A Dynamic Analysis of Food Demand Patterns in Urban China

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Abstract

Previous researchers have encountered difficulties in rationalizing the extremely high expenditure elasticities estimated for grain demanded by urban Chinese households. The high grain expenditure elasticities, which usually translate into high income elasticities, are doubtful for making a long-term prediction of grain demand in China. Unlike most previous studies using only statistic models, this study employs a dynamic Almost Ideal Demand System (DAIDS) incorporating demographic variables to explore the impact of habit effects as well as demographic impacts on household level food demand pattern in urban China. Most dynamic elements and demographic variables are found significant. The theoretical demand properties cannot be rejected in the DAIDS model while they are frequently rejected for static models. The dynamic AIDS model clearly provides improvement in estimating food demand elasticities as compared with their static counterparts.

Keywords: dynamic almost ideal demand system, habit effect, grain, urban China.

I. Introduction

China, with its population surpassing the 1.3 billion mark in 2005, represents the largest market for agricultural goods and is among the fastest growing economies in the world during the last two decades. These attributes may be the main reasons that China has attracted considerable attentions from economists in efforts to assess its abilities to deal with "Who Will Feed China?" Understanding China's food demand structure for predicting its long-term food demand, especially grain demand, is essential in these investigations. In this paper, we will focus on analyzing the expenditure elasticity of grain demand by urban Chinese households because of its role in a long-term projection.

Most of previous studies on urban China food demand analysis used static models, such as extended linear expenditure system (ELES, Lewis and Andrews, 1989), linear expenditure system and quadratic expenditure system (LES and QES, Chern and Wang, 1994), linear almost ideal demand system (LA/AIDS, Wu, et al., 1995), quadratic almost ideal demand system (QAIDS, Liu 2003). These studies often offered conflicting elasticity estimates (Chern, 1997). In particular, many studies found high expenditure elasticities (nearly or greater than unity) for grain (e.g., Chen, 1996; Han and Wahl, 1998; Chern, 1997, 2000; Liu, 2003). The high grain expenditure elasticities usually translate to high income elasticities where, if used for forecasting, would yield doubtful predictions for long-term grain demand in China (World Bank, 1997). Accuracy of estimating grain demand elasticity is important because of its implication to China's long-term food security as well as world food security.

Grain is the Chinese traditional main staple food. Most Chinese purchase a certain amount of grains before allocating their remaining budget among other non-staple foods, such as animal products, fruits and the like. Therefore, we would expect a slow adjustment or habit effect for grain consumption among China's urban households. Because static demand models assume that the consumer can immediately and fully adjust to changes in prices and income and ignore the dynamic structure caused by habit formation, they might lead to functional form misspecifications and a relatively low explanatory power (Shukur, 2002). We suspect that lack of incorporating dynamic elements leads to the doubtful high grain elasticity.

In this paper, we employ a dynamic generalization of the almost ideal demand system (AIDS) developed by Ray (1984) to analyze the consumption patterns based on a two-year urban China household panel data. Ray's dynamic AIDS (DAIDS) model incorporates habit effect elements from past consumption and is derived from a generalized cost function used by Deaton and Muellbauer (1980). It satisfies globally homogeneous of degree one in current price (Blanciforti et al., 1986), adding-up, and symmetry.

This study contributes to the existing literature in three ways. First, even though various dynamic almost ideal demand systems (Anderson and Blundell 1983 and 1984, Ray 1984, Blanciforti et al. 1986, Shukur 2002, and Eakins and Gallagher 2003) have been applied to demand analysis after Deaton and Muellbauer published their AIDS model and have found improvement in elasticity estimation and functional form specification, to our best knowledge, there is no dynamic model on food demand in China. Our study will fill the void. Second, there are little, if any existing dynamic models incorporate demographic variables. We will explore the dynamic effects as well as the impact of demographic variables on the demand model specification. Third, as stated previously, the existing literature of food demand in urban China found doubtful high expenditure elasticities for grain (e.g., Chen, 1996; Han and Wahl, 1998; Chern, 1997, 2000). It is important to examine whether or not the ignorance of dynamic behavior caused the over estimation of grain expenditure elasticities. Our results indeed confirm this suspect.

The remainder of this paper is organized as follows. In section II, we present the dynamic almost ideal demand system by incorporating habit effects and other dynamic parameters together with demographic variables. In section III, the two-year panel data set used in this paper is discussed. In section IV, econometric results and elasticity estimates are reported and interpreted. In section V, additional results from unrestricted models incorporated with demographic variables and restricted models without demographic variables are presented. Finally, in section VI, we draw conclusions based on this study and propose possible future extension.

II. Methodology

Since Deaton and Muellbauer (1980) published their famous "Almost Ideal Demand System", AIDS had quickly become one of the most widely used demand models because of its theoretical consistency and functional flexibility. It satisfies the axioms of choice and allows aggregation over consumers. Deaton and Muellbauer also proposed to convert the nonlinear AIDS model into simplified linear AIDS (LA/AIDS) model by using so called "stone index" to replace the nonlinear price index. Because of its simplicity and less computation burden, LA/AIDS model was very popular for empirical demand analysis (Green and Alston, 1990). Green and Alston (1990, 1991) also hinted that there might be some econometric problems associated with the "stone index". Eales and Unnevehr (1993) pointed out a simultaneity issue of the stone index. It could be correlated with the error term because the budget shares appear on both side of the equation. Buse (1994) also argued that if the price index P was not exactly (linearly) proportional to the stone index P*, there was an errors-in-variable problem coming from the correlation between the stone index and the error term. Hahn (1994) suggested that LA/AIDS model was "at best only locally consistent with demand theory" and it had no satisfactory theoretical properties because "they can violate the symmetry restrictions of consumer demand theory for most combinations of prices and expenditures." Hahn advised empirical demand analysts to employ AIDS instead of LA/AIDS or find other linear models consistent with utility maximization. These arguments suggest that the LA/AIDS estimates may be biased and inconsistent. In this paper, we will only demonstrate the differential results from both LA/AIDS and LA/DAIDS models and compare the difference between linear and nonlinear models.

Even though many valuable results have been obtained from the AIDS model, Deaton and Muellbauer (1980) pointed out that influences other than current prices and current total expenditures should be considered in the model. Among others, they suggested generalizing and improving their AIDS model by incorporating dynamic elements. Since then, various dynamic AIDS models have been developed and showed improvement in demand estimation (Anderson and Blundell, 1983 and 1984; Ray, 1984; Blanciforti *et al.,* 1986; Shukur, 2002; and Eakins and Gallagher, 2003.) The rationality behind incorporating dynamic elements is that the static models assume consumers react instantaneously to the new equilibrium when prices or income change. Of course, it is not realistic in the real world. "Dynamic adjustment to price and income changes is more plausible" (Klonaris and Hallam, 2003). Most likely, consumers will have some delay in response to price or income changes. In other words, adjustments towards a new equilibrium may be spread over several periods (Phlips 1983).

There are two types of lags (Gracia, Gil, and Angulo, 1998): inertia and habit persistence. Inertia means consumers only slowly adjust their consumption behavior to changes of prices and income. The dynamic model associated with this kind of lag is an autoregressive specification where endogenous variable changes depend on both current and previous exogenous variables; Habit persistence means past consumption will affect consumers' current consumption. "In other words, past consumption exerts an important effect on current consumption because some habits have been developed. A partial adjustment model is behind this hypothesis where changes in consumption depend on actual values of exogenous variables and on past consumption levels." (Gracia, Gil, and Angulo, 1998).

As summarized by Gracia, Gil, and Angulo (1998), there are mainly three different ways to incorporate dynamic elements in the demand analysis: (1) modifying the intercept term α_i in the demand system equations (Blanciforti and Green,1983; Blanciforti et al., 1986; Alessie and Kapteyn 1991; Edgerton 1997; Klonaris and Hallam, 2003); (2) estimating the model in the first or four differences (Eales and Unnevehr 1988, Moschini and Meilke 1989) and (3) using a generated dynamic framework such as Anderson and Blundell (1983) and Ray (1984) (Burton and Young 1992, Kesavan *et al.* 1993, Gracia, Gil, and Angulo 1998). Among those dynamic models, the model developed by Ray (1984) is derived directly from a generalized AIDS cost function and satisfies all economic properties in duality. Ray's model take care of the second type of lag, habit persistence, by incorporating past consumption. In addition, as we mentioned above, grain is the Chinese traditional main staple food. We would assume the existence of habit persistence in grain consumption. Particularly, the way which Ray incorporates habit effects implies habit having an income effect on current demand decision. This feature is relevant because of our concern on expenditure elasticities. Given the relative high Engel Coefficients in China, we would expect the model fits China data well. The other dynamic models such as Anderson and Blundell (1983) are not relevant to this study because we have panel data only for two years, and this encounter no problems of serial correlation, stationarity, and co-intergration in time-series analysis.

