Quantifying the Structure of Food Demand in China Using a Generalized Quadratic AIDS Specification

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Abstract

This manuscript is used to examine food demand structure and its dynamics for 11 commodities in urban China. The analysis is based on household-level expenditure survey data for two cross-sectional surveys of Chinese households pertaining to food expenditure patterns during 1995 and 2003. A major focus of this presentation is on the pre-committed component of demand that is not accounted for by economic and demographic characteristics. We use the generalized quadratic almost ideal demand system (GQAIDS) for its empirical superiority to the GAIDS, and estimate the associated parameters via a full information maximum likelihood procedure (FIML) procedure, where we test for whether total food expenditure for home consumption (FAH) is endogenous. We also use quality adjusted commodity unit values to account for quality differences resulting from commodity aggregation and food choice. We find that the demand for FAH by surveyed households has changed for a majority of the 11 commodities included in the analysis. We find that more than a third of vegetables consumed in 1995 were due to pre-committed demand, while no traditional Chinese food staple had positive significant pre-committed demand in 2003. With the changing food structure this may be indicative of an increased desire for flexibility in the Chinese diet.

Keywords: Generalized Quadratic Almost Ideal Demand System, pre-committed demand, expenditure endogeneity, food preferences.

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1. Introduction

Chinese consumers have been undergoing significant changes in their food consumption patterns (Figure 1). Consumption of grains, grain products, and vegetables that previously were central to the traditional Chinese diet has been on a steady decline over the last three decades (over 46 % and 26 %, respectively). Meanwhile beef, mutton, pork, poultry, and animal products have seen a big surge in consumption. Seafood, on the other hand, that constituted an important food product in coastal areas, such as Guangdong, has been gaining popularity throughout urban China (up 78.4 %). Furthermore, milk and dairy products that have traditionally been consumed in negligible amounts seem to become an indispensable part of the modern Chinese food diet (i.e., a 3-fold increase).

[Place Figure 1 Approximately Here]

Exploring the structure of Chinese food demand and the major changes occurring is an important issue not only domestically, but also internationally, given the role China plays in the world food market. More specifically, gaining a sound understanding of the degree to which food demand responds to the changes in the economic (income, food prices) and demographic factors, and how this response has changed over time, if at all, would help Chinese farmers, various intermediaries, consumers and relevant government agencies better organize their operations, while enabling its major trade partners to better understand the potential for increased food demand.

It is thought that two of the more important factors contributing to the changing patterns of Chinese food consumption are (i) the privatization of Chinese food marketing system making it available to FDIs and (ii) abolition of the food rationing rule. As a result, local retailers have been enhancing the variety and quality of their offerings in an attempt to emulate the Western supermarket chains entering the Chinese market (Dong and Fuller, 2007). While the changing food consumption pattern can be attributed to increased food availability and accessibility some empirical studies associate it with increasing urbanization (Gale et al., 2002), yet others find that Chinese consumers have been undergoing shifts in their food preferences recently (Guo et al., 2000; Ma et al., 2006)[3]. The focus of these previous studies have been on the income and price effects, various elasticity measures and their dynamics in an attempt to characterize the structure of Chinese food demand.

In contrast to previous studies we characterize the structure of Chinese food demand from the perspective of pre-committed consumption, where pre-committed quantity is the component of demand that is insensitive to changes in the economic factors (Tonsor and Marsh, 2007). Our major focus is on the dynamics of a component of pre-committed quantities that is not impacted by consumer demographic characteristics. We estimate a relatively large demand system composed of eleven food commodities in three Chinese provinces. For this analysis we utilize the generalized quadratic almost ideal demand system (GQAIDS) a version of the nested Almost Ideal Demand Systems (AIDS) that incorporates quadratic Engel curves, and allows for the presence of a pre-committed demand component. Based on a log likelihood ratio test we find that the estimated Engel curves are quadratic in the logarithm of total FAH expenditures, implying that the GQAIDS is the correct specification to be used in this study. We also derive expenditure, own and cross-price elasticity formulas for the GQAIDS which are used in the calculation of the respective elasticity estimates.

Our main hypothesis is that Chinese consumers have historically had significant positive pre-committed demand not accounted for by consumer demographic characteristics, especially for food staples that comprised an important part of the traditional Chinese diet (i.e. grain products, vegetables). With the changing food structure our hypothesis is that the pre-committed component is less important, indicating an increased desire for flexibility in the Chinese diet.

Section 2 of this paper is used to present the theoretical model and the methodology underlying our analysis. The issues of quality variation within the commodity groups and expenditure endogeneity are addressed. Furthermore, the GQAIDS price, expenditure and income elasticities are explicitly derived.

[3] Per capita income has increased almost 10-fold in urban China, while the CPI index has grown by 3.15 % in 1990-2007. National Bureau of Statistics of China 1997, 2007.

Section 3 is used to provide an overview of the survey data underlying this study. The results of our econometric estimation are contained in Section 4.

2. Overview of the Econometric Model

The GQAIDS forms the foundation of the econometric model used to estimate an 11 commodity food demand system. We apply this demand system to household level data for 3 Chinese provinces during 1995 and 2003. The GQAIDS extends the traditional AIDS specification in that it incorporates potential pre-committed component of demand into the budget share equations and, importantly, expenditure share Engel curves are quadratic function of logarithm of total FAH expenditures.

2.1 The AIDS Specification

The GQAIDS specification for demand builds up on the traditional AIDS model (Deaton and Muellbauer, 1980), which is derived for the price independent generalized logarithmic preferences (PIGLOG). The underlying indirect utility function for the AIDS is given by $\ln V = \ln(m) - \ln(P) \big/ b(p)$, where m is the total expenditures on commodities under study, ln (P) and b(p) are translog and Cobb-Douglass price aggregator functions, respectively, with

$\ln(P) = \alpha_0 + \sum_{j=1}^{n} \alpha_j \ln(p_j) + 0.5 \sum_{j=1}^{n} \sum_{i=1}^{n} \gamma_{ij} \ln(p_j) \ln(p_i)$ and $b(p) = \prod_{k=1}^{n} p_k^{\beta_k} = \exp \sum_{l=1}^{n} \beta_l \ln(p_l)$. Here

p_j is the price of the j^{th} commodity, and $\alpha_i, \gamma_{ij}, \beta_i$ are parameters. Marshallian demand functions,

$q_i = (m / p_i) \; \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln(p_j) + \beta_i \ln \; m / P$, are obtained from the indirect utility function via Roy's identity, which are then used to obtain the AIDS share equations:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln(p_j) + \beta_i \ln \; m / P \qquad (1)$$

where w_i is the budget share for the i^{th} commodity

Theoretical restrictions of aggregation, homogeneity and symmetry imposed on the demand system are given by $\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \beta_i = 0$, $\sum_{j=1}^{n} \gamma_{ij} = 0$, and $\gamma_{ij} = \gamma_{ji} \; \forall \, j \neq i$, respectively.

2.2 The GQAIDS Specification

The GQAIDS is characterized by the following indirect utility function

$$\ln V = \left[\left(\frac{\ln(s) - \ln(P)}{b(p)} \right)^{-1} + \lambda(p) \right]^{-1} \tag{2}$$

Where $s = m - \sum_{i=1}^{n} t_i p_i$ is the supernumerary expenditure (i.e. part of total expenditure sensitive to changes in the economic and demographic factors), $\sum_{i=1}^{n} t_i p_i$ is defined as pre-committed expenditure, with t_i being a parameter for the pre-committed quantity of the i^{th} commodity.

Bollino (1987) generalizes the AIDS model by incorporating the pre-committed expenditures into the total expenditures (supernumerary expenditures used in the GAIDS vis-à-vis total expenditures in the AIDS indirect utility). Furthermore, Banks et al. (1997) incorporate a function of $\lambda(p)$ into the indirect utility function ($\lambda(p)$ is differentiable and homogeneous in prices) in a fashion that makes expenditure share Engel curves dependent on the quadratic logarithm of income (here total expenditures, due to separability assumption). Theoretical consistency of the GQAIDS model requires that $\sum_{i=1}^{n} \lambda_i = 0$ (i.e. homogeneity), in addition to the AIDS restrictions of aggregation, homogeneity and symmetry. Following the procedures described earlier, one derives the budget share equations for the GQAIDS demand specification

$$w_i = \frac{t_i p_i}{m} + \frac{s}{m} \left\{ \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{s}{P}\right) + \frac{\lambda_i}{b(p)} \left[\ln\left(\frac{s}{P}\right) \right]^2 \right\} \tag{3}$$

We incorporate household demographic characteristics into the budget share equations through the pre-committed quantities as follows

$$\tilde{t}_i = t_{i0} + \sum_{j=1}^{d} t_{ij} D_j \tag{4}$$

Where D_j represents the j^{th} demographic characteristic. The major focus of this study is on the term t_{i0} and how this parameter changes over the period of 1995 to 2003.

