Journal of Agricultural and Applied Economics, 42,2(May 2010):337–355

An Analysis of Food Grain Consumption in Urban Jiangsu Province of China

Zhihao Zheng and Shida Rastegari Henneberry

The impacts of economic and demographic variables on the demand for food grain commodities in urban Jiangsu province of China are estimated, using both the QUAIDS and the AIDS models. Results show that the demands for wheat flour and coarse grains are price-elastic while the demands for rice and grain products are price-inelastic. Certain demographic variables show as having a significant impact on food grain demand. Finally, a decomposition of causes of changes in rice consumption over the period of 1995–2007 is performed.

Key Words: AIDS model, China food grain demand, China urban household demand

JEL Classifications: D12, Q18, Q13

Food grain consumption in urban China has decreased dramatically over the past decade. Per capita at-home consumption of food grains declined from an annual average of 93.5 kg during 1995–1997 to 79.1 kg during 2002–2004. The dramatic decrease in food grain consumption is a reflection of an overall change in consumers' diet in urban China toward more meats, fish, milk, and fruits. Not only has the per capita total volume decreased, the composition of food grain consumption of urban households has also changed significantly. Between the periods of 1995–1997 and 2002–2004, the average annual per capita rice consumption declined from 54.0 kg to 43.4 kg, a decrease of 19.6%; wheat flour consumption decreased from 20.9 kg to 12.5 kg, a decrease of 40.2%; while consumption of coarse grains increased from 2.3 kg to 3.0 kg, an increase of 27.0%; and consumption of grain products increased from 16.2 kg to 19.8 kg, an increase of 22.3% [China's National Bureau of Statistics (NBS), 1996–2005].

China is the world's largest producer and consumer of both wheat and rice. Prior to the mid 1990s, China was one of the largest wheat importers in the world. As China's government embarked on a self-sufficiency campaign to boost wheat production in 1995, China's wheat imports have remained low and erratic since 1997, mainly depending on the domestic production situation (Carter and Zhong, 1999; Lohmar, 2004). Contrary to wheat, China has been an exporter of rice in the global market. Considering that urban residents account for more than 40% of China's total population and this urban population share is expected to grow to 50% by 2020 (Hsu, Chern, and Gale, 2002), the changing food grain consumption patterns in urban China have the potential to significantly impact both the domestic and the world food and feed grain markets. For example, the continuous decrease in per capita consumption of wheat and rice since the early 1990s has caused China to grow less wheat but more corn in order to meet the feed needs of a growing livestock industry in China. Moreover, China has used some low-quality wheat and rice

Zhihao Zheng is professor, College of Economics and Management, China Agricultural University, Beijing, China. Shida R. Henneberry is professor, Department of Agricultural Economics, Oklahoma State University, Stillwater, OK.

This study was partially funded by the Hatch Project No. 02702 of the Oklahoma State University Agricultural Experiment Station. The authors gratefully acknowledge helpful comments from JAAE editor, Ashok Mishra and four anonymous reviewers.

for livestock feed in recent years. These recent changes in the cropping structure and the usage of wheat and rice suggest that while China might retain its long-term self-sufficiency objective for wheat and rice until 2020, it will produce more feed grains than its current levels.[1] This prospect has important repercussions for grain exporting country producers, such as those in the United States and Australia, who have viewed China as a potential large destination for wheat and feed grains.