Following Ray (1984), we define the dynamic AIDS cost function as

$$\ln c(u, p_t) = \alpha_0 + \sum_i \delta_i e_{it-1} + \sum_i \alpha_i \ln p_{it} + \frac{1}{2}\sum_i \sum_j (\tilde{\gamma}_{ij} + \theta_{ij} x_{t-1}) \ln p_{it} \ln p_{jt} + u\beta_0 \prod_i p_{it}^{\beta_i + \eta_i x_{t-1}}$$

Where $e_{it\text{-}1}$ represents the lagged expenditure of food item i, p_{it} stands for the current price of item i, $x_{t-1} = \Sigma_i\, e_{it\text{-}1}$ is the lagged aggregate expenditures, u is the unobservable utility variable, and $\alpha_i, \delta_i, \beta_i, \eta_i, \theta_{ij}, \gamma_{ij}$ $(=(\tilde{\gamma}_{ij} + \tilde{\gamma}_{ji})/2)$ are parameters to be estimated. The parameters, θ_{ij} 's, η_i's, and δ_i's are the dynamic elements of particular interest in this study. As pointed out by Ray (1984), the η_i's enable the consumer's marginal budget share of an item to change over the sample period. The θ_{ij} 's enable the real expenditure compensated cross price responses to also vary over the sample period. Furthermore, the parameters, δ_i's capture the consumption persistence, i.e. the habit effects.

By applying Shephard's Lemma to the current price of each item and substituting the unobservable utility variable u, we can obtain the following dynamic AIDS budget share equations:

$$w_{it} = \alpha_i + \Sigma_j\, (\gamma_{ij} + \theta_{ij}\, x_{t-1})\ln p_{jt} + (\beta_i + \eta_i\, x_{t-1})\ln (x_t / P_t^*) + \varepsilon_{it}, \qquad (1)$$

where w_{it} represents the expenditure share allocated to the ith food item, ε_{it} denotes the stochastic error term, P_t^* denotes the dynamic AIDS price index, and x_t is the total expenditure. Similar to its static counterpart, P_t^* is given by

$$\ln P_t^* = \alpha_0 + \Sigma_i\, \delta_i\, e_{it-1} + \Sigma_i\, \alpha_i \ln p_{it} + 0.5 * \Sigma_i\, \Sigma_j\, (\gamma_{ij} + \theta_{ij}\, x_{t-1})\ln p_{it} \ln p_{jt} \qquad (2)$$

To analyze the demographic effect, we also incorporate nine demographic variables. These demographic variables are included by replacing the α_i in equations (1) and (2) with:

$$\alpha_i = \alpha_i^* + \alpha_{i1}\, HSIZE + \alpha_{i2}\, MALE + \alpha_{i2}\, AGE + \alpha_{i3}\, AGE512 + \alpha_{i4}\, EDUH + \alpha_{i5}\, EDUM + \alpha_{i6}\, SD + \alpha_{i7}\, GD + \alpha_{i8}\, HN \quad (3)$$

where: HSIZE: number of household members,

MALE: gender of the householder, 1: male, 0: female;

AGE: age of householder;

AGE512: indicator of household with children between 5 and 12 years old, 1: yes, 0: otherwise;

EDUH: indicator of householder with at least a bachelor degree, 1: yes, 0: otherwise;

EDUM: indicator of householder with at least middle school education but with no bachelor or above degree, 1: yes, 0: otherwise;

SD: household is in Shandong province, 1: yes, 0: otherwise;

GD: household is in Guangdong province, 1: yes, 0: otherwise;

HN: household is in Henan, 1:yes, 0: otherwise.

In the following context, unless noted, α_i in the system is α_i in equation (3).

The static AIDS model is similar to its dynamic counterpart without all dynamic parameters. The differences lie in that there are no lagged expenditure e_{it-1} and lagged aggregated expenditure x_{t-1} terms in the static AIDS models. In other words, static AIDS model is nested within DAIDS model by restricted $\delta_{i,}, \theta_{ij}$ and η_i to zeroes. The LA/AIDS and LA/DAIDS models are the nested models using an approximation for the price index. Specifically, the only difference is the price index $\ln P_t^*$ is replaced with the Stone price index, (=$\Sigma_i\ w_{it}\ lnP_{it}$) for LA/AIDS and (=$\Sigma_i\ w_{it-1}\ lnP_{it}$) for LA/DAIDS. In order to examine the performance of the DAIDS, it is important to compare it with other three widely used AIDS models. These three alternative models are listed below:

LA/AIDS: $w_{it} = \alpha_i + \Sigma_j\ \gamma_{ij} \ln p_{jt} + \beta_i \ln (x_t / P_t^*) + \varepsilon_{it}$, where $\ln P_t^* = \Sigma_i\ w_{it} \ln P_{it}$

LA/DAIDS: $w_{it} = \alpha_i + \Sigma_j\ (\gamma_{ij} + \theta_{ij}\ x_{t-1}) \ln p_{jt} + (\beta_i + \eta_i\ x_{t-1}) \ln (x_t / P_t^*) + \varepsilon_{it}$,

where $\ln P_t^* = \Sigma_i\ w_{it-1}\ lnP_{it}$

AIDS: $w_{it} = \alpha_i + \Sigma_j\ \gamma_{ij} \ln p_{jt} + \beta_i \ln (x_t / P_t^*) + \varepsilon_{it}$,

where $\ln P_t^* = \alpha_0 + \Sigma_i\ \alpha_i \ln p_{it} + 0.5 * \Sigma_i\ \Sigma_j\ \gamma_{ij} \ln p_{it} \ln p_{jt}$

In the DAIDS model, the consumer's perception of current period "fixed cost" ($\ln P_t^*$) depends on current prices p_{it} and on his 'standard of living' in the last period as measured by lagged expenditure ($\Sigma_i\ \delta_i\ e_{it-1}$). The parameter δ_i measures the habit effects on the price "index", $\ln P_t^*$. We can see that in this manner, the habit effects influence the demand function only through income effect. For most developed countries with low Engel coefficients, the income effects can be limited and this manner of incorporating habit effect in the model may be not "entirely satisfactory" (Blanciforti, at el. 1986). Note that, Blanciforti, at el. (1986) proposed an alternative DAIDS model, where they replaced the $\Sigma_i\ \delta_i\ e_{it-1}$ in Ray's DAIDS model with $\delta_i\ e_{it-1}$ for individual commodity. The problem with this method is that the economic restrictions, homogeneity and adding-up, only hold locally. China, the largest developing country in the world, has relatively high Engel coefficients. In 2004, Engel coefficients for urban China and rural China still stand at 37.7% and 47.2%, respectively (China Statistical Yearbook 2005.) We would expect to see a significant income effect on food demand from the habit consumption side and expect this model to fit China data well.

Similar to the static AIDS models, the dynamic AIDS model can be used to test homogeneity, adding-up and symmetry. The following restrictions of economic theory can be readily imposed on this system (Blanciforti, et al. 1986):

Homogeneity: $\Sigma_j \gamma_{ij} = \Sigma_j \theta_{ij} = 0 \ \forall_i$.

Adding up: $\Sigma_i \alpha_i = 1$, $\sum_{i=1}^{8} \alpha_{ik} = 0$, for $k = 1,2,\cdots,9$ and $\Sigma_i \beta_i = \Sigma_i \eta_i = \Sigma_i \gamma_{ij} = \Sigma_i \theta_{ij} = 0 \ \forall_j$

Symmetry: $\gamma_{ij} = \gamma_{ji}$, $\theta_{ij} = \theta_{ji} \ \forall_{i,j}$.

The following additional restrictions are imposed in the systems incorporating demographic variables to satisfy the adding-up condition:

$$\sum_{i=1}^{8} \alpha_{ik} = 0, \text{ for } k = 1,2,\cdots,9$$

Due to the covariance matrices of the error terms being singular, we have to drop one of the budget share equations in estimation. In addition as noted earlier, we do not encounter serial correlation because we have only panel data for two years. Nevertheless, as noted by Blanciforti and Green (1982), the differences in the estimates for their dynamic model with or without considering the lagged correlation are small. They stated, "It appears that if autocorrelation reflects a misspecification of the model, then the inclusion of habit effects corrects for most of this error." Therefore, ε_{it} is treated as a classical error with zero mean and constant variance in this study.

Following Green and Alston (1990), the Marshallian price elasticities and expenditure elasticities are calculated as follows:

For the LA/AIDS model:

Expenditure elasticity: $E_i = 1+\beta_i/w_i$

Marshallian price elasticities: $E_{ij} = \gamma_{ij} / w_i - \lambda_{ij}$

For the dynamic LA/AIDS model:

Expenditure elasticity: $E_i = 1+(\beta_i + \eta_i x_{t-1})/w_i$

Marshallian price elasticities: $E_{ij} = (\gamma_{ij}+\theta_{ij} x_{t-1})/w_i - \lambda_{ij}$

For the AIDS model:

Expenditure elasticity: $E_i = 1+\beta_i/w_i$

Marshallian price elasticities: $E_{ij} = [\gamma_{ij} - \beta_i (\alpha_j + \Sigma_k \gamma_{kj} \ln P_k)]/w_i - \lambda_{ij}$

For the dynamic AIDS model:

Expenditure elasticity: $E_i = 1+(\beta_i + \eta_i x_{t-1})/w_i$

Marshallian price elasticities: $E_{ij} = [(\gamma_{ij} + \theta_{ij} x_{t-1}) - (\beta_i + \eta_i x_{t-1})(\alpha_j + \Sigma_k \gamma_{kj} \ln P_k)]/w_i - \lambda_{ij}$

Where λ_{ij} is Kroneker's delta: $\lambda_{ij}=1$ for $i=j$ and 0 otherwise, x_{t-1}, w_i, and $\ln P_k$ will be calculated at sample means.