Following Alston et al. (2001), one can show that introducing consumer demographic variables into the GQAIDS via the pre-committed share term guarantees the invariance of the economic effects (i.e. elasticities) to the scale of data. That is with (4) the GQAIDS has the characteristic of being Closed Under Unit Scaling (CUUS). As first noted by Pollak and Wales (1981), a demand system has the CUUS characteristic if "…whenever some demand system in the class is exactly consistent with the data in one set of units, and the data are rescaled in new units, then there exists another demand system in the class which is exactly consistent with the rescaled data" (p.1536). They believe that only demand systems that have the CUUS characteristics should be used for empirical demand analysis. This is in contrast to the AIDS and QAIDS specifications where the share intercept terms are made a function of household characteristics which imply that they are not CUUS.

To test whether the GQAIDS adds a significant explanatory power to the GAIDS model we use Bewley (1986) likelihood ratio test statistic (LR_b) given by $LR_b=2(LL^U-LL^R)\left[(E*N-p^U)/E*N\right]$. Here LL^U and LL^R are optimal values of the log likelihood functions from the unrestricted and restricted models, respectively, E is the number of equations estimated, N is the respective sample size and p^U is the number of parameters in the unrestricted model. An important advantage of this test over the traditional likelihood ratio test is that no asymptotic assumption is needed anymore. LR_b test statistic is asymptotically distributed chi-square with degrees of freedom equal to the number of additional parameters in the unrestricted model. We also test if the household characteristics/demographics add an overall significant explanatory power to the GQAIDS model by means of a LR_b test.

2.3 Price and Expenditure Endogeneity

From our survey data we derive unit values to be used as proxies for prices where these unit values are calculated as the total expenditure on a particular commodity group divided by the quantity purchases. The use of these unit values creates a potential measurement error bias as the composition of commodity aggregates may be considered endogenous via consumer choice as to commodity quality (i.e. branded versus private label) and the composition of specific commodities purchases within the commodity aggregate. To account for this endogeneity, we adjust the unit values for quality differences by adopting the procedure of Cox and Wohlgenant (1986).

To do so, we first regress commodity unit values on household characteristics, i.e. $p_i^u = \delta_i + \sum_k \eta_{ik} D_{ik} + \upsilon_i$. More specifically, we employ household age composition, size and income, meal planner's level of education attainment, and dummy variables indicating the Chinese provinces. We also include quadratic terms for household size and income to account for economies of size. Assuming that household characteristics approximate product characteristics quite closely, we homogenize unit values by distilling the collective effect of the household characteristics from the unit values, i.e. $p_i = p_i^u - \sum_k \eta_{ik} D_{ik}$, with p_i being the quality-adjusted price that is used in the estimation. For non-observed unit values we use average values in the respective provinces.

We assume food demand is separable from other expenditures which imply the level of household food expenditures may be endogenous (LaFrance, 1991). To account for this endogeneity we adopt a full-information maximum likelihood (FIML) estimation procedure. That is we augment the GQAIDS share equations with a reduced form total expenditure function whose predicted value is used as a regressor in (3). For our application we use household specific income, provincial dummy variables and their interactions in the reduced form expenditure function. Following Dhar et al (2003) we test for expenditure endogeneity via the Durbin-Wu-Hausman test statistic (DWH)

$$DWH= \left(\Psi_{EX}-\Psi_{EN}\right)' \left(\Sigma_{EX}-\Sigma_{EN}\right)^{-1} \left(\Psi_{EX}-\Psi_{EN}\right) \quad (5)$$

Where Ψ_{EX}, Ψ_{EN} are the parameter vectors, and Σ_{EX}, Σ_{EN} are covariance matrices from the GQAIDS estimated with exogenous and endogenous expenditures, respectively. The DWH statistic has a chi-square distribution with degrees of freedom equal to the number of parameters in the restricted model.

2.4 GQAIDS Elasticities

We derive expenditure (ξ_i), uncompensated $\varepsilon_{ij}{}^{M}$ and compensated $\varepsilon_{ij}{}^{H}$ elasticity formulas for the GQAIDS demand specification, which are presented below (see Appendix).

$$\xi_i = \left\{ -\frac{t_i p_i}{m} + \frac{\sum_i t_i p_i}{m} \left\{ \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{s}{P}\right) + \frac{\lambda_i}{b(p)} \left[\ln\left(\frac{s}{P}\right) \right]^2 \right\} + \beta_i + \frac{2\lambda_i}{b(p)} \ \ln(s) \text{-} P \ \right\} \frac{1}{w_i} + 1 \tag{6}$$

$$\begin{aligned}\varepsilon_{ij}{}^{M} = \frac{1}{w_i} \{ \frac{t_i p_i \delta_{ij}}{m} - \frac{t_j p_j}{m} \left\{ \alpha_i + \sum_{k=1}^{n} \gamma_{ik} \ln(p_k) + \beta_i \ln\left(\frac{s}{P}\right) + \frac{\lambda_i}{b(p)} \left[\ln\left(\frac{s}{P}\right) \right]^2 \right\} + \frac{s}{m} \left\{ \gamma_{ij} - \beta_i \left(\alpha_j + \frac{t_j p_j}{s} + \sum_{k=1}^{n} \gamma_{ik} \ln(p_k) \right) \right\} \\ - \frac{\lambda_i \beta_j}{e^{\sum_k \beta_k \ln(p_k)}} \left[\ln\left(\frac{s}{P}\right) \right]^2 - \frac{2\lambda_i}{b(p)} \left\{ \frac{t_j p_j \ln(s)}{s} - \frac{t_j p_j P}{s} + \ln(s) \left(\alpha_j + \sum_{k=1}^{n} \gamma_{ik} \ln(p_k) + 2P \left(\alpha_j + \sum_{k=1}^{n} \gamma_{ik} \ln(p_k) \right) \right) \right\} \} - \delta_{ij}\end{aligned} \tag{7}$$

$$\varepsilon_{ij}{}^{H} = \varepsilon_{ij}{}^{M} + \xi_i w_j \tag{8}$$

Where δ_{ij} is the Kronecker delta.

Expenditure endogeneity, if not controlled for in any application, will result in parameter estimates that are biased and inconsistent (LaFrance, 1991). To obtain an estimate of this bias we calculate the absolute percentage difference between the respective elasticity estimates under the FIML and the price adjusted procedures as follows (LaFrance, 1993)

$$D = 100|\varepsilon^{EX} - \varepsilon^{EN}| \Big/ 1/2|\varepsilon^{EX} + \varepsilon^{EN}| \tag{9}$$

Where ε^{EX} and ε^{EN} are the elasticity estimates from the GQAIDS estimated with exogenous and endogenous expenditures, respectively. Following Dhar et al. (2003), we obtain the average percentage difference in respective elasticity measures.

To complement our estimated expenditure elasticities, we estimate the income elasticities of demand following the procedure outlined in Park et al. (1996). We first run an auxiliary regression of the natural logarithm of expenditure on the log of household-level income, several household characteristics, and dummy variables indicating Chinese provinces in the study. To obtain the estimated income elasticities for each commodity, we multiply the respective expenditure elasticities by the coefficient of the log of income from the auxiliary regression (income elasticity of expenditure). Standard errors are estimated according to Bohrnstedt and Goldberger (1969), where the variance of the product of two random variables is obtained by assuming independence in terms of their first two moments[4].

3. Description of the Household Data Used in Econometric Estimation

Data used in this study are obtained from annual household expenditure surveys conducted by the Chinese State Statistical Bureau (CSSB) of urban Chinese households. We use data for 1995 and 2003 for surveyed urban households located in Jiangsu, Shandong and Guangdong provinces. These data provide household-level food purchase quantities and expenditures on each commodity, along with some household demographic variables. The details on how these surveys are conducted by the CSSB are provided in Gould and Villarreal (2006). There were 2050 and 4407 households used in our analysis for 1995 and 2003, respectively. An obvious shortcoming of this analysis is that we were limited to examining the demand for food for at-home (FAH) consumption. We partition total FAH expenditures into 11 aggregate categories: beef and mutton, pork, poultry (processed and raw), seafood (fish, shrimp and other), fresh and dry vegetables, fruits, rice, other grains, milk and dairy products, eggs, and fats and oil products.

