Food Processing Degrees: Evidence from Beijing Household Survey

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1. Introduction

In the past 30 years, China has become one of the fastest growing economies with an approximate 8 percent growth rate yearly. Because of the largest population (1.3 billion) and fast-growing economy, Chinese consumption market attracts special attention from all over the world. Since food plays a central role in the life of Chinese households, understanding food consumption patterns in China is essential to large agricultural goods producers and exporters, such as the United States.

Pictures of food consumption are significantly different between the rural and urban areas in China, where people in rural areas consume more semi-processed or ready-to-eat food. In many urban areas, 30 percent of total food consumed is processed, while this number is lower than 20 percent in most rural areas. According to RNCOS' 2010 report "Chinese Processed Food Market Analysis", during the tough economic conditions, the consumption of processed food grew at double digit rate. At the end of 2009, the sales of processed food reached an estimated value of RMB 4.5 Trillion (approximately USD 660 billion). Taking our survey as an example, almost half (49.5 percent) of the food expenditure at home goes to semi-processed and ready-to-eat products, where ready-to-eat food accounts for 42 percent in total food expenditure at home. There has been a remarkable growth in the market for processed food in China, which is driven by higher concentration of wealth and busy lifestyle of people living in urban China. Especially in metropolitan cities such as Beijing and Shanghai, processed food is perhaps the most convenient option for people. With nearly 88% of urban households having refrigerators, compared to only 16% in rural households, the urban market is ready for foods that need refrigeration.

The present study focus on the household food consumption behavior by processing degrees using a data set collected in the "Beijing Households Food Consumption Survey" in July, 2007. It contributes to the current studies which mainly examine the aggregate food consumption in rural areas of China. It specifically describes consumption expenditure patterns and estimates expenditure and price elasticities of various food groups by processing degrees (raw products, semi-processed, and ready-to-eat) in Beijing.

The rest of this article is organized as follows. Section II reviews previous studies on household food demand in China. Then, Section III describes the data set we are using in this study. Section IV specifies the modeling framework. Section V shows the estimation results and a conclusion is drawn in Section VI.

2. Chinese Household Food Demand Studies

Richard Stone (1954) first estimated a practical system of demand equations derived explicitly from consumer theory, which possess properties usually considered desirable from the standpoint of elementary economic theory. He also applies this system to annual data relating to the UK consumer’s goods over the years 1920-38. And ever since, many models have been proposed, the most important in current use are the Rotterdam model (Theil, 1965, 1976; Barten, 1969), the translog model (Christensen, et al. 1975; Jorgenson and Lau, 1975), and AIDS model (Deaton and Muellbauer, 1980).

Theil (1965) approaches demand analysis in a probabilistic manner. He consideres the value share (the proportion of total expenditure spent on a particular commodity) as a probability in view of the fact that it is non-negative and adds up to one when summed over all commodities. Partly in the light of information theory, he formulizes the price and quantity indices and demand equations.

Christensen, et al. (1975) first develop tests of the demand theory that do not employ additivity or homotheticity as part of the maintained hypothesis, by introducing a new form of utility function: transcendental logarithmic. For either the direct or the indirect series of tests, they conclude that the theory of demand is inconsistent, which confirms the findings of Wold for the double logarithmic demand system and Barten for the Rotterdam demand system.

These two models had been extensively estimated and had been used to test the homogeneity and symmetry restrictions of demand theory before Deaton and Muellbauer (1980) proposed a new model which is of comparable generality to the Rotterdam and translog models but has considerable advantages over both. They call this new model the Almost Ideal Demand System (AIDS). It gives an arbitrary first order approximation to any demand system, satisfies the axioms of choice exactly, aggregates perfectly over consumers without invoking parallel linear Engel curves, has a functional form which is consistent with known household-budget data, is simple to estimate, largely avoiding the need for nonlinear estimation, and can be used to test restrictions of homegeneity and symmetry through linear restrictions on fixed parameters. In their model, the budget shares of the various commodities are linearly related to the logarithm of real total expenditure and the logarithms of relative prices. Based on postwar British data, this model is capable of explaining a high proportion of the variance of the commodity budget shares buy, unless allowance is made for omitted variables by the arbitrary use of time trends, does so in a way which is inconsistent with the hypothesis of consumers making decisions according to the model's demand functions governed by the conventional static budget constraint.

Since then, a variety of approaches have been used to calculate demand elasticities in AIDS models of demand, such as Linearized AIDS, Linear Approximate AIDS (LA/AIDS), Two-stage Linear Expenditure System AIDS (Two-stage LES-AIDS). In these alternatives of AIDS, it is common to use the Stone share weighted price index which can simplify the estimation process.

A lot of studies have investigated food consumption using the AIDS models in China since 1990s, especially in rural areas.

