpart, or the AIDS model; however, the importance of including the quadratic term decreases when demographic and censoring effects are considered. As for incorporation of demographic effects, the results show that these demographic variables have significant impacts on meat consumption. Specifically, regional differences are the most important factors in determining the heterogeneous consumption patterns among the three provinces in China. Therefore, China should be treated as several markets instead of one. The other significant demographic factor is the ownership of a refrigerator. The results imply that modernization plays an important role in changing meat consumption patterns. And finally, the ordinary budget share scaling and translation (OBSSAT), one of the unified approaches to incorporating demographic variables, provides us a potential answer to the question on "how to break down the heterogeneous consumption patterns in urban China?"

Table 1: Definitions and Descriptive Statistics of Variables in this Study
(Sample size: 2049)

Variable	Description	Sample Mean	Sample S.D. [a]
Dependent Variable			
W_1	Budget share for pork	0.444	(0.146)
W_2	Budget share for beef and mutton	0.061	(0.073)
W_3	Budget share for poultry	0.155	(0.102)
W_4	Budget share for eggs	0.171	(0.119)
W_5	Budget share for aquatic products	0.169	(0.112)
Explanatory Variable			
P_1	Price of pork (in Yuan/kg)	14.447	(3.398)
P_2	Price of beef and mutton (in Yuan/kg)	16.498	(4.937)
P_3	Price of poultry (in Yuan/kg)	14.779	(4.617)
P_4	Price of eggs (in Yuan/kg)	6.462	(1.153)
P_5	Price of aquatic products (in Yuan/kg)	14.584	(8.466)
X	Total expenditure of meat (in Yuan)	574.887	(331.615)
HS	Household size (in persons)	3.225	(0.785)
NC	Ratio of number of children to household size	0.212	(0.162)
INH	1 if high income household; 0 otherwise	0.200	(0.400)
INM	1 if middle income household; 0 otherwise	0.600	(0.490)
AGE	Age of household head (in years)	45.200	(10.744)
MALE	1 if male household head; 0 otherwise	0.652	(0.477)
EDH	1 if high education level; 0 otherwise	0.230	(0.421)
EDM	1 if middle education level; 0 otherwise	0.703	(0.457)
PR1	1 if Shandong; 0 otherwise	0.317	(0.466)
PR2	1 if Jiangsu; 0 otherwise	0.390	(0.488)
FR	1 if the ownership of refrigerator; 0 otherwise	0.874	(0.332)

[a] Standard deviations are in parentheses.

Table 2: Regression Results for the Engel Curve Analysis, 1998.

	Pork		Beef and Mutton		Poultry		Eggs		Aquatic Products	
Parameter	Coefficient	S.E. [a]	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
α	0.653**	(0.252)	-0.163	(0.099)	-0.009	(0.142)	-0.083	(0.117)	-0.257	(0.158)
β	-0.142*	(0.072)	0.052	(0.028)	0.029	(0.040)	0.051	(0.033)	0.054	(0.045)
γ	0.011*	(0.005)	-0.004	(0.002)	-0.002	(0.003)	-0.004	(0.002)	-0.002	(0.003)
δ_1 (HS)	0.005*	(0.002)	-0.0003	(0.0009)	-0.003*	(0.001)	-0.0009	(0.001)	0.003	(0.001)
δ_2 (NC)	-0.021	(0.013)	0.009	(0.005)	-0.002	(0.007)	-0.003	(0.006)	-0.006	(0.008)
δ_3 (INH)	-0.036***	(0.007)	-0.007**	(0.003)	-0.012**	(0.004)	-0.008*	(0.003)	0.007	(0.004)
δ_4 (INM)	-0.006	(0.005)	-0.003	(0.002)	0.001	(0.003)	-0.006**	(0.002)	0.009**	(0.003)
δ_5 (AGE)	-0.0001	(0.0002)	0.0001	(0.00008)	-0.0003*	(0.0001)	0.00005	(0.0001)	-0.0002	(0.0001)
δ_6 (MALE)	0.0001	(0.004)	0.002	(0.001)	0.003	(0.002)	0.003	(0.002)	-0.002	(0.002)
δ_7 (EDH)	-0.003	(0.008)	-0.002	(0.003)	-0.002	(0.004)	-0.006	(0.004)	0.006	(0.005)
δ_8 (EDM)	0.004	(0.007)	-0.002	(0.003)	-0.0008	(0.004)	-0.005	(0.003)	0.006	(0.004)
δ_9 (PR1)	-0.032***	(0.006)	0.004	(0.002)	-0.057***	(0.003)	0.060***	(0.003)	0.012**	(0.004)
δ_{10} (PR2)	-0.006	(0.005)	-0.013***	(0.002)	-0.037***	(0.003)	0.021***	(0.002)	0.034***	(0.003)
δ_{11} (FR)	-0.017**	(0.005)	0.007***	(0.002)	0.009**	(0.003)	-0.011***	(0.002)	0.005	(0.003)
Adj. R^2	0.0590		0.0615		0.2134		0.3999		0.1328	