Table 1 provides a summary of the food purchase patterns in our two samples. The average incomes in the Jiangsu and Shandong are quite similar while Guangdong is a comparably more affluent province. Despite this, income shares allotted to food consumption do not vary significantly across provinces. Households in all three provinces, and especially in Shandong, still rely on rice and other grains for the main food staples. Meanwhile, the share of income spent on seafood rose by 1.5 % in Jiangsu and Shandong, while decreasing by 3 % in Guangdong over the 8-year period. Consistent with consumption pattern shown in Figure 1, the relative consumption of milk and dairy products has increased significantly when compared to the other delineated food commodities.

To gain an idea of the growing income disparity and changing consumption patterns across the various socio-economic groups in China, we view the expenditure allocation between the upper and lower

[4] $Var(\alpha\,\beta) = E^2(\alpha)\,Var(\beta) + E^2(\beta)\,Var(\alpha) + Var(\alpha)\,Var(\beta)$

income groups. With less than half of the rich households' income, the consumers in the lower income group increased the share of their income spent on food from 11.6 to 21.8 %, while the former saw an increase from 7 to 11.5 % in the period of 1995 to 2003. Pork, vegetables and seafood have absorbed the biggest share of income for both groups, with that measure rising up to 45 % in 2003.

[Table 1 Approximately here]

A total of 10 demographic variables are used to explain the variation in pre-committed expenditures in addition to a binary variable indicating the availability of refrigerated storage in the household. A summary of these variables are presented in Table 2. Household age composition and size are expected to have a significant impact on the choice of FAH. From this table we see that the age composition of household members is across the various sub-samples with a majority of family members being adults between 22 and 59 years of age. The average household size seems to decline over time, with fewer children and more adults over 59. Meal planners' education attainment is also hypothesized to be important for the household food purchase decision and quality choice (see Sabates et al., 2001; Gould and Villarreal, 2006). Sampled meal planners without high school education accounted for 23 and 15 %, and those with high school education made up 26 and 31 % of our samples in 1995 and 2003, respectively.

Income is yet another important determinant for household food diet, if not the most important one. Many studies attribute the recent structural changes in Chinese food diet to the steady growth in household income levels (Guo et al., 2000; Gale, 2003). Since the assumption of weak separability of preferences makes the total food expenditures fall short of household income, we incorporate the latter variable into the model along with household demographics. In terms of average provincial income Jiangsu and Shandong are quite similar in our sample, with that measure for Guangdong being twice as high in 1995. With doubling income levels in Jiangsu and Shandong, and about 35% rise in the average income in Guangdong from 1995 to 2003, it would be important to capture the effect of income dynamics on the shifting composition of urban Chinese household food diet.

Provided that our survey data cover annual food expenditures, the availability of a refrigerator may not be as important as for studies analyzing more frequent food purchases. Based on results from Gould and Villarreal (2002), we also include a dummy variable indicating availability of a refrigerator, with the expectation that it may affect household food choices in a developing country context. Over 84 % of sampled households had refrigerated storage in 1995, while this figure grew to 87 % in 2003.

[Table 2 Approximately here]

4. Econometric Analysis of Pre-Committed Food Demand

The GAUSSX module of the GAUSS software system was used to obtain parameter estimates for the various model specifications. A total of 195 parameters are estimated under the GQAIDS model specification when food expenditures were assumed exogenous. For all model specifications we utilize quality adjusted unit values. Applying FIML to the GQAIDS results in 8 additional parameters to estimate due to the inclusion of the reduced form total expenditure equation. We also estimate the GAIDS specification via the FIML to test whether the Engel curves are quadratic or, equivalently, whether the GQAIDS adds significant additional explanatory power to the GAIDS model. The parameter estimates for the omitted equation are obtained from the theoretical restrictions imposed on the model. Appendix Table A.1 and A.2 contain the parameter estimates of the GQAIDS specification for 1995 and 2008 respectively.

In Table 3 we provide an overview of various joint hypothesis tests. As noted above the GAIDS specification is nested within GQAIDS via the joint test λ_i=0 (i=1,…, 11). As shown in Tables A.1 and A.2 a majority of estimated λ_i values have individual t-statistics that are relatively large in both years. Not surprisingly in Table 3 we reject the null hypothesis that the GQAIDS model does not provide additional explanatory power over the GAIDS specification. Based on t-values of these coefficients, beef, seafood, vegetables, rice, other grains, dairy, eggs, oil and fats have quadratic Engel curves in the logarithm of total FAH expenditures in 1995. Engel curves are quadratic for pork, poultry, vegetables, fruit, dairy, fats and oil products in 2003.

As regards the endogeneity test of total FAH expenditures, the DWH test statistics were 3,231.7 and 14,377 for 1995 and 2003, respectively, while the critical χ^2 with 195 degrees of freedom is 228.6. This result provides a strong evidence of expenditure endogeneity in both years.

We test whether household characteristics add a significant explanatory power to the GQAIDS model where the pre-committed demands are not allowed to vary across households. The values of estimated test statistics for the Bewley log likelihood ratio test are 783.8 and 1,132.4 for 1995 and 2003, respectively, with the critical χ^2 with 99 degrees of freedom being 134.6. This implies that there is significant heterogeneity in the importance of pre-committed expenditures across households.

The parameter estimates from the GQAIDS estimated via FIML for both years are provided in Table A1 and A2, respectively. From these results we can evaluate whether pre-committed demand is significantly different from 0. In 1995, when setting the demographic variables Chinese consumers turn out to have held positive significant pre-committed demand only for vegetables in 1995. Specifically, an average urban Chinese household used to purchase 41.69 kg of vegetables, irrespective of any changes in its demographic characteristics and fluctuations in economic factors. This made up 35.8 % of the overall demand for vegetables by a representative household. Meanwhile, beef, pork, fruit, other grains, dairy products, fats and oil products had negative significant pre-committed demands. At first sight this result looks counterintuitive, however we resort to Tonsor and Marsh (2007) to show that the constant component of pre-committed demand is just the marginal response of pre-committed expenditure to the price of i^{th} commodity, i.e. $\partial(\mathrm{m\text{-}s})/\partial \mathrm{p_i} = \partial \sum_i \mathrm{t_i p_i} \Big/ \partial \mathrm{p_i} = \mathrm{t_i}$. Thus, a negative constant component of pre-committed demand points to inclination of Chinese households towards more of supernumerary expenditures at the expense of the pre-committed expenditures (food demand becoming more responsive to economic and demographic variables, and thus, more predictable).

The situation is quite different in 2003 when no commodity constituting an important component of the traditional Chinese diet (i.e. grains, vegetables) was demanded in pre-committed quantities. Only oil/fats had a positive significant pre-committed quantity of 3.11 kg, which comprised 12.9 % of the demand for this commodity by an average household. Fruit and dairy products, on the other hand, still manifest negative significant pre-committed demands in addition to seafood.

Thus, it is evident that demands for beef, pork, seafood, vegetables, other grains, and fats and oil products have undergone a structural change from the perspective of pre-committed quantities. We employ an independent t-test of difference (since the number of observations is different in the datasets) to test whether this is the case for fruit and dairy. The estimated t values are -7.44 and 4.22 for fruit and dairy products, respectively, implying that these commodities also experienced a structural change over the 8-year span as far as the pre-committed demand is concerned (pre-committed demand for dairy products became significantly more negative, and less negative for fruit).

Our basic hypothesis is that households in China have historically had significant positive pre-committed demand for food commodities constituting an indispensable component in the traditional Chinese diet (e.g. rice, vegetables), while the recent changes in food structure make the pre-committed demand less important, reflecting an inclination toward more flexible food diet. The estimation results partially validate the main hypothesis with respect to vegetables, an important share of which was still consumed in pre-committed quantities in mid 1990s. This is not the case for rice and other grains. However, we are not able to refute the hypothesis as far as consumption of other traditional food staples is concerned, since the sweeping changes in the Chinese food marketing system started in 1980s, which we do not observe. In terms of consistency, it would be important to compare our results from the pre-committed demand analysis to those of previous studies; however no known study on the Chinese food demand structure explores the potential pre-committed quantities demanded.

The uncompensated and compensated own and cross-price elasticity estimates are provided in table 4 and 5, respectively. We calculate these measures using the parameter estimates from the GQAIDS model at the means of the variables based on the formulas we derived earlier. Ten out of eleven uncompensated own-price elasticity measures are negative and statistically significant in the 1995 model. Moreover, demand for all ten commodities is inelastic, with eggs having the most own-price inelastic measure and rice having the most elastic own-price demand structure. In the 2003 model all commodities have negative significant own-price elasticities, with demand for fruit, other grains, fats and oil products being highly elastic. To test whether the own-price elasticity measures have seen significant changes we rely upon independent t test. We find that demand responsiveness of fruit, rice, other grains and eggs to variation in own price have changed significantly over the 8-year period, with only that of rice becoming less elastic. This provides some further evidence that the structure of demand for food items in traditional Chinese diet (rice, other grains) has changed.