Halbrendt, et al. (1994) analyzes Chinese consumer behavior using consumption survey data from the rural province of Guangdong. In their study, nine commodity expenditure share equations were estimated with an extended AIDS model including socioeconomic and other demographic variables by using Zellner's ITSUR (Iterative Seemingly Unrelated Regression) procedure with adding-up, homogeneity, and symmetry restrictions imposed. They find that own-price elasticities of most food items are inelastic, and except for grains, there is very little commodity substitution when relative prices change. Moreover, the commodities most responsive to expenditure fluctuations are meats, poultry, fruits, sweets, “other goods”, and durable goods.

Fan, et al. (1995) estimate a complete demand system of Chinese rural households with special emphasis on the food commodity group. using two-stage LES-AIDS model, based on provincial and time-series data from 1982 to 1990. The study shows that for most commodity groups, demand is price inelastic. Most food items have elasticities ranging from -0,005 to -0,63. Although it is less than 1, the food expenditure elasticity is still high at 0.70. And expenditure elasticities are lower for grains and higher for meat, tobacco, and alcohol. The results imply a gap between food demand and supply growth and pressure to import food.

Gao, et al. (1996) evaluate economic and demographic effects on China’s rural household demand in Jinagsu Province for nine food commodities and five non-food commodity groups. In this study, a two-stage budgeting allocation procedure is used to obtain an empirically tractable amalgamative demand system for food commodities which combines an upper-level AIDS model and a lower-level GLES (Generalized LES) as a modeling framework. The results indicate that the slow growth of food consumption in China during the latter half of the 1980s is a result of income stagnation rather than consumption saturation. And growth in the demand for better food and shelter by Chinese rural households will continue to be a major concern.

Jiang and Davis (2007) explores rural household food consumption behavior in China using a large household data set from Jilin Province. They estimate a household demand system, incorporating four households characteristics (number of people in the household, children aged between 0-11 years, children aged between 12-17 years and education, measured as the proportion of household labor educated to at least junior middle school level), and using an LA-AIDS, assuming a three-stage budget procedure. Expenditure elasticities for a range of food groups are estimated, with a particular focus on animal products.

All the four paper above concerning Chinese household consumption behavior (both food and non-food commodities) are looking at the different rural areas in China, mainly by province and using AIDS model or its alternatives. Some studies use other theoretical frameworks to analyze the Chinese household food consumption.

Dietrich (2008) examines income and food consumption patterns within Chinese households to test the assumptions and predictions of two competing models of consumer demand, the Neo-Classical unitary model and a class of bargaining models. Four standard tests (price homogeneity, symmetry of the Slutsky matrix, negative semi-definiteness of the Slutsky matrix, and individual income as an exclusion restriction) of the Neo-classical model are conducted, and two other tests (symmetry plus rank k test of the Slutsky matrix and distribution factor linearity) examining characteristics of the bargaining model specifications are also conducted. He finds that each of the assumptions and predictions of the Neo-classical unitary model are rejected by the data, similar to many other studies. The two tests on bargaining models more accurately describe households' decision-making processes, and the result suggests that multiple individuals within the household influence decisions, instead of households acting as one decision-making unit.

3. Data

The data we are using in present study was collected in July, 2007 from "Beijing Households Food Consumption Survey", covering a total of 315 households in Beijing City. The survey covers a period of seven days in a week (July 8 – July 14), and records all the detailed food consumption by meals (breakfast, lunch, and dinner). The sampling is conducted in a two-stage systematic way with a random start. First of all, we got access to the large households sample used by the Beijing Statistical Bureau in 2000 census, and then we did subsampling from this sample in a random manner. Then the households selected were contacted by our inspectors in person so they would have an instruction session before the survey started. At the end of survey, each household in the survey got a RMB 100 gift card as a reward. The food is categorized into 9 different groups: grain, meat, egg, seafood, vegetable, fruit, dairy, drink, and bean. Household maintained the logbooks that separately record food consumption-in both volume and value terms-in the 9 different food groups by meals in the one-week period. They were also asked to record the processed degrees of food (raw product, semi-processed, and ready-to-eat), and whether the food was consumed at home or away from home. As for our study, we focus on the food at home (FAH). The household demographics were also collected.

Table 1 shows a statistical summary of the household demographics and food consumption by categories.

From this table, meat product accounts for the largest part (32.4%) of food consumption in total expenditure term among the 9 groups. Grain and vegetables account on average for 12.6% and 13.2%, respectively. Other groups of food are all lower than 10%. The results of Beijing household food consumption show a significant difference from the previous studies on Chinese rural household food consumption. Jiang and Davis (2007) found that grain was the largest item accounting for 45% of the total food budget followed by meat products at 14% and vegetables at about 10% (Jiang, 2001), according to the rural household survey in Jilin province from 1991 to 1995. Halbrendt, et al. (1994) also showed that grain accounted for the largest share of the food budget, which was 31.3%, followed by meat products at 26.1% and vegetables at 15.9%. So the survey data shows us a different food consumption pattern in Beijing households.

4. Model Framework

In this empirical analysis, we apply the two-stage budgeting procedure and the Quadratic Almost Ideal Demand System (QUAIDS model) on the household food consumption by processed degrees in Beijing.