Given the relative high Engel coefficients in China, we would expect necessity food items have positive effects on "fixed cost" ($\ln P_t^*$) and δ_{grain}, δ_{oil}, δ_{eggs}, and $\delta_{fresh\ vegetables}$ to be positive. For meat, fish, and poultry, we would expect these more luxury food items have negative effects on "fixed cost" and δ_{meat}, δ_{fish}, and $\delta_{poultry}$ to be negative. The intuition behind these expectations is that regarding income effect, necessity items would put more pressure on consumers when they make expenditure decisions because they have to consume a certain amount of these food items no matter how poor they are. "Fixed cost" for these items is therefore relatively high. For more luxury items, such pressure is much less, because consumers may simply choose to consume less or even none of such items if their incomes don't allow them to do so. The "fixed cost" is therefore relatively low. Even though δ_i does not enter into the elasticity computation directly, it appears to affect the estimated magnitude of the corresponding β_i. As to be shown later, a positive δ_i is associated with a decreased β_i while a negative δ_i is paired with an increased β_i. These results indicate that without considering the dynamic specification, the expenditure elasticity for a necessity good would be overestimated while that for a luxury good would be underestimated in the static models. Because grain is the traditional Chinese staple food, we would expect a significant positive δ_i of grain that drive the grain expenditure elasticity lower.

In the AIDS model, a negative β_i implies a necessity good while a positive β_i indicates a luxury good (i.e., with respect to the total expenditure of goods included in the model). We would expect negative β_i's for grain, oil, eggs, fresh vegetables and positive β_i's for meat, poultry and fish.

Because adding-up is automatically satisfied, we only impose homogeneity and symmetry in the systems. Homogeneity and symmetry will be tested with Wald test in the unrestricted model. Since static model is nested within the dynamic model, we will perform chi-square test to justify the adoption of dynamic model.

III. Data

A panel dataset from four representative provinces, Shandong, Henan, Guangdong, and Heilongjiang in China is used. The dataset was obtained from the urban household surveys conducted by the National Bureau of Statistics (NBS) in China and covers the years, 2002 and 2003. The four provinces cover Southern China (Guangdong), Northern China (Heilongjiang), developed and offshore area (Guangdong and Shandong), and less-developed and inland area (Henan and Heilongjiang). Guangdong is the richest province among them. For the first time, a revision by keeping the household IDs the same through consecutive year survey adopted by the NBS in 2003 facilitates the creation of panel data for these two years. To bring as little noise as possible into the system, we adopt a strict same household matching criteria except for using same household ID. Two households respectively in 2002 and 2003 datasets are treated as the same household only when the following three criteria are met: First, household ID, province and city or county codes, first and second (if applies) household member's relation to householder, and householder's ethnic, gender, and marriage status are the same. Second, first and second household members' age is one year more in 2003 than 2002. Third, household members' education level in 2003 is not lower than 2002. We drop the whole Jiangsu province data because we could not find any household in Jiangsu province that meets the above criteria.[1]

The households selected in the surveys are drawn from a large population, based on proportionate stratification, sampling one out of every 10,000 households. This database contains detailed household-level data on food consumption. The survey contains 1,486 variables covering urban household expenditure, income, production, consumption, as well as household demographic variables. Detailed discussion on the survey data can be found in Fang, et al. (1998). Totally 2,914 households from this panel data set are used in this study.

Eight important food items with extremely few households with zero consumption are selected to avoid censoring problems. They are grain, oil, eggs, meat, poultry, fish, fresh vegetables, and fresh fruits. The percentages of households with positive consumption are reported in table 1. The food item with the lowest consumption percentage is oils, with 88.88% in 2002 and 89.29% in 2003. That means there were nearly 11% of households who didn't consume oils in 2002 and 2003. For other food

[1] The NBS of China later confirmed our finding on Jiangsu data that the same household ID doesn't mean same household in both 2003 and 2002 dataset.

items, household consumption percentages are no lower than 95%. These eight foods accounted for about 50.78% of total food expenditures[2] in these four provinces. Grain consists of rice and flour; meat contains pork, beef and mutton; poultry includes chicken and duck. The average total expenditure for the eight selected food items and disposable income per household from the four provinces are reported in table 2. From 2002 to 2003, household disposable incomes increased for all four provinces ranging from 4.11% to 12.08%. The total expenditures for the eight food items increased for all provinces as well except Guangdong province where it was dropped merely 0.07%. The poorest province, Heilongjiang, not only posts the highest disposable income change, also has the biggest change in total food expenditure. On the contrary, in the richest province, Guangdong, its disposable income was almost twice as large as that of the second highest province, but it had is the lowest percentage change in disposable income and posted a negative growth in total food expenditure. All of the changes in food expenditure are smaller than the changes in total disposable income. This phenomenon is consistent with the so-called Engel's law. The average consumption per household of the eight selected food items are reported in table 3. The four provinces show similar consumption patterns in grain, oil, eggs, fresh vegetables, and fresh fruits. Households in Guangdong, the richest province, consume far more meat, poultry, and fish. Average expenditures per household are reported in table 4 and average budget shares per household are reported in table 5. From table 5, we can see that in all four provinces, households allocated a large percentage of budgets on meat, grain, and fresh vegetables. In Guangdong province, households allocate smaller budget shares on grain and eggs while spent relatively much

[2] Other major food items not included in this study are: starch, dry bean and bean-made product, shrimp, dry vegetable, sauces, sugar, cigarette, wine, drink, tea, dry fruit, puddings, milk, and food away from home.

more on poultry and fish. Compared with Heilongjiang province, households in Henan province allocated larger budget shares on grain, eggs, and fresh vegetables but a smaller share for fresh fruits; In Shandong province, households spent relatively more on eggs and meat but less on oil and fresh fruits.

IV. Empirical Results and Interpretation

We estimate the four AIDS models, LA/AIDS, LA/DAIDS, AIDS, and DAIDS incorporating nine demographic variables. Adding-up is automatically satisfied and homogeneity and symmetry are imposed. In this section, we report and discuss the estimation results using this model specification. Dynamic models contain lagged expenditure for each individual food item and lagged total expenditure. The dynamic elements are used to test whether there are habit effects in urban food consumption in China.

An iterative Seemingly Unrelated Regressions (ITSUR) procedure in the SAS package is employed for estimation. The parameter α_0 is set to be a-priori the log of the lowest total expenditure for the eight food items by household following Deaton and Muellbauer (1980). The budget share function for fresh fruits is dropped in estimation to avoid the singularity problem.

Appendix table 1 presents the full estimation results for the four AIDS models: linear AIDS (LA/AIDS) model, linear dynamic AIDS (LA/DAIDS) model, AIDS model, and dynamic AIDS (DAIDS) model. Most parameters including dynamic elements are found significant at 5% significance level for all four models. But only AIDS and DAIDS models yield reasonable signs for most parameters. In the DAIDS model, except eggs, all of the estimated β*'s* are found significant at 5% level or lower. The estimated β*'s* are negative for all necessity food items (grain, oil, eggs, and fresh vegetables) and positive for all more luxury food items (meat, poultry, and fish) as expected. Except for the oils, the estimated *β's* from AIDS model have the same sign as DAIDS model. While LA/AIDS and LA/DAIDS models provide mixed signs for *β's*. The sign of β determines the calculated "luxury" or "normal" food items. We can see that the signs of *β's* from DAIDS model are the most plausible. The complete sets of price elasticities estimated from the fours models are reported in Appendix table 2. The own-price elasticities for the four AIDS models are also reported in table 6. All of the own-price elasticities are negative for four models as expected. The four models provide similar own price elasticities. All four models categorize oil and poultry as elastic goods while label the others as inelastic ones. The only noticeable own price elasticity difference lies in grain. The absolute values of own price elasticities for grain are close to unit for LA/AIDS, LA/DAIDS, and AIDS models. But grain's own price elasticity from DAIDS model is only –0.728. These results mean that price changes will only have a large effect on the demand for oil and poultry but less influence on other goods.