All but eggs have statistically significant expenditure elasticities in 1995, with other grains being the only commodity with a negative estimate. Furthermore, beef, vegetables and fruit have inelastic expenditure elasticities. These measures turn out significant for all but the fats/oils, and positive in 2003. Fruit, other grains, dairy and eggs have elastic demands. Furthermore, our expenditure elasticities for beef, pork, poultry and seafood in 2003 compare well with those from Gould and Villarreal (2006), in a sense that they are all more than unitary elastic and close in value. However, contrary to their estimates of expenditure elasticities for rice and other grains of 1.16 and 0.75, we obtain 0.801 and 1.318, respectively[5].

According to the economic effects, the demand for vegetables was less responsive to changes in economic variables in 1995 than in 2003[6]. This is consistent with the fact that more than a third of vegetable demand was due to pre-committed quantity in 1995, while in 2003 the supernumerary expenditures and economic variables accounted for greater portion of demand for vegetables. Expenditure endogeneity, if not controlled for in applied work, will result in biased and inconsistent parameter estimates, and consequently, unreliable elasticity measures. In an attempt to quantify this bias, we present the absolute percentage difference between own-price uncompensated and expenditure elasticities, respectively, for both years (table 11).

Income elasticity estimates are presented in table 4. These measures are all statistically significant, except eggs and positive, except other grains in 1995. This is suggestive of all

[5] They cover 5 provinces in 2001, and furthermore they use QAIDS specification of demand
[6] Own-price and expenditure elasticities were -0.63, 0.83 in 1995, and -0.65, 0.85 in 2003, respectively

commodities being normal goods in mid 1990s, with the other grains being the only inferior goods. Moreover, demand response to income variations is highly inelastic for the whole group of commodities, with rice having the most elastic demand in a relative sense (0.71 %). Our income elasticity estimate for vegetables (0.229) is quite close to the respective measure (0.16) in Guangdong province in 1995 as estimated by Zhang et al., (2001). Moreover, their measure for income elasticity of grain as an aggregate commodity is 0.23, while our estimates for rice and other grains are 0.71 and -0.288. Based on data from Jiangsu, Shandong and Guangdong provinces Liu and Chern (2003) estimate income elasticity for rice to be 0.75 in 1998, which is quite supportive of the respective estimate in our study in 1995.

Income elasticity of demand in 2003 is significant for all commodities but fats/oil, meanwhile becoming less elastic for pork, poultry, seafood, rice, dairy and fats vis-à-vis the 1995 results. However, the estimate for other grains incurred the biggest change in this 8 year period, in that it turned positive, implying this group was already perceived as normal goods by urban Chinese consumers in 2003. These results are partially supported by Guo et al., (2000) who also found the income elasticity for rice was positive and on the decline, while that for coarse grains and grain products was negative and on the rise (becoming less negative) from 1989 to 1993. Based on geographically more representative data and a period of 1978-2001, Zhuang and Abbott (2007) also found similar income elasticity for rice (0.34). Their estimates for pork and poultry are 0.136 and 0.225, compared to our respective measures of 0.202 and 0.208 in 2003. Finally, the estimate for vegetables became more elastic as compared to 1995, which is consistent with the dynamics in the pre-committed component for this commodity. Based on independent t test of difference we find that income elasticity of demand has undergone statistically significant changes for all commodities but vegetables and dairy products.

In an attempt to find out whether consumer food preferences have undergone structural changes in the time period covered in this study, we compare the uncompensated own-price and expenditure elasticity measures from 1995 and 2003, both sets evaluated at the 1995 mean data (table 7). The absolute difference between the expenditure elasticities from both years is 0.41 or higher for most commodities, and in the range of 0.23 to 0.27 for fruit, beef and pork. Furthermore, other grains, rice, fats/oils and eggs manifest the biggest difference ranging from 1.27 (eggs) to 2.59 (other grains). As regards the own price uncompensated elasticities, we observe a similar pattern with beef, pork and seafood being the only commodities with small differences. Interestingly, other grains and dairy products displayed the biggest difference (1.09 and 1.12, respectively). Taking account of the fact that we have controlled for the economic and demographic factors in the model across years, the only difference between the elasticity measures in 1995 and 2003 is due to consumer preference changes. Based on the above results, consumer food preferences have undergone structural changes for almost all food commodities under study in urban China in the period of 1995 to 2003.

5. Conclusions

We estimate a GQAIDS model for a system of 11 food commodities on household-level expenditure survey data from the urban Chinese Jiangsu, Shandong and Guangdong provinces. A special focus is on the potential pre-committed components of food demand, which are insensitive to demographic factors and their dynamics from 1995 to 2003. We base the analysis on the GQAIDS demand specification with quality adjusted prices and estimated via the FIML procedure, due to its empirical superiority over the GAIDS model, and empirical endogeneity of total FAH expenditures. Moreover, we incorporate a group of nine household characteristics into the GQAIDS, which enhances the explanatory power of the model significantly. Thus, the part of demand that is not accounted for by economic and demographic variables finds its reflection in the intercept of the pre-committed quantities.

The results from the analysis are supportive of the hypothesis that the traditional Chinese food diet has changed over the time span under study. Particularly, more than a third of the demand for vegetables was accounted for by pre-committed quantities in 1995, while none of the traditional Chinese food commodities had significant positive pre-committed demand in 2003. Fats and vegetable oils, on the other hand, were the only commodity group having significant positive pre-committed demand in 2003. This may be suggestive of increasing popularity of these food items in modern urban China. The results also point to a structural change in the demand for beef, pork, seafood, vegetables, fruit, other grains and dairy products. Since no known previous study explores the Chinese food demand from the perspective of pre-committed component, our main results are not directly comparable to any of those.

Contrary to our a priori expectations, we do not observe rice demanded in positive pre-committed quantities in mid 1990s. One reason for this reality may well be the fact that the sweeping changes in Chinese food marketing system started in early 1980s, and could have had their major impact on rice consumption patterns in early stages of the reforms. Therefore, data on food consumption covering this time span would prove invaluable for testing our hypothesis.

The dynamics in the uncompensated own-price, expenditure and income elasticities provide further evidence to the changing food preferences in China. Particularly, evaluating the uncompensated own-price and expenditure elasticities from 1995 and 2003 at the 1995 mean data and comparing the respective measures points to structural changes in the urban Chinese food preferences.

Some further steps towards the future work could be using alternative data sources to verify our results and estimating the demand system on panel data for more efficient estimates.

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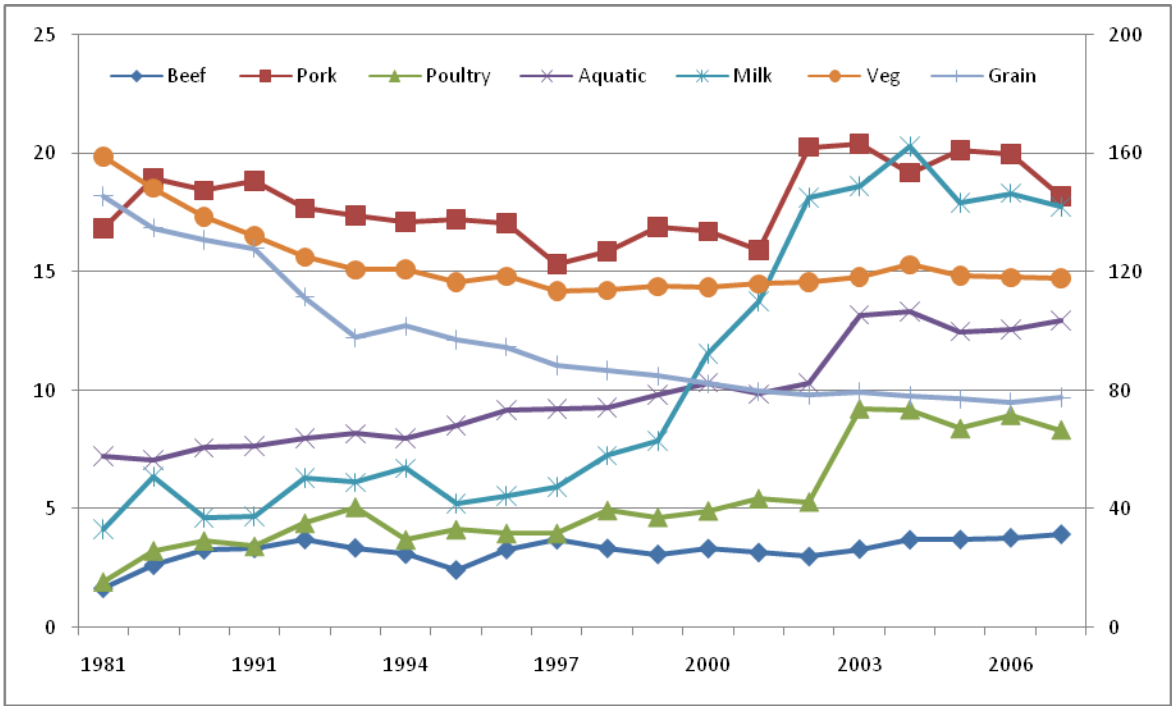
Figure 1