When estimating a complete system of demand equations, a common problem is that there are too many variables relative to the number of observations available for estimation. In the case of this study, we have three different food processed degrees (raw, semi-processed, and ready-to-eat), and nine categories of food, which would increase the number of parameters exponentially and make the estimation extremely difficult, but not impossible, to implement. One solution to this problem is the two-stage budgeting procedure. This procedure assumes that the consumer's utility maximization decision can be decomposed into two separate steps. In the first stage, total expenditure is allocated across broad groups of expenditures using a linear expenditure system (LES). The advantage of the LES is that it is parsimonious specification that provides an intuitive economic interpretation, albeit it incorporates relatively strong separability assumptions. Since our survey only includes the food consumption over a seven-day time period, our first stage in the two-stage budgeting procedure is to allocate total food expenditure across groups of food by three processed degrees. In the second stage, group expenditures are allocated over nine categories of food by using the QUAIDS model. Weak separability of the direct utility function over broad groups of food is both a necessary and sufficient condition for estimating the second stage of the two-stage budgeting procedure.

The general LES specification representing expenditure on groups by processed degrees is given by

$$P_I Q_I = P_I R_I + B_I \left[Y - \sum_J P_J R_J \right]$$

The LES functional form includes parameter constraints $0 < \beta_I < 1, \sum_I \beta_I = 1$, and $Q_J > R_J$, where $P_I Q_I$ is the expenditure on group I (P_I and Q_I are aggregated price and quantity indices for commodities within group I), R_I and B_I are parameters and Y is the total household food expenditure.

The uncompensated own-price elasticities is

$$\eta_{II} = (1 - B_I) P_I R_I / (P_I Q_I) - 1$$

The expenditure elasticities are

$$\varepsilon_I = B_I Y / (P_I Q_I)$$

Deaton and Meullbauer (1980) first combined the translog and Rotterdam models into the Almost Ideal Demand System (AIDS) that incorporate the best properties of the two, including approximating any demand system arbitrarily to first-order, aggregating perfectly over consumers, satisfying the axioms of choice and capable of test the restrictions of homogeneity and Slutsky symmetry. Since then, the AIDS model has arguably become the most widely used system approach for modeling consumption behavior for grouped commodities. The AIDS model has budget shares that are linear functions of log total expenditure

$$w_i = \alpha_i + \beta_i \log \left(\frac{Y}{P} \right) + \sum_j \gamma_{ij} \log P_j \qquad (1)$$

where,

w_i is the household budget share on the *i*th commodity;

$\alpha_i, \beta_i, \gamma_{ij}$ are the parameters of the system; and

$$\gamma_{ij} = \frac{1}{2}(\gamma^*_{ij} + \gamma^*_{ji}) \qquad (2)$$

Y is the total household income or expenditure;

P_j is the price of the *j*th commodity;

Y/P is the "real" expenditure; and in the LA-AIDS (Linear Approximate AIDS) model, P is the Stone Price Index given by

$$\log P = \sum_i w_i \log P_i \qquad (3)$$

where,

i is the *i*th commodity group;

w_i is the expenditure share of the *i*th commodity group;

P_i is the aggregate price for the *i*th commodity group.

However, the AIDS model has difficulty capturing the effects of non-linear Engel curves, as observed in various empirical demand studies. There is growing body of literature providing evidence on the importance of allowing for nonlinearity in the budget share equations (Lewbel, 1991; Banks *et al*., 1997). In order to maintain the attractive properties of AIDS model, while maintaining consistency with both Engel curve and relative price effects within a utility framework (Lewbel, 1997), a quadratic term in log income is added to AIDS model and leads to the Quadratic AIDS (QUAIDS) model specification (Banks *et al*. 1997), which has budget shares that are quadratic in log total expenditure. Increased flexibility of the demand system representation is thus achieved in a parsimonious way through the addition of the quadratic term.

Gorman (1981) proved that for demand models, the generalized linear form of rank two (where rank is the maximum dimension of the function space spanned by the Engel curves of the demand system; see Lewbel, 1991) is a necessary and sufficient condition for aggregate demands to resemble representative agent models in certain ways. Most locally flexible demand systems have rank two or less and are linear in the log of total expenditure. The QUAIDS model has rank three, and can better approximate non-linear Engel curves in empirical analysis (Xi, *et al*., 2004). Since a QUAIDS model produces a considerably larger regular region than locally flexible forms, it can be classified as effectively globally regular, where corresponding utility and indirect functions, and cost functions satisfy their theoretical properties for all non-negative demand, price and all utility levels as appropriate.

However, serious methodological challenges are presented by the many zero observations common in household survey data. When using household-level data in examining consumer's food demand it is common to find that consumers consume only a subset of the available goods, leaving observed demand for some of the goods to be zero.