The expenditure elasticities estimated for the four AIDS systems are reported in table 7. All expenditure elasticities are positive, meaning that all food items selected are normal goods. For the DAIDS models, grain, oils, eggs, and fresh vegetables can be categorized as necessity items with expenditure elasticities less than one. As expenditures on these goods may increase with rising income, but not as fast as income, the proportion of expenditure on these goods falls as income rises. The expenditure elasticities for meat, poultry, fish, and fresh fruits are all larger than one. Therefore, as income increases, the expenditure for these products would raise more relative to other foods such as fresh vegetables. These results also imply that the proportion of expenditure on these goods may increase as income rises. Note that these elasticities are with respect to the total eight food item expenditures and not total expenditures (or income). The magnitudes of income elasticities depend upon the effect of income change on the expenditure of these eight food items. If this income elasticity is less than unity (which is mostly likely), the income elasticities for these eight food items would be smaller than the expenditure elasticities estimated in this study.

In table 7, the LA/AIDS and dynamic LA/AIDS models have high grain expenditure elasticities of 1.225 and 1.359, respectively, and low expenditure elasticities for meat of 0.848 and 0.766 and poultry of 0.727 and 0.576. These results are similar to previous findings of high expenditure elasticities for necessity items and low elasticities for more luxury items from LA/AIDS models (Chern and Wang 1994; Chen 1996). As Shukur (2002) pointed out that static LA/AIDS model might be misspecified, we are not surprised to see these results. The AIDS model delivers much better results with a grain expenditure elasticity of 0.831 and 1.191 for meat. Fish and poultry have the highest expenditure elasticities, which seem to be plausible. But the grain's elasticity still seems doubtfully high. Most importantly, the theoretical constraints are not satisfied for the AIDS model. Both homogeneity and symmetry are rejected at 5% level from a Wald test. Encouragingly, the dynamic AIDS model not only delivers a much more reasonable set of expenditure elasticities for almost all of the food items we selected but also satisfies all the theoretical constraints. Grain has the lowest expenditure elasticity at 0.538, which appeared to be consistent with declining per capita consumption of grain observed in recent years in urban China. We do not believe that grain is an inferior good but expect low expenditure elasticity. Meat, poultry, fish, and fresh fruits all have expenditure elasticities larger than one, meaning that the urban households will consume more of these food items at a higher rate than other foods when their income increases. Both homogeneity and symmetry cannot be rejected at 5% level from the Wald test for the DAIDS model. Furthermore, the Chi-square tests for both restricted and unrestricted models suggest that the hypotheses test for dynamic elements being all equal to zero are rejected at 5% level, which strongly support the employment of DAIDS to analyze the urban China household food demand pattern.

In table 8, the estimated habit effect coefficients are presented. Most of the estimated δ's are found at 1% or lower significant level except fresh fruits are found at 10% significant level and eggs are not significant. The signs of the δ's are as expected as well, with grain, oil, eggs, fresh vegetables, and fresh fruits being positive and meat, poultry, and fish being negative. Grain and vegetables have the largest estimated δ coefficients at 2.681 and 2.447. These findings are similar to Ray's (1984) where food and clothing have positive δ's while drinks and fuel have negative δ's. As we mentioned earlier, δ's do not enter into elasticity computation directly but affect the expenditure elasticity through β_i. From table 9, we can see that positive δ_i lead to a decreased β_i while negative δ_i lead to an increased β_i except for fresh fruits, which is derived from the adding-up condition. As we noted earlier, these coefficients capture the habit effects of lagged purchases of the individual items. These results support that previous purchases do affect current consumption and strong habit effects exist in urban Chinese households. Without considering these dynamic effects, the demand models may be misspecified and elasticities for necessity items may be overestimated and more luxury food items be underestimated. Given the trend that average income in urban China has been increasing and Engel Coefficients decreasing steadily, we might expect the habit effects would lower the budget shares and therefore reduce the expenditure elasticities for necessity food items.

Note that the other two sets of dynamic parameters, η_i's and θ_{ij} 's, have relatively small magnitudes even though many of them are statistically significant. Therefore, these parameters do not affect the estimated expenditure elasticities much from using the dynamic specification.

In table 10, we compare the adjusted R-square (R^2) among the four AIDS models. R^2 is the measurement of goodness of fit of model to data. Two dynamic models (LA/DAIDS and DAIDS) fit better than the two static models and the DAIDS model has the best overall fit having five out seven highest R^2's, while the LA/AIDS model has the poorest fit having four out of seven lowest R^2's.

Similar to Liu (2003)'s finding, the selected demographic variables help to explain the consumption patterns in urban China. All of the adjusted R^2's are almost doubled compared to their static counterparts. For example, the adjusted R^2 for grain and poultry increase from 0.080 and 0.072 to 0.168 and 0.243. But for the dynamic model, the improvement is not of the same magnitude even though all of the adjusted R^2's increase in various levels. For example, the adjusted R^2's for grain and poultry increase merely from 0.297 and 0.266 to 0.382 and 0.336. From appendix table 1 we can see that demographic variables such as household size, householder's education level, age of householder, and region are among the most important factors that affect household consumption behavior. As expected, household size has a significant positive impact on grain consumption and a negative impact on meat and fresh fruits consumption. The households with higher education level choose to consume relatively less grain, oil but more fruits. Households with more children choose to consume relatively more oils. Most of the provincial dummy variables are found significant. Compared to Heilongjiang province, Henan households allocate more budget share to grain as expected. In all three provinces, households allocate smaller budget shares for oil consumption, which is consistent with what we find in table 5. The parameter, $\alpha_{3(hn)}$ is negative, which means households in Henan allocate higher budget shares on meat than those in Heilongjiang, which is consistent with table 5. The parameter, $\alpha_{4(gd)}$ is positive as expected. As shown in table 5, households in Guangdong allocate larger budget share for poultry consumption. The parameter, $\alpha_{5(gd)}$ is negative and $\alpha_{5(sd)}$ is positive are expected. In table 5, households in Guangdong allocate smaller budget share to egg while households in Shandong allocate larger budget shares to egg. The parameter, $\alpha 6_{(gd)}$ is positive is inline with that households in Guangdong allocate much larger budget to fish consumption. Other noticeable findings are: household size has a positive impact on the grain consumption and a negative impact on meat consumption as expected; Male householders tend to consume more oils while older households eat more fish and vegetables but less fruits.

The parameter estimates indicate that budget shares of grain will increase 1.19% but decrease 0.60% in meat when household size increase by one unit (person). Because grain is the traditional Chinese staple food and meat is mainly an expensive food item, the results make sense.

The most significant contribution of the demographic variables is from the provincial dummy variables. Twenty-two out of twenty-four coefficients are found statistically significant from zero, meaning the regional food consumption difference is significant among the four provinces.

V. Additional Results from Models without Demographic Variables

In this study, we also estimate the four models without incorporating nine demographic variables for comparing purpose. Detailed regression results are not presented in this paper. However, we note that similar to the models with demographic variables, most of the dynamic coefficients are found significant. The signs of habit effect coefficients are the same as the ones from the demographic models. The only differences are habit effect coefficients for fresh fruits being found not significant and the magnitude of habit effect coefficients are nearly one tenth of the coefficients from models with demographic variables.

Since we focus on the expenditure elasticities in this study, only the expenditure elasticities are presented in appendix table 4. Comparing these elasticities with those presented previously, we find that all expenditure elasticities remain very similar. Specifically, the expenditure elasticity of grain from DAIDS model without demographic variables is found at 0.563. Like the DAIDS model with demographic, the DAIDS model without demographic variables still provides the most reasonable demand elasticity estimates and has the best fit. But, we want to point out that, as see from above findings, demographic variables make a significant contribution to the model estimation. Ignorance of demographic variable is inappropriate.

VI. Conclusions

In this paper, we expand Ray's DAIDS model by incorporating demographic variables to analyze urban China household food consumption pattern. We compare the results from DAIDS with those from LA/AIDS, LA/DAIDS, and AIDS models. The DAIDS model presented in this study provide the best fit overall and the most reasonable estimation of demand elasticities for the eight food items we select from urban China dataset.

The empirical results strongly support the presence of habit effects in food consumption behavior by China urban households. Most of the dynamic coefficients are found significant at 5% level or lower. All of the habit effect coefficients δ's except for eggs are found significant. Six out of eight habit effects are found significant at 1% level. The signs of the δ's are as expected with grain, oil, eggs, and fresh vegetables being positive and meat, fish, poultry being negative. The Wald tests cannot reject the homogeneity and symmetry in the DAIDS models. Adding-up is automatically satisfied. Chi-square tests also support the employment of dynamic models. Thus, the dynamic almost ideal demand system appears to be a viable model to analyze household food demand in urban China. Similar to previous studies, the static AIDS models yield doubtful high grain expenditure elasticities. But the DAIDS model delivers a much lower grain expenditure elasticity of 0.538. Our findings also suggest that a dynamic specification should work well for food demand analysis in rural China since rural China has a higher Engel coefficient. One may find stronger consumption persistence by rural Chinese households, particularly in grain. Unfortunately, a panel data cannot be constructed from the NBS' rural household survey data.

Even though we have found encouraging results by employing the DAIDS model, much more can be done in this area. We would conduct future work to improve our model specification and estimation. First, we will test and compare the DAIDS model with other dynamic model specifications, especially those proposed by Anderson and Blundell to see if there exists another model, which can fit the urban China data better. Second, we will extend the model to include other foods with frequent zero consumption at the household level and therefore we have to deal with the censoring problem. Third, we would like to have a longer time series of the panel data. Our study is limited with only two years' data. It is more desirable to have a long time-series for investigating dynamic behavior.