Per capita food consumption in urban China in 1981-2007 (kg)



Source: ERS, China Agricultural and Economic Data (note: vegetables and grains scaled on the right axis)

Table 1 . Allocation of food expenditures across food products, income groups, and regions

	Entire Sample		Income: Lower half		Income: Upper half		Jiangsu		Shandong		Guangdong	
	1995	2003	1995	2003	1995	2003	1995	2003	1995	2003	1995	2003
Beef	6	2.5	5.7	2.7	6.3	2.3	4.7	2.2	7	2.9	6.4	2.6
Pork	16.4	17.1	17.4	18	15.4	16.2	19	17.8	15.3	13.5	14.3	21
Poultry	9	9.3	7.2	8.6	10.9	9.9	8.6	10	5.9	6.1	13.1	12.6
Seafood	12.7	12.9	10.3	11.5	15	14.3	12.5	14.1	8.5	10	17.6	14.5
Vegetables	14.9	15.6	14.8	16.3	14.9	14.9	14.7	15.9	14.7	15.8	15.3	14.2
Fruit	9.2	9.9	8.4	8.2	10	11.6	8.1	8.7	10.3	11.8	9.5	10.2
Rice	9.2	5.9	9.5	6.9	8.9	4.9	13.6	7.5	3.7	2.4	9.3	7.2
Other grain	9	7.8	11.2	8.7	6.9	6.9	5.4	5	17	14.1	5.2	5.1
Dairy	2.6	9.2	2	7.6	3	10.9	2.5	8.8	2.6	12.1	2.6	5.7
Eggs	6.3	5	8	5.8	4.7	4.2	5.9	4.8	9.8	6.9	3	2.4
Fats/Oils	4.7	4.8	5.5	5.7	4	3.9	5	5.2	5.2	4.4	3.7	4.5
Household Income (1000 Yuan)	20.0	30.7	11.6	16.5	28.3	44.9	15.7	28.7	14.0	27.0	32.2	43.1
Income as % of All Urban Chinese	514	339	300	182	727	496	402	317	360	298	827	475
% of Income Spent on 11 Commodities	8.3	14.2	11.6	21.8	7	11.5	10	14.6	7.8	12.6	7.5	15.4
Number of Households	2,050	4,407	1,025	2,203	1,025	2,203	800	2,300	650	1,336	600	771

Table 2 . Summary of the household demographics and other characteristics

		Unit	Entire sample		Lower half		Upper half		Jiangsu		Shandong		Gu
			1995	2003	1995	2003	1995	2003	1995	2003	1995	2003	199
							Household Composition						
D_P6	Child < 6 years old	0/1	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.0
D_P14	6 <= and <14 years old	0/1	0.12	0.08	0.14	0.08	0.1	0.09	0.11	0.08	0.13	0.09	0.1
D_P21	14 <= and < 22 years old	0/1	0.11	0.1	0.1	0.11	0.12	0.08	0.1	0.08	0.11	0.11	0.1
D_PM	22 <= and < 59 years old	0/1	0.61	0.64	0.58	0.62	0.64	0.66	0.58	0.61	0.63	0.68	0.6
D_PS	>= 59		0.12	0.15	0.15	0.16	0.1	0.14	0.18	0.2	0.09	0.09	0
HSIZE	Household size	#	3.2	3	3	2.9	3.4	3.1	3.1	2.9	3.2	3	3
			0.84	0.89	0.76	0.85	0.89	0.91	0.89	0.98	0.69	0.69	0.8
							Meal Planner Education						
D_ADV	4 < years of education	0/1	0.51	0.54	0.58	0.42	0.44	0.66	0.59	0.45	0.44	0.67	0.4
D_HSC	4 years of education	0/1	0.26	0.31	0.25	0.38	0.28	0.24	0.25	0.34	0.26	0.25	0.2
D_LT_HSC	4 > years of education	0/1	0.23	0.15	0.17	0.2	0.28	0.1	0.16	0.21	0.3	0.08	0.2
HINC	Total household income	Yuan	19,99	30,71	11,67	16,52	28,31	44,9	15,67	28,72	14,03	26,99	32
			13,27	22,4	2,73	5,19	14,38	23,96	6,56	21,7	5,37	15,29	17,3
D_REFRIG	Own refrigerator	0/1	0.84	0.87	0.68	0.79	1	0.95	0.78	0.86	0.72	0.87	
							Province						
D_JS	Jiangsu	0/1	0.39	0.52	0.47	0.56	0.31	0.48	1	1	-	-	
D_SD	Shandong	0/1	0.32	0.3	0.46	0.33	0.18	0.28	-	-	1	1	
D_GD	Guangdong	0/1	0.29	0.18	0.07	0.11	0.51	0.24	-	-	-	-	

Table 3. Summary of the results from joint tests

Null hypothesis	χ^2-Value		DF	Critical χ^2-Value
	1995	2003		
Engel curves are linear in the log of total FAH expenditures (GAIDS vs. GQAIDS)	233.7	306.1	11	24.7
Total FAH expenditures are endogenous in the GQAIDS model	3,231.7	14,377.0	195	228.6
9 demographic factors affect FAH purchase in the GQAIDS estimated via FIML	776.7	1,127.7	99	134.6

Note: The critical χ^2 value is at a 1% level of significance.

Table 4. Uncompensated Price, Expenditure and Income Elasticities , 1995 and 2003

		Price Elasticities											Expenditure Elasticity	Income Elasticity
		Beef	Pork	Poultry	Seafood	Veg	Fruit	Rice	Other	Dairy	Eggs	Fats		
Beef	1995	**-0.681**	-0.012	**0.115**	**0.086**	**-0.055**	**-0.105**	**0.111**	0.037	0.057	**-0.061**	0.003	**0.505**	**0.139**
	2003	-0.377	**0.376**	**-0.328**	**0.131**	**-0.360**	**0.258**	**-0.025**	**-0.552**	0.010	**-0.033**	**-0.061**	**0.959**	**0.294**
Pork	1995	**-0.041**	**-0.472**	**-0.069**	**-0.037**	**-0.047**	-0.060	**-0.265**	-0.065	**-0.129**	-0.011	**-0.171**	**1.365**	**0.377**
	2003	**0.052**	**-0.544**	**0.061**	**-0.094**	0.057	-0.062	**-0.078**	0.039	-0.197	**0.053**	**0.052**	**0.661**	**0.202**
Poultry	1995	**0.030**	**-0.178**	**-0.646**	0.028	**-0.236**	**-0.126**	**-0.222**	**-0.115**	0.044	**-0.075**	**-0.134**	**1.630**	**0.450**
	2003	**-0.067**	0.102	**-0.864**	**0.061**	**0.120**	0.010	**0.074**	0.027	-0.248	**-0.034**	**0.140**	**0.678**	**0.208**
Seafood	1995	-0.011	**-0.057**	0.023	**-0.658**	**-0.211**	**-0.098**	**-0.095**	**-0.206**	-0.007	**-0.119**	**-0.062**	**1.501**	**0.414**
	2003	**0.023**	**-0.131**	0.035	**-0.558**	-0.026	0.043	**-0.096**	**0.064**	-0.089	-0.016	**-0.039**	**0.789**	**0.241**
Veg	1995	**-0.027**	0.034	**-0.032**	**-0.057**	**-0.628**	-0.041	0.020	-0.019	-0.077	0.002	-0.004	**0.829**	**0.229**
	2003	**-0.040**	0.029	**0.053**	-0.025	**-0.645**	-0.018	0.041	-0.060	**-0.161**	**-0.062**	**0.039**	**0.849**	**0.260**
Fruit	1995	-0.029	0.060	0.016	0.038	0.018	**-0.640**	0.104	0.096	-0.042	-0.005	-0.053	**0.436**	**0.120**
	2003	**0.026**	**-0.102**	-0.023	0.001	-0.046	**-1.192**	**-0.062**	**0.169**	0.129	**0.052**	-0.021	**1.067**	**0.327**
Rice	1995	-0.030	**-0.601**	**-0.237**	**-0.261**	**-0.263**	-0.099	**-0.750**	-0.039	-0.122	-0.081	**-0.092**	**2.574**	**0.710**
	2003	-0.005	**-0.201**	**0.092**	**-0.187**	0.111	**-0.133**	-0.208	**-0.140**	-0.295	0.001	**0.163**	**0.801**	**0.245**
Other	1995	**0.088**	**0.212**	**0.091**	0.034	**0.292**	**0.335**	0.249	**-0.463**	-0.003	0.061	0.146	**-1.043**	**-0.288**
	2003	**-0.100**	-0.028	-0.024	0.017	**-0.150**	**0.234**	**-0.108**	**-1.146**	0.052	0.015	**-0.081**	**1.318**	**0.403**
Dairy	1995	-0.036	**-0.256**	0.013	-0.054	**-0.345**	**-0.263**	-0.047	**-0.276**	**-0.467**	**-0.092**	**-0.083**	**1.903**	**0.525**
	2003	-0.007	**-0.230**	**-0.153**	**-0.118**	**-0.197**	0.047	**-0.119**	0.016	**-0.618**	-0.019	-0.051	**1.449**	**0.443**
Eggs	1995	**-0.041**	**0.133**	-0.011	**-0.148**	**0.144**	0.030	0.044	0.034	-0.026	-0.331	**0.112**	0.060	0.016
	2003	**-0.016**	**0.137**	**-0.097**	**-0.073**	**-0.263**	**0.221**	-0.013	**0.064**	-0.025	**-0.991**	0.001	**1.055**	**0.323**
Fats	1995	-0.023	**-0.539**	**-0.176**	**-0.132**	-0.066	-0.273	-0.068	0.138	-0.118	**0.075**	0.067	**1.115**	**0.308**
	2003	-0.025	0.166	0.279	-0.117	0.152	-0.052	0.245	-0.169	-0.157	0.009	**-1.159**	0.828	0.253