Ignoring such censoring of the dependent variables in the estimation can lead to biased parameter estimates. The bias in the parameters estimates resulting from the use of only positive consumption values when there are many zero observations is a common result. There exist a number of estimation procedures that handle this censoring problem (Wales and Woodland, 1983; Lee and Pitt, 1986). They uses a Kuhn-Tucker model that treats zero consumption as a corner solution of a consumer's utility maximization problem. The second is a statistical approach, which proceeds by assuming all interior solution but uses a truncated distribution for random disturbance to correct for any zero consumption. With the difficulty of evaluating multiple integrals in the likelihood function, maximum likelihood estimation in the second approach is not widely used. Instead, a two-step procedure is commonly used. Heien and Wessels (1990) proposed a two-step procedure wehre the estimating model is augmented with a "Mills ratio" regressor to account for the bias in the estimates. They used an augmented AIDS model. However, the model by Heien and Wessels was shown to lack proper interaction of the censoring rule and the mean of the latent variable.

In this paper, we propose a Bayesian procedure for estimating a censored demand system using an QUAIDS model following the method discussed by Ishdorj and Jensen (2008). Estimating an QUAIDS model with a Bayesian approach avoids the need to evaluate the multiple probability integrals. The marginal distribution of model parameters and latent shares are simulated by numerical methods. Specifically, we fit the model using the Gibbs sampler. Implementation of the Gibbs sampler involves deriving and then iteratively simulating from the conditional posterior distribution of the model parameters.

The QUAIDS model can be expressed in the latent expenditure share form as:

$$w_{ih}^{*} = \alpha_i + \sum_{j=1}^{n+1} \gamma_{ij} \ln p_{jh} + \beta_i \ln(Y_h/P_h) + \frac{\lambda_i}{\prod_1^{n+1} {p_i}^{\beta_i}} \{\ln(Y_h/P_h)\}^2 + \varepsilon_{ih}$$

$i, j = 1, \cdots, n+1, h = 1, \cdots, H$ (1) and

$$w_{ih} = \begin{cases} w_{ih}^{*}, & if\ w_{ih}^{*} > 0 \\ 0, & if\ w_{ih}^{*} \leq 0 \end{cases} \quad (2)$$

where, w_{ih}^{*} and w_{ih} are latent and observed expenditure shares, respectively, if good i of household h, p_{jh} is the price of the jth good, Y_h represents total expenditure on n goods and P_h is a price index defined as:

$$\ln P_h = \alpha_0 + \sum_{1}^{n+1} \alpha_i \ln p_{ih} + \frac{1}{2} \sum_{i=1}^{n+1} \sum_{j=1}^{n+1} \gamma_{ij} \ln p_{ih} \ln p_{jh}$$

The theoretical properties of adding-up, homogeneity and symmetry can be imposed by following parameter restriction

$$\sum_{i=1}^{n+1} \alpha_i = 1, \sum_{i=1}^{n+1} \gamma_{ij} = \sum_{i=1}^{n+1} \beta_i = 0\,; \quad (4)$$

$$\sum_j \gamma_{ij} = 0; \quad (5)$$

$$\gamma_{ij} = \gamma_{ji}; \quad (6)$$

$i \neq j, i, j = 1, \cdots, n+1.$

Provided (4), (5), and (6) hold, equation (1) represents a system of demand functions which add up to total expenditure ($\sum w_i = 1$) are homogeneous of degree of zero in prices and total expenditure taken together, and which satisfy Slutsky symmetry. In our case, we assume Y is the total food expenditure. And we have 9 groups of food commodities as mentioned above. So for each day, we have a set of observation covering the aggregate price and aggregate consumption for each group of food.

For household h we can express a system of equations, one equation for each good $i = 1, \cdots, n+1$ as

$$\begin{bmatrix} w_{1h}^* \\ w_{2h}^* \\ \vdots \\ w_{(n+1)h}^* \end{bmatrix} = \begin{bmatrix} x'_{1h} & 0 & \cdots & 0 \\ 0 & x'_{2h} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & x'_{(n+1)h} \end{bmatrix} \begin{bmatrix} \theta_1 \\ \theta_2 \\ \vdots \\ \theta_{(n+1)} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1h} \\ \varepsilon_{2h} \\ \vdots \\ \varepsilon_{(n+1)h} \end{bmatrix} \tag{7}$$

where $x'_{ih} = \left[1, z'_{ih}, \ln p_{1h}, \cdots, \ln p_{(n+1)h}, \ \ln(Y_h/P_h), \ \{\ln(Y_h/P_h)\}^2\right]$ is a $1 \times k$ vector and $\theta_i = [\alpha_i \quad \delta'_i \quad \gamma_{i1} \quad \cdots \quad \gamma_{i(n+1)} \quad \beta_i \quad \lambda_i]'$ is a $k \times 1$ vector of parameters. For each household h system of equations (7) in stacked form can be rewritten as

$$w_h^* = X_h\theta + \varepsilon_h, h = 1, \cdots, H \tag{8}$$

where $w_h^* = [w_{1h}^* \quad w_{2h}^* \quad \cdots \quad w_{(n+1)h}^*]'$ and $\varepsilon_h = [\varepsilon_{1h} \quad \varepsilon_{2h} \quad \cdots \quad \varepsilon_{(n+1)h}]'$ i.i.d $N(0, \Sigma)$ are $(n+1) \times 1$ vectors, $X_h = diag(x'_{1h}, \cdots, x'_{(n+1)h})$ is an