There have been several studies that have focused on the demand for the broad category of food grains in China; however, only a few have analyzed the demand for individual commodities, namely rice, wheat, and coarse grains. Table 1 provides a summary of these studies (Carter and Zhong, 1999; Fan, Wailes, and Cramer, 1995; Gould and Villarreal, 2006; Huang, David, and Duff, 1991; Liu and Chern, 2003; Peterson, Jin, and Ito, 1991; Wu, Li, and Samuel, 1995; Zhuang and Abbott, 2007). Although all of the above studies are consistent in showing an inelastic demand response to own-price and income changes, the elasticity figures vary considerably. Variations in estimation procedures, data (annual aggregate or household-level), and data period might explain the differences in elasticity estimates. Nevertheless, considering the significant changes that have occurred in urban household food consumption since the mid 1990s, the findings from previous work may no longer be applicable.[2] Moreover, few studies have explicitly addressed the impact of both economic and demographic variables on the consumption of food grains in China using household survey data. Therefore, an updated study of the demand for disaggregated food grain commodities will be useful for marketing and policy recommendations.

In this light, the overall objective of this study is to estimate the impacts of economic factors (prices and expenditures) and noneconomic factors (demographic variables) on China's urban household demand for food grain commodities. Specifically, this study has two objectives. The first is to estimate a complete demand system for four food grain commodities: rice, wheat flour, coarse grains, and grain products, using a more recent data set—NBS urban household survey data for Jiangsu province in 2004. Given that rice is an important component of food grain demand in China, the second objective is focused on the analysis of demand for rice. More specifically, through a decomposition analysis, the contribution of demographic and economic effects to the decline in rice consumption in urban Jiangsu province during the period of 1995–2007 is measured.

This study focuses on urban consumer food grain demand in Jiangsu, one of China's major provinces with a population of over 70 million in 2004, accounting for 5.3% of China's total population. Geographically Jiangsu province consists of two parts, one to the north and another to the south of the Yangtze River. The southern region of Jiangsu is more economically developed with its consumers having a larger per capita income and different food preferences compared with the northern region of this province. In general, people in the south prefer to eat more rice; while people in the north like to have more wheat products in their diets. Thus, Jiangsu province may be viewed as a miniature China, consisting of regions with differential economic development levels and a large population with diverse food consumption habits. A study of consumption of food grains in urban Jiangsu is expected to shed light on the national food grain demand. Understanding the demand for food grains and the factors affecting it in urban China would be

[1] According to the Mid-Long-Term National Grain Security Plan (2008–2020) issued in November 2008, the government of China will maintain grain self sufficiency rate at above 95 percent through 2020. China defines grains to include wheat, rice, corn, legumes, and tubers.

[2] China's government has introduced a set of policies in cities and towns aimed at transferring the responsibility of education, health services, and housing from state-owned enterprises and public institutions to individuals themselves since the mid 1990s. This transfer of responsibilities from the local governments to individuals has caused a diversion of expenditures from present consumption to savings for protection against future economic uncertainties. The structural change in China's welfare system, along with the rapid economic growth in urban areas since the mid 1990s, suggests that estimations based on the earlier data would no longer be an accurate reflection of the current urban household food consumption patterns.

Table 1. Review of Previous Studies

Researcher(s)	Approach	Data Period	Product	Own-Price Elasticity	Income Elasticity
Huang, David, and Duff (1991)[a]	Single-Equation	1961–1988	Rice/China	—	0.301
Peterson, Jin, and Ito (1991)	Single-Equation	1968–1986	Rice/China	—	−0.150
Fan, Wailes, and Cramer (1995)	AIDS	1982–1990	Rice/rural China	−0.629	0.496
Fan, Wailes, and Cramer (1995)	AIDS	1982–1990	Wheat/rural China	−0.536	0.771
Fan, Wailes, and Cramer (1995)	AIDS	1982–1990	Coarse grains/rural China	−0.240	0.263
Wu, Li, and Samuel (1995)	LA/AIDS	1990	Rice/urban China	−0.700	0.370
Carter and Zhong (1999)	Single-Equation	1993–1994	Wheat/rural Jiangsu province	−0.260	−0.370
Liu and Chern (2003)	QUAIDS	1998	Rice/three urban provinces	−0.862	0.748
Liu and Chern (2003)	QUAIDS	1998	Wheat flour/three urban provinces	−0.964	0.719
Liu and Chern (2003)	QUAIDS	1998	Coarse grains/three urban provinces	−0.925	0.601
Gould and Villarreal (2006)	QUAIDS	2001	Rice/urban Jiangsu province	−0.720	1.130[b]
Gould and Villarreal (2006)	QUAIDS	2001	Other grains/urban Jiangsu province	−1.000	0.500[b]
Zhuang and Abbott (2007)	AIDS	1978–2001	Rice/China	−0.445	0.339
Zhuang and Abbott (2007)	AIDS	1978–2001	Wheat/China	−0.244	0.768
Zhuang and Abbott (2007)	AIDS	1978–2001	Corn/China	−0.329	0.079