Note: Values in bold identify elasticities statistically different from 0 at the 0.001 level of significance. For expenditure and income elasticities, gray area indicates estimates statistically different from 1 and 0, respectively, at the 0.01 level of significance. Standard errors are not presented for space limitations but are available upon request.

Table 5. Compensated Price Elasticities, 1995 and 2003

		Beef	Pork	Poultry	Seafood	Veg	Fruit	Rice	Other	Dairy	Eggs	Fats
Beef	1995	**-0.659**	0.055	**0.145**	**0.142**	0.035	-0.036	**0.150**	0.082	**0.102**	**-0.039**	0.023
	2003	-0.362	**0.495**	**-0.258**	**0.230**	**-0.231**	**0.400**	**0.026**	**-0.463**	0.189	0.001	-0.027
Pork	1995	0.019	-0.291	0.015	**0.115**	**0.195**	0.127	**-0.158**	0.057	-0.008	**0.047**	**-0.117**
	2003	**0.062**	**-0.462**	**0.109**	-0.026	**0.146**	0.036	**-0.043**	**0.099**	-0.074	**0.076**	**0.076**
Poultry	1995	**0.101**	0.038	**-0.547**	**0.209**	**0.053**	0.097	**-0.095**	0.030	**0.190**	-0.006	**-0.069**
	2003	**-0.056**	**0.186**	**-0.815**	**0.131**	**0.212**	**0.111**	**0.110**	**0.090**	-0.121	-0.010	**0.164**
Seafood	1995	**0.054**	**0.142**	**0.115**	**-0.492**	0.055	**0.107**	0.022	**-0.072**	**0.127**	**-0.055**	-0.003
	2003	**0.035**	-0.033	**0.092**	**-0.477**	**0.081**	**0.160**	**-0.054**	**0.137**	0.059	0.012	-0.012
Veg	1995	0.009	**0.144**	**0.019**	**0.035**	**-0.481**	0.072	**0.084**	**0.055**	-0.003	**0.037**	**0.029**
	2003	**-0.027**	**0.135**	**0.114**	**0.062**	**-0.530**	**0.108**	**0.086**	0.018	-0.003	**-0.032**	**0.069**
Fruit	1995	-0.010	0.118	**0.043**	0.087	**0.095**	-0.581	0.138	0.135	-0.003	0.013	-0.035
	2003	**0.043**	0.031	**0.055**	**0.111**	**0.098**	**-1.034**	-0.005	**0.267**	**0.328**	**0.090**	0.017
Rice	1995	**0.081**	**-0.261**	**-0.079**	0.025	**0.194**	0.253	-0.549	0.190	0.108	**0.028**	0.010
	2003	**0.007**	-0.101	**0.150**	**-0.105**	**0.219**	-0.014	-0.165	**-0.067**	-0.146	**0.029**	**0.192**
Other	1995	**0.043**	0.074	0.027	**-0.082**	0.108	0.193	0.167	**-0.556**	-0.096	0.017	0.105
	2003	**-0.079**	**0.136**	**0.071**	**0.152**	0.028	**0.430**	**-0.038**	**-1.025**	0.298	**0.062**	-0.035
Dairy	1995	0.047	-0.004	**0.130**	**0.157**	-0.007	-0.003	**0.102**	-0.107	-0.297	-0.011	-0.008
	2003	0.016	-0.050	-0.048	0.030	-0.002	**0.262**	-0.042	**0.149**	**-0.348**	0.033	0.000
Eggs	1995	**-0.038**	**0.141**	-0.007	**-0.141**	**0.155**	0.038	**0.049**	0.039	-0.021	-0.329	**0.114**
	2003	0.001	**0.268**	-0.021	0.035	**-0.121**	**0.377**	**0.043**	**0.161**	0.172	**-0.954**	**0.038**
Fats	1993	0.025	**-0.391**	**-0.108**	-0.008	0.131	-0.121	0.019	**0.237**	-0.018	**0.123**	0.111
	2003	-0.012	0.269	**0.339**	-0.032	**0.263**	0.071	**0.289**	-0.093	-0.002	0.038	**-1.130**

Note: Values in bold identify elasticities statistically different from 0 at the 0.01 level of significance. For own price elasticities, gray area indicates estimates statistically different from 1 at the 0.01 level of significance. Standard errors are not presented for space limitations but are available upon request.

Table 6. Absolute % difference between own-price and expenditure elasticities estimated via FIML vs. NLS

	Price Elasticity		Expend. Elas.	
	1995	2003	1995	2003
Beef	7.3	26.9	43.9	5.0
Pork	38.9	2.2	37.8	27.9
Poultry	14.4	2.3	72	32.5
Seafood	11.4	39.8	46.4	25.2
Veg.	0.5	21.7	2	3.4
Fruit	7.8	14.7	66.3	19.4
Rice	188.2	106.8	91.4	2.4
Oth. Gr.	2.2	35.2	875.5	32.1
Dairy	4.1	0.5	23.7	0.3
Eggs	43.7	12.6	175.4	15.6
Fats	70.7	8.7	20.1	4.1

Table 7. Elasticity estimates in 1995 and 2003, both sets evaluated at 1995 mean data points

	Own Price Uncomp. Elasticity			Expenditure Elasticity		
	1995	2003	Abs. diff.	1995	2003	Abs. diff.
Beef	-0.681	-0.611	0.071	0.505	0.773	1.116
Pork	-0.472	-0.336	0.136	1.365	1.092	1.701
Poultry	-0.646	-0.869	0.222	1.630	1.221	2.499
Seafood	-0.658	-0.781	0.122	1.501	0.689	2.281
Veg.	-0.628	-0.313	0.315	0.829	1.675	1.142
Fruit	-0.640	-1.312	0.671	0.436	0.671	1.748
Rice	-0.750	-0.286	0.463	2.574	0.735	2.860
Oth. Gr.	-0.463	-1.555	1.092	-1.043	1.544	0.512
Dairy	-0.467	-1.588	1.122	1.903	1.222	3.492
Eggs	-0.331	-1.081	0.750	0.060	1.331	1.141

Appendix A.

Derivation of GQAIDS Elasticity Formulas

We derive the Expenditure (ξ_i), Uncompensated ε_{ij}^{M} and Compensated ε_{ij}^{H} elasticity formulas for the GQAIDS model following the method proposed by Banks et al. (1997).