$(n+1) \times (n+1)k$ matrix and $\theta = [\theta'_1 \quad \theta'_2 \quad \cdots \quad \theta'_{(n+1)}]'$ is an $(n+1)k \times 1$ vector of parameters. The AIDS model is a seemingly unrelated regression (SUR) model proposed by Zellner (1962) with the same regressors in each equation. QUAIDS model is an extension of the AIDS model. Since the expenditure shares are censored we follow Huang (2001) and estimate SUR Tobit model. Due to the specification of the QUAIDS model the variance matrix is singular. Hence n equations are used in the estimation and the parameters of the dropped equations are recovered from the QUAIDS adding-up, homogeneity and symmetry restrictions.

According to Alston, et al. (1994), the uncompensated own-price, and expenditure elasticities for this system are,

$$\xi_i = \frac{\Gamma_i}{w_i} + 1$$

where $\Gamma_i = \frac{\partial w_i}{\partial \ln (Y)} = \beta_i + \frac{2\lambda_i}{\prod_1^{n+1} p_i{}^{\beta_i}} \ln(Y/P)$

$$\pi_{ii} = \frac{\Gamma_{ii}}{w_i} \tag{4.15}$$

where $\Gamma_{ii} = \frac{\partial w_i}{\partial \ln (p_i)} = \gamma_{ij} - \xi_i\left[\alpha_i + \sum_{j=1}^{n} \ln (p_j)\right] - \frac{\lambda_i \beta_i}{\prod_1^{n+1} p_i{}^{\beta_i}} [\ln(Y/P)]^2$

As a matter of fact, a household would not always buy all categories of food in the one-week period, i.e. a proportion of expenditure on commodities may be at their censoring points. To derive the likelihood function with censoring, first note that, since we use n equations in the estimation, there would be 2^n possible combinations of commodities at their censoring points. Let us represent the 2^n possible combinations by the $2^n \times 1$ vector $S_r, r = 1,2,\cdots,2^n$, as

$$S_r = (\underbrace{0,0,\cdots,0}_{l}, \underbrace{+,+,\cdots,+}_{n-l})'$$

where "+" means the observed expenditure, i.e. the budget share, is positive and equals the desired expenditure, i.e. not censored; "0" implies the desired expenditure is non-positive so that any expenditure, i.e. the budget share, on that particular commodity cannot be observed.

Then the likelihood function of household h's budget share pattern falling in the S_r case can be given by

$$L_h^{S_r}(w_h; \theta, \Sigma) = \int_{-\infty}^{-x'_{1h}\theta_1} \cdots \int_{-\infty}^{-x'_{lh}\theta_l} L(w_h^*; \theta, \Sigma) dw_{lh}^* \cdots dw_{1h}^*$$

where

$$L(w_h^*; \theta, \Sigma) = (2\pi)^{-n/2} |\Sigma^{-1}|^{1/2} exp\left[-\frac{1}{2}(w_h^* - X_h\theta)'\Sigma^{-1}(w_h^* - X_h\theta)\right]$$

The likelihood function which accounts for all censoring combinations of the sample of H households is

$$L(W;\theta,\Sigma)=\prod_{h=1}^{H}\prod_{S_r}\left[L_h^{S_r}(w_h;\theta,\Sigma)\right]^{I_h(S_r)}$$

where $W=(w_1',w_2',\cdots,w_h')$ and $I_h(S_r)$ is an indicator function equal to 1 if household h is in the case S_r and 0 otherwise. It is clear that the likelihood function for all households is intractable, especially when the number of commodities or, equivalently, the number of regressions, n, becomes large.

The advance in the simulation-based approach, e.g. Markov Chain Monte Carlo, has inspired many empirical applications in a Bayesian framework. Among these, the Gibbs sampler, first introduces by Geman and Geman (1984), is an algorithm for generating random variates from an intractable marginal distribution indirectly from the full conditional distributions which are usually available in a simple form.

In general, direct sampling from a posterior distribution $\theta|W$ is commonly infeasible. However, assume that the full conditional distributions of the latent variable W^* along with the partitioned parameters θ are all available and in standard forms. Assume that the priors are independent and of the form

$$\theta\sim\mathbb{N}(\mu_\theta,V_\theta)$$

$$\Sigma^{-1}\sim W(\nu_0,\Omega)$$

where $\mathbb{N}$ denotes a multivariate normal distribution and W denotes a Wishart distribution (Ishdorj and Jensen, 2008). Assume we have a complete dataset y_h, $h=1,\cdots,H$, where the ith element equals w_{ih} if it is not censored and w_{ih}^* if it is censored. Given the assumed priors and the complete dataset $Y=(y_1',\cdots,y_H')$, the full conditional densities of θ and Σ^{-1} can be derived as

$$\theta|w^*,\Sigma^{-1}\sim\mathbb{N}_k(D_\theta d_\theta,D_\theta)$$

$$\Sigma^{-1}|w^*,\theta\sim W_i(\nu_1,R)$$

where

$$D_\theta = (X'(\Sigma^{-1} \otimes I_H)X + V_\theta^{-1})^{-1}$$

$$d_\theta = X'(\Sigma^{-1} \otimes I_H)Y + V_\theta^{-1}\mu_\theta$$

$$R = [\Omega^{-1} + (Y - X\theta)'(Y - X\theta)]^{-1}$$

and $\nu_1 = \nu_0 + H$.