Table 1. Percentages of Household with Positive Consumption by Food Items (%)

Year	Grain	Oil	Eggs	Fresh vegetables	Meat	Poultry	Fish	Fresh fruits
2003	99.97	89.29	99.25	100.00	99.97	98.04	96.16	99.42
2002	99.97	88.88	99.21	100.00	99.93	98.25	95.68	99.66

Table 2. Average Total Expenditure and Disposable Income per Household, 2002 and 2003 (in Yuan)

	Total Expenditure[a]			Disposable Income		
Province	2002	2003	Percentage Change	2002	2003	Percentage Change
Guangdong	6,178	6,173	-0.07%	35,509	36,967	4.11%
Heilongjiang	2,795	2,987	6.85%	16,720	18,740	12.08%
Henan	2,657	2,832	6.61%	18,890	20,384	7.91%
Shandong	2,769	2,906	4.95%	22,815	24,488	7.33%
Total	3,115	3,260	4.66%	21,662	23,336	7.73%

[a]Total expenditure of grain, oil, eggs, fresh vegetables, meat, poultry, fish, and fresh fruits

Table 3. Average Consumption per Household, 2002 and 2003 (in Kg)

	Grain		Oil		Eggs		Fresh vegetables		Meat		Poultry		Fish		Fresh fruits	
Province	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Guangdong	252	250	29	29	21	22	362	359	128	127	60	58	69	68	115	104
Heilongjiang	267	268	31	33	39	40	339	335	64	67	13	13	22	23	111	111
Henan	289	297	22	24	42	44	437	417	60	61	19	19	11	12	96	97
Shandong	211	219	14	15	48	49	311	309	65	64	17	16	19	19	122	123
Total	251	257	22	23	41	43	360	352	70	71	22	21	23	23	111	110

Table 4. Average Expenditure per Household, 2002 and 2003 (in Yuan)

	Grain		Oil		Eggs		Fresh vegetables		Meat		Poultry		Fish		Fresh fruits	
Province	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Guangdong	799	809	265	289	131	133	809	837	1953	1943	926	757	753	875	541	530
Heilongjiang	603	606	176	226	163	161	437	485	783	842	146	177	164	148	325	343
Henan	612	642	159	200	188	190	517	564	700	753	211	82	80	209	190	192
Shandong	518	545	112	149	215	218	446	502	809	848	210	160	159	202	300	282
Total	633	651	178	216	174	176	552	597	1061	1096	373	294	289	359	339	337

Table 5. Average Budget Share, 2002 and 2003 (%)

	Grain		Oil		Eggs		Fresh vegetables		Meat		Poultry		Fish		Fresh fruits	
Province	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Guangdong	13	13	4	5	2	2	13	14	32	31	15	12	12	14	9	9
Heilongjiang	22	20	6	8	6	5	16	16	28	28	5	6	6	5	12	11
Henan	23	23	6	7	7	7	19	20	26	27	8	3	3	7	7	7
Shandong	19	19	4	5	8	8	16	17	29	29	8	6	6	7	11	10
Total	20	20	6	7	6	5	18	18	34	34	12	9	9	11	11	10

Table 6. Comparison of Own-price Elasticities by Model

Food item	DAIDS	AIDS	LA/DAIDS	LA/AIDS
Grain	-0.728	-0.958	-0.909	-0.930
Oils	-1.082	-1.114	-1.127	-1.121
Meat	-0.819	-0.901	-0.839	-0.915
Poultry	-0.999	-1.033	-1.025	-1.028
Eggs	-0.336	-0.374	-0.345	-0.277
Fish	-0.435	-0.479	-0.411	-0.460
Fresh vegetables	-0.624	-0.649	-0.710	-0.788
Fresh fruits	-0.694	-0.676	-0.703	-0.708

Table 7. Comparison of Estimated Expenditure Elasticities by Model

Food item	DAIDS	AIDS	LA/DAIDS	LA/AIDS
Grain	0.538	0.831	1.359	1.225
Oils	0.778	1.108	1.478	1.297
Meat	1.344	1.191	0.766	0.848
Poultry	1.481	1.169	0.576	0.727
Eggs	0.967	0.848	0.984	0.948
Fish	1.335	1.290	0.825	1.008
Fresh vegetables	0.741	0.802	1.131	1.064
Fresh fruits	1.066	0.911	0.802	0.897

Table 8. Comparison of Habit Effect (δ) from DAIDS

Present Study		Ray (1984)	
Parameters	Estimate (S.E.)	Parameters	Estimate (S.E.)
δ_1[a]	2.681(0.618)***	δ_{Food}	0.044(0.006)***
δ_2	0.631(0.216)***	$\delta_{Drinks\ and\ Tobacco}$	-0.025(0.018)
δ_3	-0.524(0.117)***	$\delta_{Footwear\ and\ Clothing}$	0.009(0.011)
δ_4	-0.425(0.104)***	$\delta_{Fuel\ and\ Light}$	-0.035(0.021)*
δ_5	0.062(0.152)		
δ_6	-0.319(0.088)***		
δ_7	2.447(0.574)***		
δ_8	0.184(0.102)*		

[a]The eight food items are: (1) grain (2) oils, (3) meat, (4) poultry, (5) eggs, (6) fish, (7) fresh vegetables, and (8) fresh fruits
*** Significant at 1% level
* Significant at 10% level

Table 9. Influence of Including Habit Effect (δ_i) on β_i

Items	Estimate of β_i		Estimate of δ_i
	DAIDS	AIDS	DAIDS
Grain	-0.111(0.005)***	-0.034(0.004)***	2.681(0.618)***
Oils	-0.013(0.003)***	0.007(0.002)***	0.631(0.216)***
Meat	0.119(0.005)***	0.053(0.004)***	-0.524(0.117)***
Poultry	0.036(0.003)***	0.012(0.002)***	-0.425(0.104)***
Eggs	-0.001(0.002)	-0.01(0.002)***	0.062(0.152)
Fish	0.014(0.002)***	0.015(0.002)***	-0.319(0.088)***
Fresh Vegetables	-0.057(0.004)***	-0.035(0.003)***	2.447(0.574)***
Fresh Fruits	0.013[a]	-0.008 [a]	0.184(0.102)*

***Significant at 1% level
* Significant at 10% level
[a]Derived from the adding-up condition.

Table 10. Comparison of adjusted R-square (R^2) by Model

Budget Share Equation	DAIDS	AIDS	LA/DAIDS	LA/AIDS
Grain (W_1)	0.382	0.168	0.241	0.182
Oils (W_2)	0.152	0.138	0.173	0.150
Meat (W_3)	0.299	0.081	0.130	0.070
Poultry (W_4)	0.336	0.243	0.287	0.255
Eggs (W_5)	0.242	0.240	0.245	0.234
Fish (W_6)	0.431	0.373	0.403	0.358
Fresh Vegetables (W_7)	0.270	0.170	0.165	0.122

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Appendix Table 1. Parameter Estimates (with Standard Errors) by Models with Demographic Variables