Expenditure Elasticity

$$\xi_i=\frac{\Gamma_i}{w_i}+1,\ \text{where}\ \Gamma_i=\frac{\partial w_i}{\partial \ln(m)}=\frac{\partial\left(\frac{t_i p_i}{m}+\frac{s}{m}\left\{\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ln(p_j)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}\right)}{\partial \ln(m)}$$

$$\frac{\partial\left(\frac{t_i p_i}{m}\right)}{\partial \ln(m)}=-\frac{t_i p_i}{m},\ \text{since}\ \frac{\partial (m)^{-1}}{\partial \ln(m)}=\frac{\partial e^{\ln(m)^{-1}}}{\partial \ln(m)}=e^{\ln(m)^{-1}}\frac{\partial \ln(m)^{-1}}{\partial \ln(m)}=e^{\ln(m)^{-1}}(-1)=-\frac{1}{m}$$

$$\frac{\partial\left(\frac{s}{m}\left\{\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ln(p_j)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}\right)}{\partial \ln(m)}=\frac{\sum_{i=1}^{n}t_i p_i}{m}\left\{\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ln(p_j)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}$$

$$+\frac{s}{m}\left\{\frac{\beta_i m}{s}+\frac{2\lambda_i}{b(p)}\left(\frac{\ln(s)m}{s}-\frac{Pm}{s}\right)\right\}=\frac{\sum_{i=1}^{n}t_i p_i}{m}\left\{\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ln(p_j)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}+$$

$$\beta_i+\frac{2\lambda_i}{b(p)}\left(\ln(s)-P\right),\ \text{given that}\ s=m-\sum_{i=1}^{n}t_i p_i$$

$$\text{Thus,}\ \xi_i=\left\{-\frac{t_i p_i}{m}+\frac{\sum_{i=1}^{n}t_i p_i}{m}\left\{\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ln(p_j)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}+\beta_i+\frac{2\lambda_i}{b(p)}\ \ln(s)-P\right\}\frac{1}{w_i}+1$$

Uncompensated Elasticity

$$\varepsilon_{ij}^{M}=\frac{\Gamma_{ij}}{w_i}-\delta_{ij},\ \text{where}\ \Gamma_{ij}=\frac{\partial w_i}{\partial \ln(p_j)}\ \text{and}\ \delta_{ij}\ \text{is the Kronecker delta}$$

$$\Gamma_{ij}=\frac{\partial w_i}{\partial \ln(p_j)}=\frac{\partial\left(\frac{t_i p_i}{m}+\frac{s}{m}\left\{\alpha_i+\sum_{k=1}^{n}\gamma_{ik}\ln(p_k)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}\right)}{\partial \ln(p_j)}=$$

$$\frac{t_i p_i \delta_{ij}}{m}-\frac{t_j p_j}{m}\left\{\alpha_i+\sum_{k=1}^{n}\gamma_{ik}\ln(p_k)+\beta_i\ln\left(\frac{s}{P}\right)+\frac{\lambda_i}{b(p)}\left[\ln\left(\frac{s}{P}\right)\right]^2\right\}+\frac{s}{m}\left\{\gamma_{ij}-\beta_i\left(\alpha_j+\frac{t_j p_j}{s}+\sum_{k=1}^{n}\gamma_{ik}\ln(p_k)\right)\right\}$$

$$-\frac{\lambda_i\beta_j}{e^{\sum_k \beta_k \ln(p_k)}}\left[\ln\left(\frac{s}{P}\right)\right]^2-\frac{2\lambda_i}{b(p)}\left\{\frac{t_j p_j \ln(s)}{s}-\frac{t_j p_j P}{s}+\ln(s)\left(\alpha_j+\sum_{k=1}^{n}\gamma_{ik}\ln(p_k)+2P\left(\alpha_j+\sum_{k=1}^{n}\gamma_{ik}\ln(p_k)\right)\right)\right\}$$

$$\text{since }\frac{\partial\left(\frac{s}{m}\right)}{\partial \ln(p_j)}=\frac{\partial\left(\frac{m-\sum_k t_k p_k}{m}\right)}{\partial \ln(p_j)}=-\frac{t_j p_j}{m}$$

Compensated Elasticity

$\varepsilon_{ij}{}^{H}=\varepsilon_{ij}{}^{M}+\xi_i w_j$, where $\varepsilon_{ij}{}^{M}$ and ξ_i are the Marshallian and Expenditure elasticities, respectively

Table A.1. Parameter Estimates from GQAIDS in 1995

	Beef	Pork	Poultry	Seafood	Veg.	Fruit	Rice	Other	Dairy	Eggs	Fats
constant (t)	**-2.998**	-13.418	-0.971	1.872	**41.694**	**-81.632**	-4.255	**-65.906**	**-6.807**	4.608	**-7.865**
	0.896	*5.476*	*1.745*	*1.778*	*8.718*	*15.835*	*15.696*	*9.411*	*1.250*	*3.690*	*2.293*
< 6 years of age	1.229	-3.592	-2.061	-3.868	**-63.883**	**25.187**	**-50.584**	-4.726	**7.802**	-3.228	**-4.558**
	0.753	*3.034*	*1.803*	*2.536*	*13.290*	*6.265*	*12.787*	*5.691*	*1.441*	*1.619*	*1.360*
6<=and<14	**1.892**	**-6.551**	-1.278	**-6.183**	**-64.048**	5.768	**-47.686**	-5.883	**3.299**	-2.276	**-3.891**
	0.569	*2.338*	*1.429*	*2.072*	*9.944*	*4.682*	*10.162*	*4.622*	*1.223*	*1.192*	*1.025*
14<=and<22	**1.471**	**-6.298**	-1.206	**-5.347**	**-31.600**	3.450	**-31.946**	6.669	1.312	-1.071	**-2.720**
	0.535	*2.238*	*1.372*	*2.006*	*9.533*	*4.375*	*9.882*	*4.309*	*1.110*	*1.109*	*0.967*
22<=and<59	0.302	-2.679	-2.145	-2.995	**-15.616**	0.227	**-23.118**	1.152	1.300	0.412	-1.491
	0.367	*1.445*	*0.914*	*1.321*	*6.014*	*2.997*	*6.543*	*3.253*	*0.780*	*0.791*	*0.642*
hh size	**-0.278**	**-1.428**	**-1.660**	**-1.307**	**-4.624**	**-5.986**	-4.054	**2.801**	0.155	-0.294	-0.273
	0.090	*0.392*	*0.237*	*0.349*	*1.685*	*0.739*	*1.727*	*0.692*	*0.173*	*0.187*	*0.166*
advanced	0.285	0.040	0.715	1.176	0.664	-1.527	1.937	-0.044	**-1.082**	-0.473	**0.813**
	0.165	*0.634*	*0.376*	*0.539*	*2.760*	*1.352*	*2.709*	*1.231*	*0.325*	*0.350*	*0.292*
high school	0.351	-0.051	0.169	0.777	1.187	1.427	-0.988	-2.894	**-1.024**	-0.161	0.036
	0.176	*0.701*	*0.415*	*0.586*	*3.057*	*1.464*	*3.017*	*1.327*	*0.335*	*0.379*	*0.320*
refrigerator	**0.455**	**-2.542**	0.286	-1.081	**-9.930**	**-4.287**	**-9.148**	-2.151	0.165	-0.501	**-1.245**
	0.136	*0.562*	*0.333*	*0.469*	*2.442*	*1.152*	*2.445*	*1.075*	*0.289*	*0.293*	*0.250*
income/1000	**0.035**	0.027	**0.145**	**0.146**	0.113	**0.155**	-0.025	**-0.272**	-0.021	**-0.087**	0.002
	0.006	*0.025*	*0.015*	*0.022*	*0.114*	*0.054*	*0.108*	*0.055*	*0.011*	*0.015*	*0.011*
constant (z)	**-0.019**	-0.003	0.006	-0.014	**-0.070**	0.009	**0.027**	**-0.074**	**0.173**	**-0.029**	-0.006
	0.003	*0.008*	*0.004*	*0.007*	*0.006*	*0.010*	*0.006*	*0.009*	*0.008*	*0.003*	*0.003*
constant (α)	0.011	**0.068**	-0.009	**-0.039**	**0.072**	**0.396**	**0.099**	**0.291**	**0.037**	0.024	**0.050**
	0.005	*0.021*	*0.008*	*0.009*	*0.020*	*0.043*	*0.030*	*0.026*	*0.011*	*0.012*	*0.009*
ln (s/P)	**0.020**	0.028	**0.045**	**0.122**	**0.159**	**-0.174**	**0.078**	**-0.107**	**-0.197**	0.026	0.000
	0.008	*0.028*	*0.010*	*0.012*	*0.015*	*0.031*	*0.019*	*0.025*	*0.019*	*0.010*	*0.010*
ln p(beef)	**0.016**	-0.004	0.002	0.001	-0.003	**-0.007**	0.001	-0.002	0.001	-0.002	-0.001
	0.004	*0.002*	*0.001*	*0.001*	*0.001*	*0.002*	*0.001*	*0.002*	*0.001*	*0.001*	*0.001*
ln p(pork)		**0.111**	**-0.007**	-0.005	-0.003	**-0.022**	**-0.026**	**-0.013**	**-0.015**	0.000	**-0.017**
		0.015	*0.002*	*0.002*	*0.003*	*0.007*	*0.003*	*0.005*	*0.003*	*0.002*	*0.002*
ln p(poultry)			**0.026**	0.001	**-0.006**	-0.003	**-0.010**	0.000	**0.003**	-0.001	**-0.005**
			0.006	*0.001*	*0.002*	*0.003*	*0.002*	*0.002*	*0.001*	*0.001*	*0.001*
ln p(seaf)				**0.029**	**-0.011**	0.002	**-0.011**	-0.003	**0.006**	**-0.005**	**-0.004**
				0.006	*0.002*	*0.003*	*0.002*	*0.002*	*0.002*	*0.001*	*0.001*
ln p(veg)					**0.033**	-0.003	-0.005	0.001	-0.001	0.000	-0.002
					0.007	*0.004*	*0.002*	*0.003*	*0.003*	*0.002*	*0.002*
ln p(fruits)						**0.108**	0.002	**-0.032**	**-0.029**	-0.003	**-0.014**