The problem thus shrinks to the simulation of the censored data from a multivariate truncated normal distribution. For the purpose of illustration, the S_r case is still considered to illustrate the simulation procedure of the latent values. Note that, in this case, the first l dependent variables are censored at zero. As a result, we have to generate only censored data conditional on the realized values from the following truncated multivariate (l-dimensional) normal distribution

$$w_{ih}^* | w_{1h}^*, w_{2h}^*, \cdots, w_{(i-1)h}^*, w_{ih} = 0, w_{(i+1)h}, w_{nh}, \theta, \Sigma \sim TN_{(-\infty,0]}(\mu_{i|-i}, \sigma_{i|-i}^2)$$

where

$$\mu_{i|-i} = \mu_i + \Sigma_{i-i}' \Sigma_{-i-i}^{-1}(w_{-i}^* - \mu_{-i})$$

$$\sigma_{i|-i}^2 = \sigma_{ii}^2 + \Sigma_{i-i}' \Sigma_{-i-i}^{-1} \Sigma_{i-i}$$

where $TN_{(a,b]}(\mu, \sigma^2)$ denotes a normal distribution with mean μ and variance σ^2 truncated to the interval $(a, b]$. And $\mu = X_i\theta$, μ_i is the ith row element of μ and μ_{-i} is obtained by deleting the ith row element of μ. The matrix Σ_{-i-i} is the $(n-1) \times (n-1)$ matrix derived from Σ by eliminating the ith column and row, Σ_{i-i} is the $(n-1) \times 1$ vector derived from the ith column of Σ by removing the ith row term. By iterating the procedures, once convergence is reached, the Gibbs output is from the target distribution.

5. Results

Based on the LES parameter estimation, we are able to calculate the price and expenditure elasticities for food groups with different processed degrees (raw, semi-processed, and ready-to-eat). All the own-price elasticities are negative; however, the absolute value of the price elasticity for semi-processed food is smaller than those other two groups of food, which implies that the consumption of semi-processed food is more price inelastic than others. This also explains the trend that the consumption of processed food is increasing quickly in China, especially in large cities, like Beijing and Shanghai. The fast-paced life in these cities makes people consume more convenient food at home, such as semi-processed. Since Chinese people prefer hot food, ready-to-eat food is more consumed away from home but not at home. As for the expenditure elasticities in LES, they are all positive and very close to each other. With the rapid increase of household disposable income, the food consumption in China is also increasing, since food still accounts for a large percentage of total expenditure in the household.

According to the elasticity estimates from the QUAIDS model, there are some interesting findings that attract our attention.

1) First of all, the raw meat is more price-elastic than the semi-processed and processed meat. One reason would be that the raw meat is more difficult to prepare, and people would rather buy processed (or semi-processed) meat and cook them with other food, like vegetables and beans. This is pretty common in China at present time.
2) Second, the seafood is price-inelastic in all three processed degrees. Generally speaking, the seafood is more expensive than other meat, so the change in price of seafood will not induce a big change in consumption.
3) Third, the own-price elasticities of vegetables are very close to each other among the processed degrees. The fruit is price-elastic. Chinese household consume more and more fruits and vegetables so as to live on a healthy diet. The expenditure of fruits and vegetables in our survey account for almost one-fourth of the total food consumption. Considering the comparatively low price of fruits and vegetables, we can imagine that they are consumed in a pretty large amount. So the change in price may dramatically reduce the consumption of fruits and vegetables, compared to their large total consumption.

4) Now let's look at the expenditure elasticities. The expenditure elasticities for vegetables are all larger than those for meat, which also implies that people would like to consume more vegetables than meat if they spend more money on food. This also explains that Chinese households are looking to seek healthier eating habit by consuming more vegetables. The ready-to-eat fruits also have large expenditure elasticity, and they are also part of the healthy diet in Chinese households.
5) Most of the expenditure elasticities are greater than one, which implies that food still plays an important part in the daily life of Chinese households, and most categories of food exhibits more income-responsive market behavior.

6. Conclusion and Discussion

In this study, we use a two-stage LES-QUAIDS budgeting system to estimate demand parameters for household sampled in Beijing with special emphasis on food groups by different processed degrees.

Compared to the western world, China has a higher Engel coefficient, which implies that Chinese people generally spend more on food. So food is important in China and is part of the Chinese culture. On the other hand, the household disposable income has been increasing with fast growing economy since late 1970's, which also increase the consumption of food, both at home and away from home. However, life has never been tougher nowadays in the largest cities, such as Beijing and Shanghai. To save time and release the pressure people in these cities choose to consume more processed or semi-processed food, even if they are more expensive than raw food products.