Parameter	DAIDS	AIDS	LA/DAIDS	LA/AIDS
α_1	0.175(0.024)***	0.22(0.018)***	-0.292(0.03)***	-0.082(0.027)***
$\alpha_1(age)$	1.6E-04(1.4E-04)	3.6E-04(1.6E-04)**	1.7E-04(1.5E-04)	-4.2E-04(1.6E-04)***
$\alpha_1(age12d)$	-0.001(0.003)	-0.003(0.004)	-0.001(0.003)	0.001(0.004)
$\alpha_1(edh)$	-0.042(0.006)***	-0.054(0.007)***	-0.045(0.007)***	-0.049(0.007)***
$\alpha_1(edm)$	-0.025(0.006)***	-0.033(0.007)***	-0.029(0.006)***	-0.032(0.007)***
$\alpha_1(gd)$	-2.8E-04(0.006)	-0.045(0.006)***	-0.017(0.006)**	-0.077(0.006)***
$\alpha_1(hn)$	0.016(0.004)***	0.027(0.004)***	0.02(0.004)***	0.026(0.004)***
$\alpha_1(hsize)$	0.012(0.002)***	0.013(0.002)***	0.009(0.002)***	0.002(0.002)
$\alpha_1(male)$	0.008(0.003)***	0.011(0.003)***	0.007(0.003)**	0.008(0.003)**
$\alpha_1(sd)$	0.008(0.004)**	-1.0E-04(0.004)	0.004(0.004)	8.6E-05(0.004)
α_2	0.067(0.01)***	0.035(0.011)***	-0.12(0.018)***	-0.044(0.016)***
$\alpha_2(age)$	8.2E-06(8.9E-05)	-1.0E-05(8.8E-05)	-7.0E-05(8.8E-05)	-1.2E-04(8.7E-05)
$\alpha_2(age12d)$	0.004(0.002)*	0.004(0.002)*	0.005(0.002)**	0.005(0.002)**
$\alpha_2(edh)$	-0.021(0.004)***	-0.022(0.004)***	-0.018(0.004)***	-0.02(0.004)***
$\alpha_2(edm)$	-0.009(0.004)**	-0.01(0.004)***	-0.008(0.004)**	-0.009(0.004)**
$\alpha_2(gd)$	-0.021(0.004)***	-0.033(0.004)***	-0.017(0.004)***	-0.032(0.003)***
$\alpha_2(hn)$	-0.006(0.003)**	-0.006(0.003)**	-0.007(0.003)**	-0.006(0.003)**
$\alpha_2(hsize)$	0.002(0.001)	0.001(0.001)	2.0E-05(0.001)	-4.3E-04(0.001)
$\alpha_2(male)$	0.008(0.002)***	0.008(0.002)***	0.006(0.002)***	0.007(0.002)***
$\alpha_2(sd)$	-0.021(0.003)***	-0.023(0.003)***	-0.019(0.003)***	-0.022(0.003)***
α_3	0.203(0.027)***	0.105(0.022)***	0.641(0.034)***	0.467(0.031)***
$\alpha_3(age)$	-1.5E-04(1.5E-04)	-4.7E-04(1.7E-04)***	-1.9E-04(1.6E-04)	0.001(1.7E-04)***
$\alpha_3(age12d)$	-0.005(0.003)	-0.002(0.004)	-0.004(0.004)	-0.007(0.004)*
$\alpha_3(edh)$	0.008(0.007)	0.023(0.008)***	0.012(0.008)	0.017(0.008)**
$\alpha_3(edm)$	0.008(0.006)	0.017(0.007)**	0.013(0.007)*	0.015(0.007)**
$\alpha_3(gd)$	-0.023(0.007)***	0.013(0.007)*	-0.005(0.007)	0.055(0.006)***
$\alpha_3(hn)$	-0.009(0.004)**	-0.022(0.005)***	-0.016(0.005)***	-0.02(0.005)***
$\alpha_3(hsize)$	-0.006(0.002)***	-0.008(0.002)***	-0.004(0.002)*	0.005(0.002)**
$\alpha_3(male)$	-0.004(0.003)	-0.007(0.003)**	-0.003(0.003)	-0.004(0.004)
$\alpha_3(sd)$	-0.009(0.004)*	-0.002(0.005)	-0.006(0.005)	-0.002(0.005)
α_4	0.053(0.012)***	0.036(0.011)***	0.259(0.019)***	0.172(0.016)***
$\alpha_4(age)$	-2.7E-04(8.8E-05)***	-3.5E-04(9.2E-05)***	-2.8E-04(9.1E-05)***	-2.0E-05(9.2E-05)
$\alpha_4(age12d)$	0.002(0.002)	0.003(0.002)	0.002(0.002)	0.001(0.002)
$\alpha_4(edh)$	0.007(0.004)*	0.012(0.004)***	0.007(0.004)*	0.009(0.004)**
$\alpha_4(edm)$	0.001(0.004)	0.004(0.004)	0.002(0.004)	0.004(0.004)
$\alpha_4(gd)$	0.065(0.004)***	0.084(0.004)***	0.071(0.004)***	0.096(0.003)***
$\alpha_4(hn)$	0.027(0.003)***	0.023(0.003)***	0.025(0.003)***	0.024(0.003)***
$\alpha_4(hsize)$	-0.001(0.001)	-0.001(0.001)	4.2E-04(0.001)	0.003(0.001)***
$\alpha_4(male)$	-0.001(0.002)	-0.002(0.002)	5.3E-05(0.002)	-4.0E-04(0.002)
$\alpha_4(sd)$	0.017(0.003)***	0.02(0.003)***	0.017(0.003)***	0.02(0.003)***
α_5	0.035(0.008)***	0.063(0.009)***	0.036(0.016)**	0.063(0.013)***
$\alpha_5(age)$	3.9E-05(6.8E-05)	3.9E-05(6.7E-05)	5.0E-05(6.8E-05)	-2.0E-05(6.7E-05)
$\alpha_5(age12d)$	0.001(0.002)	0.001(0.002)	0.001(0.002)	0.001(0.002)
$\alpha_5(edh)$	0.003(0.003)	0.001(0.003)	0.002(0.003)	0.002(0.003)
$\alpha_5(edm)$	0.004(0.003)	0.004(0.003)	0.004(0.003)	0.004(0.003)
$\alpha_5(gd)$	-0.026(0.003)***	-0.027(0.003)***	-0.027(0.003)***	-0.034(0.003)***
$\alpha_5(hn)$	-0.003(0.002)	-0.002(0.002)	-0.002(0.002)	-0.002(0.002)
$\alpha_5(hsize)$	0.001(0.001)	0.001(0.001)	0.001(0.001)	3.5E-04(0.001)
$\alpha_5(male)$	1.5E-04(0.001)	4.8E-04(0.001)	2.2E-04(0.001)	3.0E-04(0.001)
$\alpha_5(sd)$	0.009(0.002)***	0.009(0.002)***	0.01(0.002)***	0.009(0.002)***

α_6	0.066(0.009)***	0.037(0.009)***	0.125(0.015)***	0.062(0.013)***
$\alpha_6(age)$	2.1E-04(6.9E-05)***	1.3E-04(7.1E-05)*	1.6E-04(7.0E-05)**	2.7E-04(7.2E-05)***
$\alpha_6(age12d)$	-0.002(0.002)	-0.002(0.002)	-0.002(0.002)	-0.003(0.002)*
$\alpha_6(edh)$	0.002(0.003)	0.003(0.003)	0.003(0.003)	0.004(0.003)
$\alpha_6(edm)$	0.002(0.003)	0.004(0.003)	0.004(0.003)	0.004(0.003)
$\alpha_6(gd)$	0.033(0.003)***	0.046(0.003)***	0.038(0.003)***	0.057(0.003)***
$\alpha_6(hn)$	-0.026(0.002)***	-0.027(0.002)***	-0.027(0.002)***	-0.027(0.002)***
$\alpha_6(hsize)$	-0.001(0.001)	-0.002(0.001)**	-0.001(0.001)	1.6E-05(0.001)
$\alpha_6(male)$	-0.002(0.001)	-0.002(0.001)	-0.001(0.001)	-0.002(0.002)
$\alpha_6(sd)$	-0.007(0.002)***	-0.005(0.002)**	-0.007(0.002)***	-0.004(0.002)*
α_7	0.202(0.015)***	0.28(0.014)***	0.037(0.023)	0.109(0.021)***
$\alpha_7(age)$	0.001(1.1E-04)***	0.001(1.1E-04)***	0.001(1.1E-04)***	3.2E-04(1.1E-04)***
$\alpha_7(age12d)$	-0.001(0.002)	-0.003(0.003)	-0.002(0.003)	4.0E-04(0.003)
$\alpha_7(edh)$	0.017(0.005)***	0.01(0.005)**	0.015(0.005)***	0.013(0.005)**
$\alpha_7(edm)$	0.007(0.005)	0.003(0.005)	0.005(0.005)	0.003(0.005)
$\alpha_7(gd)$	0.009(0.005)**	-0.007(0.004)	-0.002(0.005)	-0.03(0.004)***
$\alpha_7(hn)$	0.034(0.003)***	0.041(0.003)***	0.039(0.003)***	0.04(0.003)***
$\alpha_7(hsize)$	-0.002(0.001)	-3.4E-04(0.001)	-0.003(0.001)*	-0.007(0.001)***
$\alpha_7(male)$	-0.001(0.002)	4.8E-04(0.002)	-0.001(0.002)	-0.001(0.002)
$\alpha_7(sd)$	0.018(0.003)***	0.016(0.003)***	0.018(0.003)***	0.015(0.003)***
α_8	0.2(0.011)***	0.224(0.013)***	-	-
$\alpha_8(age)$	-0.001(1.1E-04)***	-0.001(1.1E-04)***	-	-
$\alpha_8(age12d)$	0.002(0.002)	0.002(0.002)	-	-
$\alpha_8(edh)$	0.025(0.005)***	0.026(0.005)***	-	-
$\alpha_8(edm)$	0.01(0.005)**	0.011(0.005)**	-	-
$\alpha_8(gd)$	-0.038(0.005)***	-0.03(0.004)***	-	-
$\alpha_8(hn)$	-0.034(0.003)***	-0.034(0.003)***	-	-
$\alpha_8(hsize)$	-0.005(0.001)***	-0.003(0.001)**	-	-
$\alpha_8(male)$	-0.008(0.002)***	-0.009(0.002)***	-	-
$\alpha_8(sd)$	-0.016(0.003)***	-0.014(0.003)***	-	-
β_1	-0.111(0.005)***	-0.034(0.004)***	0.066(0.005)***	0.045(0.004)***
β_2	-0.013(0.003)***	0.007(0.002)***	0.03(0.003)***	0.018(0.002)***
β_3	0.119(0.005)***	0.053(0.004)***	-0.052(0.005)***	-0.042(0.004)***
β_4	0.036(0.003)***	0.012(0.002)***	-0.026(0.003)***	-0.02(0.002)***
β_5	-0.001(0.002)	-0.01(0.002)***	-0.001(0.002)	-0.003(0.002)*
β_6	0.014(0.002)***	0.015(0.002)***	-0.008(0.002)***	4.2E-04(0.002)
β_7	-0.057(0.004)***	-0.035(0.003)***	0.011(0.004)***	0.011(0.003)***
γ_{11}	-0.016(0.01)	-0.002(0.007)	-0.016(0.012)	0.014(0.007)**
γ_{12}	-0.015(0.006)***	-0.019(0.003)***	-0.008(0.006)	-0.016(0.003)***
γ_{13}	0.023(0.008)***	0.019(0.006)***	0.046(0.011)***	0.011(0.006)*
γ_{14}	0.012(0.005)**	0.016(0.003)***	0.024(0.006)***	0.012(0.003)***
γ_{15}	-0.007(0.005)	-0.006(0.003)**	-0.01(0.005)*	-0.007(0.003)**
γ_{16}	0.003(0.005)	0.011(0.003)***	0.008(0.005)	0.008(0.003)***
γ_{17}	-0.025(0.006)***	-0.032(0.004)***	-0.051(0.007)***	-0.035(0.004)***
γ_{18}	0.024(0.006)***	0.014(0.004)***	-	-
γ_{22}	-0.028(0.007)***	-0.007(0.003)**	-0.025(0.007)***	-0.007(0.003)**
γ_{23}	0.027(0.008)***	0.016(0.004)***	0.032(0.008)***	0.014(0.004)***
γ_{24}	-0.01(0.005)**	0.001(0.002)	-0.008(0.005)	2.1E-04(0.002)
γ_{25}	0.009(0.005)*	0.008(0.002)***	0.005(0.005)	0.007(0.002)***
γ_{26}	0.007(0.004)*	-0.002(0.002)	0.006(0.004)	-0.003(0.002)
γ_{27}	0.001(0.005)	-0.002(0.003)	-0.007(0.005)	-2.0E-05(0.003)
γ_{28}	0.008(0.005)*	0.004(0.003)	-	-
γ_{33}	-0.022(0.015)	0.034(0.011)***	-0.075(0.018)***	0.024(0.011)**
γ_{34}	0.019(0.007)***	0.003(0.004)	-0.002(0.008)	0.003(0.004)