	0.008	*0.004*	*0.006*	*0.004*	*0.003*	*0.003*
ln p(rice)		**0.048**	0.007	-0.001	-0.001	-0.004
		0.012	*0.003*	*0.002*	*0.002*	*0.002*
ln p(other)			**0.066**	**-0.019**	-0.002	-0.002
			0.007	*0.003*	*0.002*	*0.002*
ln p(dairy)				**0.060**	-0.001	**-0.005**
				0.007	*0.001*	*0.001*
ln p(eggs)					0.013	0.001
					0.007	*0.001*
ln p(fats)						**0.053**
						0.006

Note: Values in bold identify elasticities statistically different from 0 at the 0.01 level of significance.

Table A.2. Parameter Estimates from GQAIDS in 2003

	Beef	Pork	Poultry	Seafood	Veg.	Fruit	Rice	Other	Dairy	Eggs	Fats
constant (t)	-1.206	1.848	0.934	**-9.672**	5.804	**-34.490**	-5.156	11.568	**-38.726**	1.287	3.106
	1.109	*4.510*	*2.623*	*3.138*	*16.038*	*9.368*	*13.310*	*9.801*	*3.686*	*3.501*	*1.309*
< 6 years of age	-1.841	-7.861	1.691	-13.652	-51.196	35.573	**-76.707**	5.136	**37.246**	1.325	-6.712
	1.682	*8.056*	*4.156*	*6.442*	*39.422*	*17.907*	*20.051*	*16.524*	*8.769*	*5.650*	*3.394*
6<=and<14	0.181	-3.390	2.862	-3.934	-12.953	**38.479**	**-30.219**	-0.749	**21.144**	4.600	-3.176
	1.010	*5.238*	*3.158*	*4.149*	*24.427*	*14.005*	*12.111*	*11.722*	*7.308*	*4.088*	*1.932*
14<=and<22	0.076	-6.224	2.383	-8.370	-38.734	1.902	**-31.576**	-13.030	-10.339	-2.233	**-6.801**
	0.861	*4.699*	*2.925*	*3.922*	*23.358*	*14.172*	*11.061*	*11.366*	*6.894*	*3.690*	*2.005*
22<=and<59	-0.040	1.137	0.330	2.475	5.378	**28.052**	-2.967	1.792	6.018	2.666	0.055
	0.499	*2.714*	*1.647*	*2.201*	*13.126*	*7.430*	*6.227*	*6.104*	*3.876*	*2.046*	*1.067*
hh size	0.005	1.328	-0.564	-0.019	4.480	**-6.887**	**6.123**	0.421	**-5.167**	-0.701	**1.646**
	0.175	*0.862*	*0.483*	*0.732*	*4.113*	*2.463*	*2.135*	*2.015*	*1.075*	*0.660*	*0.339*
advanced	0.747	-5.017	-2.790	-2.350	-22.551	9.732	**-15.406**	-0.927	**18.884**	-0.373	**-2.719**
	0.448	*2.143*	*1.302*	*1.809*	*10.472*	*5.431*	*4.970*	*4.718*	*3.226*	*1.617*	*0.849*
high school	0.388	-4.277	-2.120	-1.079	-10.061	6.365	-7.761	-3.432	**7.882**	-0.953	-1.904
	0.457	*2.203*	*1.322*	*1.952*	*10.626*	*5.296*	*4.916*	*4.739*	*3.190*	*1.661*	*0.844*
refrigerator	-0.407	1.354	1.246	2.807	6.241	0.710	1.069	**-14.171**	1.427	-0.512	0.218
	0.308	*1.748*	*0.924*	*1.642*	*8.504*	*4.498*	*3.955*	*3.636*	*2.504*	*1.285*	*0.657*
income/1000	0.012	0.043	**0.096**	**0.113**	-0.076	-0.113	0.057	**-0.218**	**0.092**	**-0.089**	**-0.052**
	0.006	*0.028*	*0.016*	*0.022*	*0.116*	*0.067*	*0.077*	*0.075*	*0.036*	*0.020*	*0.012*
constant (z)	0.000	**-0.018**	**-0.010**	0.000	**-0.018**	0.008	-0.002	0.001	**0.045**	-0.002	**-0.004**
	0.002	*0.005*	*0.003*	*0.003*	*0.002*	*0.004*	*0.003*	*0.004*	*0.005*	*0.001*	*0.001*
constant (α)	0.004	0.000	0.029	**0.137**	0.037	**0.203**	**0.112**	0.002	**0.469**	0.007	0.000
	0.019	*0.053*	*0.034*	*0.035*	*0.026*	*0.045*	*0.046*	*0.057*	*0.055*	*0.020*	*0.012*
ln (s/P)	-0.001	**0.089**	**0.049**	-0.019	**0.106**	-0.042	0.007	0.024	**-0.253**	0.014	**0.025**
	0.011	*0.031*	*0.021*	*0.021*	*0.014*	*0.026*	*0.022*	*0.031*	*0.033*	*0.010*	*0.007*
ln p(beef)	**0.010**	**0.005**	**-0.004**	0.002	**-0.005**	0.003	0.000	**-0.008**	-0.001	0.000	-0.001
	0.003	*0.002*	*0.002*	*0.001*	*0.002*	*0.002*	*0.001*	*0.001*	*0.004*	*0.001*	*0.001*
ln p(pork)		**0.032**	0.000	**-0.012**	-0.007	-0.008	**-0.011**	0.000	-0.008	0.004	0.003
		0.013	*0.004*	*0.004*	*0.005*	*0.005*	*0.004*	*0.004*	*0.011*	*0.003*	*0.003*
ln p(poultry)			0.002	0.003	0.001	0.000	0.004	0.000	-0.009	**-0.003**	**0.008**
			0.007	*0.003*	*0.003*	*0.004*	*0.003*	*0.003*	*0.007*	*0.001*	*0.002*
lnp(seaf)				**0.046**	-0.002	-0.002	**-0.010**	0.005	**-0.025**	-0.002	-0.003
				0.005	*0.003*	*0.004*	*0.003*	*0.004*	*0.007*	*0.001*	*0.002*
ln p(veg)					**0.028**	0.000	0.004	**-0.011**	0.000	**-0.009**	0.002
					0.006	*0.004*	*0.003*	*0.004*	*0.005*	*0.002*	*0.002*
ln p(fruits)						-0.007	**-0.008**	**0.022**	-0.008	**0.007**	-0.001

	0.008	*0.003*	*0.005*	*0.008*	*0.002*	*0.002*
ln p(rice)		**0.038**	**-0.007**	**-0.017**	0.000	**0.008**
		0.007	*0.003*	*0.007*	*0.002*	*0.002*
ln p(other)			-0.005	0.009	0.002	**-0.006**
			0.012	*0.011*	*0.001*	*0.002*
ln p(dairy)				**0.058**	0.001	0.001
				0.015	*0.003*	*0.002*
ln p(eggs)					0.002	0.000
					0.004	*0.001*
ln p(fats)						**-0.010**
						0.002

Note: Values in bold identify elasticities statistically different from 0 at the 0.01 level of significance.