Meanwhile, Chinese people have shown strong desire for healthy life, especially healthy diet. They tend to consume more vegetables, fruit, and dairy products with the increase of income. Meat is still the largest portion of expenses in food consumption. And we learn from empirical results that the raw meat is more price-elastic than the semi-processed and processed meat.

The demand for meat, vegetables, fruits, beans, dairy products and drink will continue to increase, and the demand for raw and processed seafood will also be likely to increase in the future. As for dairy products, food safety issue of domestic producers has forced people to choose foreign brands instead. Even with adjustments in production patterns, China is likely to continue import meat, beans, and dairy products.

Appendix: Tables and Figures

Table 1 Statistical Summary of Demographics and Food Consumption

Demographic Variable	N	Mean	Std Dev	Minimum	Maximum
Household Size	315	2.9492063	0.6561500	1.0000000	6.0000000
Total Monthly Disposal Income	315	5447.93	2777.15	900.0000000	24900.00
Per capita Monthly Disposal Income	315	1914.08	1079.15	300.0000000	10000.00
Expenditure Share of Food Consumption by Groups, aggregate level					
Meat	**32.4%**				
Vegetable	**13.2%**				
Grain	**12.6%**				
Seafood	**9.8%**				
Fruit	**9.1%**				
Drink	**8.0%**				
Dairy	**7.8%**				
Egg	**4.4%**				
Bean	**2.6%**				

Table 2 Summary Statistics by Food Category

Variable	N	Mean	Median	Minimum	Maximum	Range	Std Dev	Lower 95% CL for Mean	Upper 95% CL for Mean
household	315	159.2	160.0	1.0000	317.0	316.0	91.8843	149.0	169.4
total	315	206.7	182.1	30.5375	1344.8	1314.3	121.4	193.3	220.2
grain	315	26.1330	23.8550	2.3820	394.7	392.4	23.7480	23.5004	28.7657
meat	315	67.0860	58.7998	0	237.9	237.9	44.3983	62.1640	72.0079
egg	315	9.0716	6.8915	0	168.5	168.5	11.4267	7.8048	10.3383
seafood	315	20.2976	12.3500	0	272.4	272.4	25.4666	17.4744	23.1208
vegetable	315	27.1967	23.4700	1.8000	106.6	104.8	15.8268	25.4422	28.9512
fruit	315	18.8448	14.1600	0	78.9636	78.9636	17.1099	16.9481	20.7416
dairy	315	16.2198	10.4496	0	786.2	786.2	45.9708	11.1235	21.3161
drink	315	16.4398	10.4470	0	149.4	149.4	21.4665	14.0601	18.8196
bean	315	5.4551	3.6000	0	162.6	162.6	10.4652	4.2949	6.6152

Table 3 Summary Statistics by Processed Degrees

Variable	N	Mean	Median	Minimum	Maximum	Range	Std Dev	Lower 95% CL for Mean	Upper 95% CL for Mean
household	315	159.2	160.0	1.0000	317.0	316.0	91.8843	149.0	169.4
total	315	206.7	182.1	30.5375	1344.8	1314.3	121.4	193.3	220.2
raw	315	104.5	93.2105	3.3500	374.6	371.3	60.2052	97.8085	111.2
semi	315	15.4935	8.5150	0	181.3	181.3	22.3125	13.0199	17.9670
ready	315	86.7682	72.7241	0	968.7	968.7	76.8779	78.2456	95.2908

Table 4 Linear Expenditure System Estimates

Processed Degree	Parameter Estimates		Elasticities	
	B	R	Price	Expenditure
Raw	0.408(14.31)	12.655(15.58)	-0.523	0.812
Semi	0.076(4.67)	13.888(11.88)	-0.114	1.089
Ready	0.516(18.82)	10.387(10.59)	-0.691	1.118

Table 5 The Elasticity Estimates for Censored Demand System (QUAIDS)

Food Category	Own-price Elasticity			Expenditure Elasticity		
	Raw	Semi	Ready	Raw	Semi	Ready
Grain	-1.839	-1.630	-1.549	1.237	0.267	0.322
Meat	-1.618	-0.785	-0.653	1.300	0.807	1.017
Egg	-1.509	-0.910	-1.085	0.496	0.976	0.783
Seafood	-0.490	-0.371	-0.409	1.651	0.158	1.544
Vegetable	-0.800	-0.940	-1.112	1.396	2.139	1.897
Bean	-0.274	-0.594	-0.354	1.269	1.253	1.198
Fruit	-	-	-1.456	-	-	1.631
Dairy	-	-	-0.435	-	-	1.266
Drink	-	-	-0.964	-	-	1.103