*p<.05;**p<.01;***p<.001.

[a] Asymptotic standard errors are in parentheses.

Note: sample size= 2049.

Table 3: The Wald Test Results (with P-values)

(Sample size: 2049)

Test [a]	The QAIDS [b]	The QAIDS + D [c]	The QAIDS + D + C [d]
$\lambda_i = 0$ vs. $\lambda_i \neq 0$			
Pork	0.55 (0.4570)	1.10 (0.2949)	2.39 (0.1224)
Beef and Mutton	7.36 (0.0067)	1.42 (0.2337)	1.83 (0.1767)
Poultry	0.41 (0.5200)	0.43 (0.5101)	0.77 (0.3791)
Eggs	0.54 (0.4628)	0.03 (0.4628)	0.77 (0.7843)
Aquatic Products	10.52 (0.0012)	2.59 (0.1075)	2.24 (0.1341)

[a] P-values are in parentheses.

[b] The original QAIDS model without demographic and censoring effects.

[c] The QAIDS model with demographic variables.

[d] The censored QAIDS model with demographic variables.

Table 4: Expenditure and Price Elasticities of the QAIDS, 1998.

Marshallian						
Food			Price	of		Total
Item [a]	Pork	BM	Poultry	Eggs	AP	Expenditure
Pork	**-1.001**	0.107	0.068	-0.144	-0.091	1.060
BM	1.057	**-0.999**	-0.483	-0.335	0.039	0.722
Poultry	-0.007	-0.177	**-1.084**	0.230	-0.142	1.180
Eggs	0.039	-0.067	0.058	**-0.595**	0.060	0.504
AP	-0.415	-0.052	0.014	-0.119	**-0.706**	1.279

Hicksian					
Food			Price	of	
Item	Pork	BM	Poultry	Eggs	AP
Pork	**-0.530**	0.172	0.233	0.037	0.088
BM	1.378	**-0.955**	-0.371	-0.211	0.160
Poultry	0.517	-0.105	**-0.902**	0.432	0.057
Eggs	0.263	-0.036	0.137	**-0.509**	0.146
AP	0.153	0.026	0.212	0.099	**-0.490**

[a] BM =beef and mutton; AP = aquatic products.

Table 5: Parameter Estimates in the QAIDS Model with Demographic Variables, 1998.
(Sample Size: 2,049)

Parameter	Coeff.	S.E. [a]	Parameter	Coeff.	S.E. [a]	Parameter	Coeff.	S.E. [a]
α1	0.379***	(0.065)	λ1	-0.005	(0.005)	γ2,2	-0.001	(0.004)
α2	-0.030	(0.051)	λ2	-0.004	(0.003)	γ2,3	-0.010	(0.010)
α3	0.264***	(0.038)	λ3	0.002	(0.003)	γ2,4	-0.003	(0.004)
α4	0.236***	(0.060)	λ4	-0.0003	(0.002)	γ3,3	0.008	(0.009)
β1	0.039	(0.033)	γ1,1	-0.020	(0.022)	γ3,4	-0.002	(0.003)
β2	0.032	(0.025)	γ1,2	0.014	(0.015)	γ4,4	0.002	(0.005)
β3	-0.008	(0.019)	γ1,3	0.003	(0.005)			
β4	-0.025	(0.017)	γ1,4	0.013	(0.014)			