[a] Except for Carter and Zhong, Liu and Chern, and Gould and Villarreal who use NBS household survey data, all other studies use aggregated data.
[b] Food expenditure elasticities.

useful to policymakers, marketers, and food processing firms in developing effective policies and marketing programs.

The remainder of this study is organized as follows. A model of urban household demand for grain commodities in China is presented in the following section. Data and estimation procedure are then described. Results of the economic and demographic effects are presented next, followed by an analysis of rice consumption over the past decade. This study ends with the summary remarks and conclusions.

Model Specification

The quadratic almost ideal demand system (QUAIDS), developed by Banks, Blundell, and Lewbel (1997), is used to estimate a complete demand system for grain commodities for urban households in China's Jiangsu province. In addition to having the same degree of price flexibility as the usual AIDS (Deaton and Muellbauer, 1980) and translog (Christensen, Jorgenson, and Lau, 1975) models and having the AIDS model nested within it as a special case, the QUAIDS model has the income flexibility—having leading terms that are linear in logarithmic income while including the empirically necessary rank 3 quadratic term, which provides a sufficiently general approximation to the Engel relationship in the raw microdata (Banks, Blundell, and Lewbel, 1997). Assuming that the studied food grain commodities are weakly separable from other at-home food items and nonfood items in the consumer's budget (Figure 1), the QUAIDS model for grain commodities is given as:

$$(1)\quad w_{ih} = \alpha_{ih} + \sum_{j=1}^{N} \gamma_{ij} \ln(p_{jh}) + \beta_i \ln\left[\frac{m_h}{a(p_h)}\right] + \frac{\lambda_i}{b(p_h)} \left\{ \ln\left[\frac{m_h}{a(p_h)}\right] \right\}^2 + u_{ih},$$

where subscripts i and j indicate the studied grain commodities (here, rice, wheat flour, coarse grains, and grain products), and $h = 1, \ldots, H$ representing the number of surveyed households; γ_{ij}, β_i, and λ_i are parameters to be estimated; w_{ih} is the share of total grain expenditure allocated to the ith grain commodity for household h; p_{jh} is the price of jth grain commodity for household h; m_h is the hth household expenditure on grain commodities in the system; u_{ih} is an error term; $a(p_h)$ is the price index for household h and defined as

$$(2)\quad \ln a(p_h) = \alpha_0 + \sum_{j=1}^{N} \alpha_{jh} \ln(p_{jh}) + 0.5 \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \ln(p_{ih}) \ln(p_{jh});$$

and $b(p_h)$ is the Cobb-Douglas price aggregator for household h and defined as

$$(3)\quad b(p_h) = \prod_{i=1}^{N} p_{ih}^{\beta_i}.$$

Demographic variables that affect food grain consumption are incorporated into the model by allowing the intercept in Equation (1) to be a function of these variables. That is,

$$(4)\quad \alpha_{ih} = \rho_{i0} + \sum_{k=1}^{K} \rho_{ik} d_{kh},$$

where ρ_{i0} and the ρ_{ik} are parameters to be estimated, and d_{kh} represents demographic variables ($k = 1, \ldots, K$) which are considered in this study. The demographic variables include region dummy variable (south versus north), city size dummy variable (city versus town), household size variable, ratio of the number of seniors (aged 61 and above) to total household members, ratio of the number of children (aged 17 and below) to total household members, dummy variable reflecting the educational levels of household heads (college and above versus others), and ratio of expenditures for food-away-from-home (FAFH) to total food expenditures.