Figure 1 Where the Food is Consumed

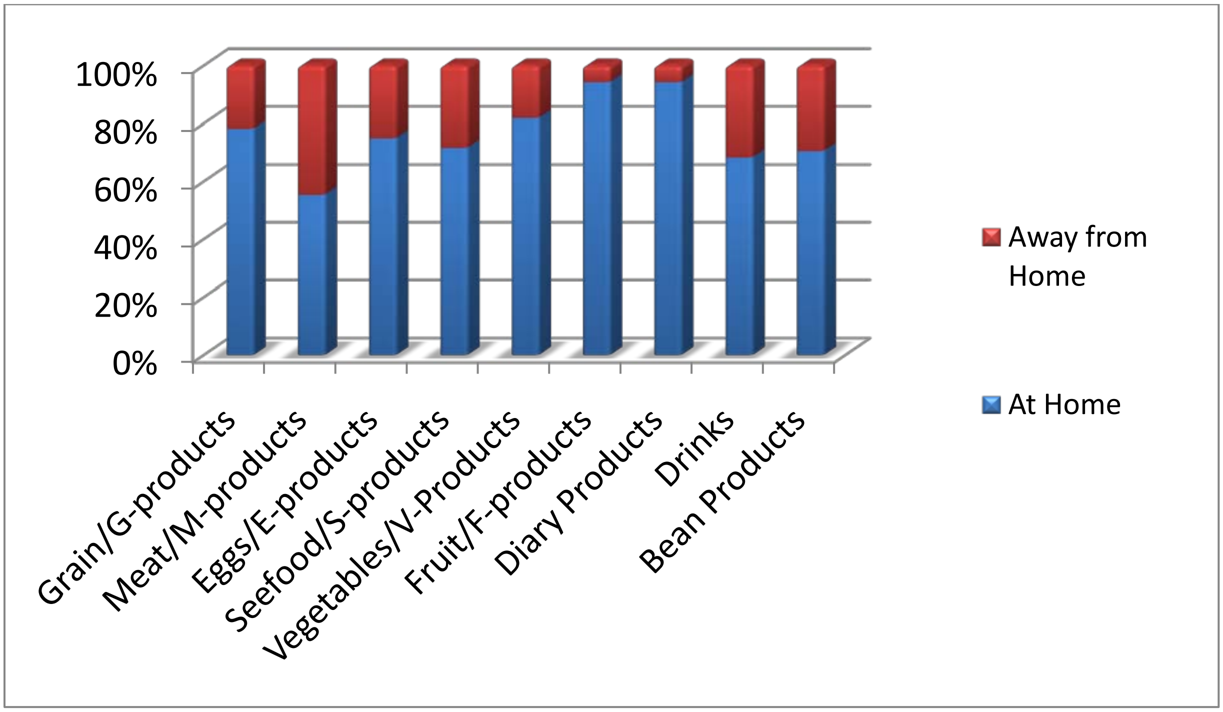
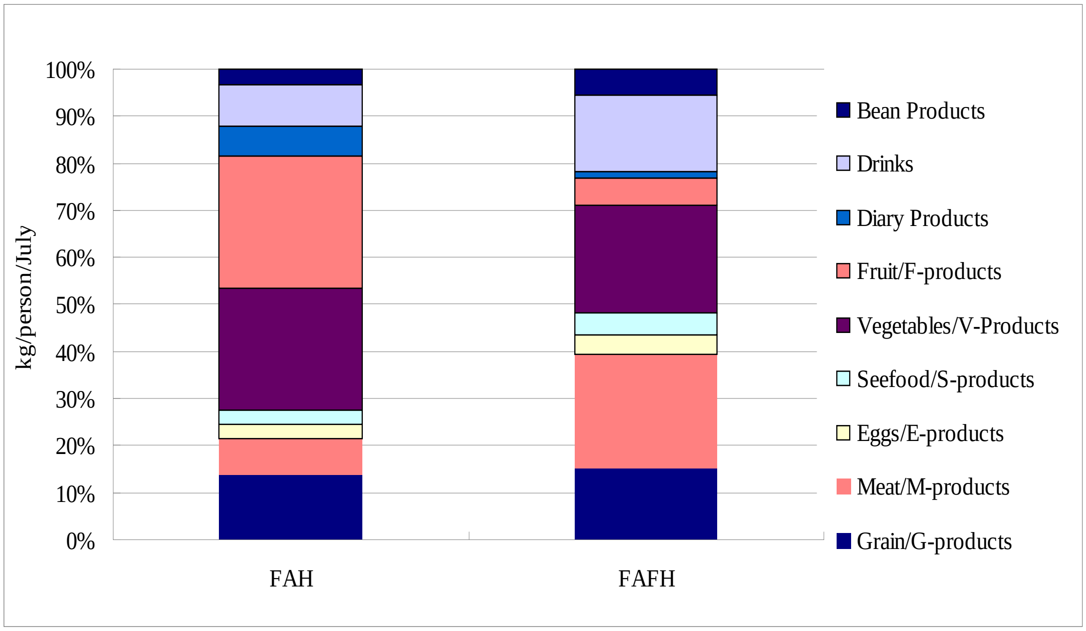


Figure 2 Food Consumption Structures for "At Home" and "Away from home"



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