γ_{35}	-0.014(0.007)**	-0.015(0.005)***	-0.013(0.008)	-0.015(0.005)***
γ_{36}	0.017(0.007)***	-0.018(0.004)***	0.015(0.007)**	-0.016(0.004)***
γ_{37}	-0.011(0.007)	-0.009(0.005)*	0.028(0.009)***	0.007(0.005)
γ_{38}	-0.039(0.007)***	-0.031(0.005)***	-	-
γ_{44}	0.006(0.006)	-0.002(0.003)	-0.003(0.007)	-0.002(0.003)
γ_{45}	-0.008(0.004)*	0.006(0.002)***	-0.005(0.004)	0.006(0.002)***
γ_{46}	-0.027(0.004)***	-0.016(0.002)***	-0.029(0.004)***	-0.015(0.002)***
γ_{47}	0.001(0.004)	-0.007(0.003)**	0.02(0.005)***	-0.004(0.003)
γ_{48}	0.005(0.004)	-0.001(0.003)	-	-
γ_{55}	0.064(0.007)***	0.039(0.004)***	0.064(0.008)***	0.047(0.004)***
γ_{56}	0.007(0.004)	-0.002(0.002)	0.008(0.005)*	-0.005(0.002)*
γ_{57}	-0.02(0.004)***	-0.01(0.003)***	-0.024(0.005)***	-0.012(0.003)***
γ_{58}	-0.03(0.004)***	-0.021(0.003)***	-	-
γ_{66}	-0.02(0.006)***	0.027(0.003)***	-0.021(0.006)***	0.028(0.003)***
γ_{67}	0.006(0.004)	-3.1E-06(0.002)	0.012(0.005)***	0.002(0.002)
γ_{68}	0.007(0.004)	-4.4E-04(0.003)	-	-
γ_{77}	0.044(0.006)***	0.052(0.004)***	0.016(0.008)*	0.038(0.004)***
γ_{78}	0.003(0.005)	0.007(0.003)**	-	-
γ_{88}	0.022(0.007)***	0.029(0.004)***	-	-
θ_{11}	8.2E-06(2.6E-06)***	-	1.1E-05(3.2E-06)***	-
θ_{12}	-9.2E-07(1.6E-06)	-	-2.7E-06(1.7E-06)	-
θ_{13}	-5.6E-06(2.1E-06)***	-	-1.0E-05(2.8E-06)***	-
θ_{14}	-3.1E-07(1.5E-06)	-	-4.3E-06(1.7E-06)**	-
θ_{15}	5.8E-08(1.3E-06)	-	6.3E-07(1.4E-06)	-
θ_{16}	1.5E-06(1.3E-06)	-	-9.8E-07(1.4E-06)	-
θ_{17}	2.2E-07(1.7E-06)	-	8.1E-06(2.0E-06)***	-
θ_{18}	-3.1E-06(1.6E-06)**	-	-	-
θ_{22}	7.0E-06(2.1E-06)***	-	5.5E-06(2.1E-06)***	-
θ_{23}	-5.6E-06(2.2E-06)***	-	-6.4E-06(2.4E-06)***	-
θ_{24}	3.0E-06(1.4E-06)**	-	2.9E-06(1.4E-06)**	-
θ_{25}	-1.6E-07(1.4E-06)	-	1.4E-07(1.4E-06)	-
θ_{26}	-2.8E-06(1.3E-06)**	-	-2.2E-06(1.3E-06)*	-
θ_{27}	3.7E-07(1.3E-06)	-	2.3E-06(1.6E-06)	-
θ_{28}	-9.2E-07(1.3E-06)	-	-	-
θ_{33}	2.3E-05(3.7E-06)***	-	3.9E-05(4.9E-06)***	-
θ_{34}	-3.8E-06(2.1E-06)*	-	2.3E-06(2.4E-06)	-
θ_{35}	-4.2E-07(1.8E-06)	-	-1.5E-07(2.2E-06)	-
θ_{36}	-1.0E-05(1.8E-06)***	-	-9.5E-06(2.0E-06)***	-
θ_{37}	-5.5E-07(1.9E-06)	-	-1.0E-05(2.5E-06)***	-
θ_{38}	4.0E-06(1.6E-06)**	-	-	-
θ_{44}	-2.4E-06(1.8E-06)	-	4.4E-07(2.0E-06)	-
θ_{45}	4.7E-06(1.2E-06)***	-	4.2E-06(1.3E-06)***	-
θ_{46}	4.1E-06(1.2E-06)***	-	4.8E-06(1.3E-06)***	-
θ_{47}	-3.6E-06(1.2E-06)***	-	-9.3E-06(1.6E-06)***	-
θ_{48}	-1.7E-06(1.2E-06)	-	-	-
θ_{55}	-6.9E-06(1.8E-06)***	-	-7.2E-06(2.0E-06)***	-
θ_{56}	-3.2E-06(1.2E-06)***	-	-3.6E-06(1.3E-06)***	-
θ_{57}	3.3E-06(1.2E-06)***	-	4.1E-06(1.4E-06)***	-
θ_{58}	2.7E-06(1.0E-06)***	-	-	-
θ_{66}	1.6E-05(1.6E-06)***	-	1.7E-05(1.7E-06)***	-
θ_{67}	-1.9E-06(1.1E-06)	-	-4.4E-06(1.4E-06)***	-
θ_{68}	-2.8E-06(1.0E-06)***	-	-	-
θ_{77}	2.4E-06(1.7E-06)	-	1.1E-05(2.5E-06)***	-
θ_{78}	-3.3E-07(1.2E-06)	-	-	-

θ_{88}	2.1E-06(1.6E-06)	-	-	-
δ_1	2.681(0.618)***	-	-	-
δ_2	0.631(0.216)***	-	-	-
δ_3	-0.524(0.117)***	-	-	-
δ_4	-0.425(0.104)***	-	-	-
δ_5	0.062(0.152)	-	-	-
δ_6	-0.319(0.088)***	-	-	-
δ_7	2.447(0.574)***	-	-	-
δ_8	0.184(0.102)*	-	-	-
η_1	5.7E-06(9.9E-07)***	-	2.0E-06(6.7E-07)***	-
η_2	-9.8E-08(6.7E-07)	-	-3.4E-07(4.3E-07)	-
η_3	-7.4E-06(1.0E-06)***	-	-4.3E-06(8.1E-07)***	-
η_4	-1.4E-07(6.8E-07)	-	-1.6E-06(4.6E-07)***	-
η_5	-4.0E-07(5.2E-07)	-	1.2E-07(3.8E-07)	-
η_6	1.1E-06(5.6E-07)**	-	-4.4E-07(3.7E-07)	-
η_7	3.7E-06(7.5E-07)***	-	4.0E-06(5.8E-07)***	-