The properties from neoclassical demand theory can be imposed on Equation (1) by restricting its parameters using the general properties of demand. The adding-up restriction is imposed as:

$$(5a)\quad \sum_{i}^{N} \rho_{i0} = 1, \quad \sum_{i}^{N} \rho_{ik} = 0, \quad \sum_{i=1}^{N} \gamma_{ij} = 0, \quad \sum_{i}^{N} \beta_i = 0, \quad \text{and} \quad \sum_{i}^{N} \lambda_i = 0.$$

Homogeneity is imposed as:

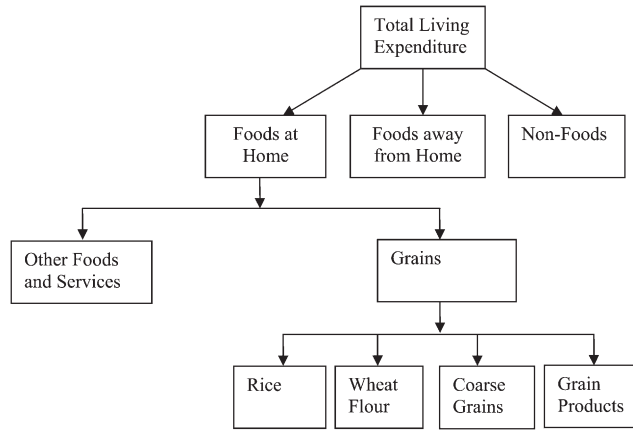

Figure 1. Household Utility Tree for Food Grain Consumption in Urban Jiangsu, China

(5b) $$\sum_{j}^{N} \gamma_{ij} = 0 \text{ for any } j.$$

Slutsky symmetry is given by:

(5c) $$\gamma_{ij} = \gamma_{ji} \text{ for any } i \text{ and } j.$$

Given the likely correlation between u_{ih} and the logarithms of expenditure variables, $\ln(m_h)$ and $[\ln(m_h)]^2$ in the QUAIDS specification, an endogeneity problem might exist leading to biased model parameter estimates (Blundell and Robin, 1999). To control for the expenditure endogeneity problem (Henneberry, Piewthongngam, and Qiang, 1999), a nonlinear full information maximum likelihood estimation procedure is used in this study. As pointed out by Dhar, Chavas, and Gould (2003), this procedure can generate consistent and asymptotically efficient estimates under the assumption that the error terms are normally distributed. Similar to Blundell, Pashardes, and Weber (1993), a reduced form expenditure equation in this study is specified as:

(6) $$\ln(m_h) = a_0 + \sum_{l=1}^{K} a_l d_{lh} + \sum_{r=1}^{N} a_r \ln(p_{rh}) + e_y \ln(y_h),$$

where m_h, d_{lh}, and p_{rh} are the variables defined above; y_h denotes disposable household income for household h, which is used as an identifying instrument; and a_0, a_l, a_r and e_y are parameters to be estimated. Note that e_y is also the income elasticity for grain expenditure.

Data Set

The data set used for this study was collected by NBS for Jiangsu province in 2004. The NBS conducts a nationwide urban household survey annually to collect extensive socio-economic information on income, consumption, employment, housing, demographics, education, and asset ownership. The survey is China's primary source of information on its urban residents. Since 2002, the survey sample has included households registered in an urban area and those who lived there at least 6 months but are registered elsewhere, which means that the survey includes both urban households and migrants from rural areas. This change in survey population inclusion makes the current survey data more representative of all income classes than those collected prior to 2002. The survey data are compiled from diaries of income and expenditures kept by the chosen households over the course of an entire year. Thus, the data set used for this study reflects actual consumption patterns of the surveyed households during an entire year.