	Pork		Beef and Mutton		Poultry		Eggs		Aquatic Products	
	Coeff.	S.E. [a]	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
HS	0.025	(0.027)	0.002	(0.003)	0.003	(0.016)	0.002	(0.009)	0.006	(0.009)
NC	-0.306	(0.269)	-0.005	(0.032)	-0.163	(0.157)	-0.090	(0.086)	-0.090	(0.087)
INH	-0.311	(0.211)	-0.035	(0.024)	-0.187	(0.122)	-0.099	(0.068)	-0.048	(0.064)
INM	-0.373	(0.229)	-0.039	(0.025)	-0.219	(0.132)	-0.125	(0.074)	-0.085	(0.068)
AGE	0.004	(0.002)	0.0005	(0.0003)	0.002	(0.001)	0.001*	(0.0007)	0.001	(0.0007)
MALE	0.038	(0.047)	0.006	(0.006)	0.031	(0.029)	0.020	(0.015)	0.011	(0.016)
EDH	0.105	(0.113)	0.010	(0.014)	0.059	(0.067)	0.014	(0.034)	0.040	(0.032)
EDM	-0.040	(0.136)	-0.010	(0.017)	-0.034	(0.081)	-0.030	(0.041)	-0.008	(0.037)
PR1	-0.203	(0.132)	0.009	(0.017)	-0.226	(0.078)	0.127**	(0.043)	-0.063	(0.041)
PR2	-0.367	(0.232)	-0.061*	(0.028)	-0.301*	(0.136)	-0.038	(0.075)	-0.068	(0.070)
FR	0.044	(0.077)	0.026*	(0.009)	0.057	(0.046)	-0.016	(0.025)	0.030	(0.023)

*p<.05;**p<.01;***p<.001.

[a] Asymptotic standard errors are in parentheses.

[b] HS=household size; NC= Ratio of number of children to household size; INH= 1 if high income household; 0 otherwise; and INM= 1 if middle income household; 0 otherwise. AGE=age of household head; MALE= 1 if male household head; 0 otherwise; EDH= 1 if high education level; 0 otherwise; and EDM= 1 if middle education level; 0 otherwise. PR1= 1 if Shandong; 0 otherwise; PR2= 1 if Jiangsu; 0 otherwise; FR= 1 if the ownership of refrigerator; 0 otherwise.

Table 6: Expenditure and Price Elasticities of the QAIDS with Demographic Variables, 1998.

Marshallian

Food Item [a]	Price of Pork	Price of BM	Price of Poultry	Price of Eggs	Price of AP	Total Expenditure
Pork	**-1.042**	0.037	0.005	0.025	-0.030	1.006
BM	0.260	**-0.986**	-0.175	-0.080	-0.044	1.023
Poultry	0.004	-0.069	**-0.958**	-0.018	0.003	1.038
Eggs	0.127	-0.019	0.029	**-0.953**	-0.024	0.839
AP	-0.117	-0.020	-0.017	-0.067	**-0.884**	1.105

Hicksian

Food Item	Price of Pork	Price of BM	Price of Poultry	Price of Eggs	Price of AP
Pork	**-0.595**	0.098	0.161	0.196	0.139
BM	0.715	**-0.923**	-0.016	0.095	0.129
Poultry	0.465	-0.005	**-0.798**	0.159	0.179
Eggs	0.500	0.033	0.159	**-0.809**	0.118
AP	0.374	0.048	0.154	0.122	**-0.697**

[a] BM =beef and mutton; AP = aquatic products.

Table 7: Parameter Estimates for the Censored QAIDS, 1998.

(Sample Size: 2,049)

Parameter	Coeff.	S.E. [a]	Parameter	Coeff.	S.E. [a]	Parameter	Coeff.	S.E. [a]
α1	0.324***	(0.084)	λ1	-0.010	(0.007)	γ1,5	0.020	(0.022)
α2	0.034***	(0.008)	λ2	0.0009	(0.0006)	γ2,2	-0.0006	(0.0008)
α3	0.263***	(0.044)	λ3	0.003	(0.003)	γ2,3	-0.0002	(0.0006)
α4	0.245***	(0.074)	λ4	-0.0009	(0.003)	γ2,4	-0.002	(0.002)
β1	0.077	(0.049)	**φ2**	**0.038*** **	**(0.001)**	γ3,3	0.014	(0.015)
β2	-0.002	(0.003)	γ1,2	0.0002	(0.013)	γ3,4	-0.008	(0.008)
β3	-0.014	(0.023)	γ1,3	0.002	(0.003)	γ4,4	0.003	(0.007)
β4	-0.026	(0.026)	γ1,4	-0.007	(0.009)			