*** Significant at 1% level
* Significant at 10% level

Appendix Table 2. Marshallian Elasticity Matrix for DAIDS, AIDS, LA/DAIDS, LA/AIDS Models With Demographic Variables

Demand Models	Food Items	Price of							
		Grain	Oil	Meat	Poultry	Eggs	Fish	Fresh Vegetables	Fresh Fruits
DAIDS	Grain	-0.728	-0.039	0.021	0.041	-0.001	0.037	0.026	0.105
	Oil	-0.179	-1.082	0.152	-0.011	0.148	-0.020	0.112	0.102
	Meat	-0.147	-0.001	-0.819	0.039	-0.081	-0.058	-0.154	-0.122
	Poultry	-0.077	-0.052	0.110	-0.999	0.060	-0.197	-0.286	-0.039
	Eggs	-0.088	0.128	-0.245	0.106	-0.336	-0.054	-0.148	-0.331
	Fish	-0.020	-0.058	-0.305	-0.265	-0.090	-0.435	-0.103	-0.061
	Fresh Vegetables	-0.012	0.041	-0.074	-0.064	-0.039	0.001	-0.624	0.031
	Fresh fruits	0.123	0.050	-0.288	0.000	-0.237	-0.020	0.001	-0.694
AIDS	Grain	-0.958	-0.089	0.113	0.083	-0.014	0.053	-0.110	0.090
	Oil	-0.350	-1.114	0.254	0.009	0.127	-0.027	-0.057	0.050
	Meat	0.010	0.051	-0.901	0.005	-0.071	-0.065	-0.087	-0.132
	Poultry	0.160	0.004	0.027	-1.033	0.072	-0.218	-0.141	-0.039
	Eggs	-0.048	0.136	-0.211	0.105	-0.374	-0.034	-0.108	-0.314
	Fish	0.113	-0.042	-0.374	-0.313	-0.070	-0.479	-0.083	-0.043
	Fresh Vegetables	-0.119	-0.001	-0.028	-0.031	-0.036	0.001	-0.649	0.061
	Fresh fruits	0.181	0.045	-0.320	-0.012	-0.223	-0.004	0.097	-0.676
LA/DAIDS	Grain	-0.909	-0.080	0.017	0.052	-0.041	0.026	-0.130	0.066
	Oil	-0.264	-1.127	0.196	0.022	0.093	-0.021	-0.001	0.102
	Meat	0.012	0.043	-0.839	0.020	-0.048	-0.053	-0.029	-0.106
	Poultry	0.142	0.018	0.076	-1.025	0.117	-0.189	-0.124	-0.015
	Eggs	-0.129	0.088	-0.207	0.133	-0.345	-0.054	-0.175	-0.311
	Fish	0.098	-0.024	-0.283	-0.264	-0.067	-0.411	-0.028	-0.021
	Fresh Vegetables	-0.148	0.000	-0.045	-0.051	-0.063	-0.008	-0.710	0.027
	Fresh fruits	0.143	0.067	-0.318	-0.012	-0.217	-0.012	0.051	-0.703
LA/AIDS	Grain	-0.930	-0.081	0.057	0.060	-0.033	0.039	-0.175	0.064
	Oil	-0.268	-1.121	0.234	0.003	0.117	-0.042	0.000	0.076
	Meat	0.041	0.051	-0.915	0.011	-0.055	-0.057	0.026	-0.102
	Poultry	0.164	0.003	0.040	-1.028	0.079	-0.205	-0.055	0.001

	Eggs	-0.102	0.110	-0.236	0.090	-0.277	-0.073	-0.183	-0.329
	Fish	0.149	-0.049	-0.299	-0.286	-0.090	-0.460	0.029	0.006
	Fresh Vegetables	-0.199	0.000	0.041	-0.023	-0.066	0.008	-0.788	0.027
	Fresh fruits	0.138	0.050	-0.307	0.001	-0.229	0.003	0.051	-0.708

Appendix Table 3. Marshallian Demand Elasticity Matrix for LA/AIDS, LA/DIADS, AIDS, DAIDS Models Without Demographic Variables

Demand Models	Food Items	Price of							
		Grain	Oil	Meat	Poultry	Eggs	Fish	Fresh Vegetables	Fresh Fruits
LA/AIDS	Grain	-0.969	-0.074	0.154	0.102	-0.039	0.058	-0.221	-0.012
	Oil	-0.246	-1.317	0.325	0.006	0.219	-0.088	0.016	0.086
	Meat	0.112	0.071	-0.966	-0.060	-0.021	-0.157	0.0948	-0.073
	Poultry	0.282	0.005	-0.229	-1.104	0.167	-0.276	0.084	0.071
	Eggs	-0.121	0.206	-0.090	0.190	-0.442	0.011	-0.151	-0.603
	Fish	0.223	-0.102	-0.830	-0.385	0.013	-0.517	0.114	0.484
	Fresh Vegetables	-0.251	0.005	0.1483	0.034	-0.055	0.0338	-0.846	-0.070
	Fresh fruits	-0.026	0.056	-0.220	0.056	-0.419	0.274	-0.135	-0.586
LA/DAIDS	Grain	-0.927	-0.075	0.051	0.064	-0.040	0.019	-0.147	0.055
	Oil	-0.249	-1.331	0.219	0.031	0.188	-0.064	0.049	0.157
	Meat	0.037	0.048	-0.829	-0.003	-0.043	-0.106	0.011	-0.113
	Poultry	0.175	0.026	-0.012	-1.051	0.208	-0.224	-0.073	-0.050
	Eggs	-0.124	0.178	-0.187	0.237	-0.494	0.033	-0.107	-0.535
	Fish	0.074	-0.074	-0.564	-0.313	0.040	-0.421	-0.058	0.315
	Fresh Vegetables	-0.167	0.017	0.017	-0.030	-0.039	-0.017	-0.747	-0.034
	Fresh fruits	0.120	0.103	-0.340	-0.039	-0.372	0.179	-0.066	-0.584
AIDS	Grain	-1.012	-0.100	0.197	0.108	-0.008	0.053	-0.145	0.087
	Oil	-0.377	-1.336	0.401	0.040	0.219	-0.051	-0.032	0.091
	Meat	0.069	0.079	-0.927	-0.031	-0.064	-0.125	-0.028	-0.160
	Poultry	0.183	0.012	-0.175	-1.052	0.100	-0.234	-0.139	-0.085
	Eggs	-0.012	0.224	-0.153	0.161	-0.460	0.013	0.005	-0.528
	Fish	0.057	-0.090	-0.764	-0.338	-0.035	-0.459	-0.189	0.267
	Fresh Vegetables	-0.158	0.004	0.067	-0.014	-0.001	-0.016	-0.692	0.019
	Fresh fruits	0.202	0.077	-0.361	-0.021	-0.368	0.193	0.042	-0.523
DAIDS	Grain	-0.780	-0.037	0.064	0.048	0.010	0.027	0.015	0.089
	Oil	-0.140	-1.278	0.219	-0.013	0.261	-0.068	0.204	0.158
	Meat	-0.108	0.007	-0.812	0.023	-0.082	-0.099	-0.129	-0.130
	Poultry	-0.079	-0.069	0.008	-0.984	0.126	-0.218	-0.304	-0.092
	Eggs	-0.038	0.231	-0.238	0.194	-0.489	0.016	-0.053	-0.539
	Fish	-0.082	-0.129	-0.568	-0.295	-0.017	-0.464	-0.180	0.254
	Fresh Vegetables	-0.003	0.070	-0.016	-0.056	-0.003	-0.010	-0.626	-0.017
	Fresh fruits	0.080	0.075	-0.335	-0.038	-0.389	0.162	-0.117	-0.570

Appendix Table 4. Comparison of Own-price Elasticities by Models without Demographic Variables

Food item	LA/AIDS	LA/DAIDS	AIDS	DAIDS
Grain	-0.969	-0.927	-1.012	-0.780
Oil	-1.317	-1.331	-1.336	-1.278
Meat	-0.966	-0.829	-0.927	-0.812

Poultry	-1.104	-1.051	-1.052	-0.984
Eggs	-0.442	-0.494	-0.460	-0.489
Fish	-0.517	-0.421	-0.459	-0.464
Fresh vegetables	-0.846	-0.747	-0.692	-0.626
Fresh fruits	-0.586	-0.584	-0.523	-0.570

Appendix Table 5. Comparison of Estimated Expenditure Elasticities by Models without Demographic Variables

Food item	LA/AIDS	LA/DAIDS	AIDS	DAIDS
Grain	1.214	1.444	0.818	0.563
Oil	1.331	1.611	1.045	0.658
Meat	0.891	0.751	1.187	1.331
Poultry	0.844	0.437	1.390	1.612
Eggs	0.876	1.010	0.749	0.916
Fish	1.113	0.624	1.552	1.481
Fresh vegetables	1.036	1.169	0.791	0.662
Fresh fruits	0.720	0.707	0.759	1.131