	Pork		Beef and Mutton		Poultry		Eggs		Aquatic Products	
	Coeff.	S.E. [a]	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
HS	0.018	(0.027)	0.003	(0.003)	0.0007	(0.016)	0.0005	(0.008)	0.005	(0.008)
NC	-0.088	(0.177)	0.013	(0.018)	-0.036	(0.109)	-0.027	(0.054)	-0.027	(0.056)
INH	-0.152	(0.126)	-0.015	(0.013)	-0.096	(0.076)	-0.049	(0.039)	-0.008	(0.038)
INM	-0.177	(0.122)	-0.017	(0.012)	-0.106	(0.074)	-0.064	(0.038)	-0.033	(0.035)
AGE	0.004*	(0.002)	0.0006**	(0.0002)	0.002	(0.001)	0.002*	(0.0006)	0.001	(0.0006)
MALE	0.076	(0.060)	0.011	(0.006)	0.054	(0.036)	0.031	(0.018)	0.023	(0.018)
EDH	0.052	(0.101)	-0.005	(0.010)	0.024	(0.061)	-0.003	(0.030)	0.022	(0.029)
EDM	0.055	(0.093)	-0.003	(0.009)	0.023	(0.055)	-0.003	(0.028)	0.019	(0.026)
PR1	-0.322	(0.208)	-0.033	(0.021)	-0.315*	(0.124)	0.087	(0.063)	-0.098	(0.060)
PR2	-0.528	(0.310)	-0.079*	(0.031)	-0.403*	(0.185)	-0.085	(0.093)	-0.113	(0.091)
FR	0.007	(0.060)	0.014*	(0.006)	0.036	(0.036)	-0.025	(0.019)	0.019	(0.018)

*p<.05;**p<.01;***p<.001.

[a] Asymptotic standard errors are in parentheses.

[b] HS=household size; NC= Ratio of number of children to household size; INH= 1 if high income household; 0 otherwise; and INM= 1 if middle income household; 0 otherwise. AGE=age of household head; MALE= 1 if male household head; 0 otherwise; EDH= 1 if high education level; 0 otherwise; and EDM= 1 if middle education level; 0 otherwise. PR1= 1 if Shandong; 0 otherwise; PR2= 1 if Jiangsu; 0 otherwise; FR= 1 if the ownership of refrigerator; 0 otherwise.

Table 8: Expenditure and Price Elasticities, Censored QAIDS, 1998.

Marshallian						
Food			Price	of		Total
Item [a]	Pork	BM	Poultry	Eggs	AP	Expenditure
Pork	**-0.972**	0.005	-0.019	0.038	-0.047	0.995
BM	0.009	**-1.010**	-0.020	-0.037	-0.004	1.062
Poultry	-0.075	-0.003	**-0.920**	-0.054	-0.001	1.054
Eggs	0.156	-0.003	0.016	**-0.944**	-0.035	0.810
AP	-0.166	-0.003	-0.031	-0.091	**-0.838**	1.128

Hicksian					
Food			Price	of	
Item	Pork	BM	Poultry	Eggs	AP
Pork	**-0.530**	0.066	0.135	0.208	0.121
BM	0.481	**-0.945**	0.144	0.145	0.175
Poultry	0.393	0.061	**-0.757**	0.126	0.177
Eggs	0.516	0.046	0.142	**-0.805**	0.101
AP	0.336	0.066	0.144	0.101	**-0.647**

Endnotes

[1] See more restrictions in Lewbel (1985, p.10).

[2] A violation of $r_j \geq 0$ may happen in empirical studies.

[3] In the Extended Gorman (Bollino et al., 2000) w_i is a function of w_j* (i.e., not independent from w_j*.)

[4] The AIDS model is introduced by Deaton and Muellbauer (1980b).

[5] A test of quadratic terms will be executed in the following sections in order to investigate the impact of other effects on the importance of quadratic terms in the QAIDS.

[6] In this section, the analysis of parameter estimates of demographic variables is not offered due to the present focus on expenditure variable. Analyses of demographic variables will be conducted starting in Section 4.2.

[7] The parameter estimates for the model are not presented here but are available upon request from the authors of this paper.

[8] The results are available from the authors upon request.

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