The sample of households selected for the survey in Jiangsu province has a total of 4,600 households in 28 cities and towns in the province in 2004. Data for a total of 922 households are used for this study. These households are drawn randomly from the 4,600 sample households. Moreover, after deleting two households with missing observations for four grain items,

a total of 920 households are actually used for this study. Four grain commodity categories that are analyzed in this study are: rice (including Japonica, Indica, and Glutinous rice), wheat flour (standard- and premium-grade flour), coarse grains (including corn, millet, and oats), and grain products (including uncooked and cooked products, such as steamed bread, noodles, and dumplings).

Households report their grain expenditures and the physical quantities that pertain to their consumption of grain commodities in the survey diary. Commodity prices are implicit prices, obtained by dividing expenditures on quantity consumed by the quantity consumed. Thus, the calculated price is not a uniform exogenous market price of a particular grain commodity; but instead, it reflects household food quality choices as well as price variations (Yu and Abler, 2009). For example, within the broad category of rice, there is a scope for household choice with respect to the type of rice, appearance, stickiness, fragrance, and nutrient content (Gao, Wailes, and Cramer, 1994). The quality and price adjustments can be made utilizing the procedure proposed by Cox and Wohlgenant (1986). However, not all households purchase all the four studied grain commodities during the survey period. The data set used for this study indicates that zero expenditures are reported for rice, wheat flour, coarse grains, and grain products for 5.65%, 38.91%, 28.70%, and 0.76% of households, respectively. The nonpurchases could be due to no preference for the commodity or survey errors because the data are from a household's diary for food consumption/expenditure over an entire year. The missing prices resulting from the nonpurchases are handled using Heckman's (1979) sample selection procedure in this study. Specially, the first step of Heckman's procedure is to estimate a univariate probit model separately for rice, wheat flour, coarse grains, and grain products using complete observations in order to compute the inverse Mills ratios for each of the four studied grain commodities. The estimated inverse Mills ratios are then incorporated into the second step hedonic price equations provided by Cox and Wohlgenant (1986) using the observations for consuming households so as to account for any bias resulting from zero values in the dependent variables. The resulting relationship is used to generate corresponding quality-adjusted prices for grain commodities for those consuming households, while the average quality-adjusted prices estimated with this procedure are set to equal the missing prices for nonconsuming households [see Zheng and Henneberry (in press) for detailed explanation].

Table 2 contains summary statistics along with a description of the demographic variables. The average per capita disposable income reported for 2004 is 10,538 Yuan (equivalent to U.S. $1,302 using 2004 nominal exchange rates), while the average per capita grain expenditure is 240 Yuan only. Thus, the per capita grain expenditure in urban Jiangsu accounts for a marginal share of the per capita disposable income. The budget shares for rice, wheat flour, coarse grains, and grain products are 62%, 6%, 3%, and 30%, respectively, in urban Jiangsu. These statistics indicate that rice is the dominant commodity in the consumer food grain diet in urban Jiangsu. In addition, as shown in the table, the low percentage of the number of children and the high percentage of the number of people aged 61 and above indicate that population in urban Jiangsu has been aging. This aging of the population has been attributed to government policies advocating later marriages, fewer births, and one birth per couple in urban areas. This changing age structure of the population has had a notable impact on the composition and quantity of foods consumed (Zheng and Henneberry, 2009). It is expected that the changing age structure of the population in China has also had an impact on the composition and quantity of food grains consumed.

Estimation Procedures

This study employs the consistent two-step (CTS) estimation procedure for a system of equations with limited variables, proposed by Shonkwiler and Yen (1999), to account for zero expenditure shares resulting from missing values. The first step of CTS procedure involves a probit regression to determine the

Table 2. Summary Statistics, Urban Jiangsu Province, China, 2004[a]

	Mean	SD	Minimum	Maximum
	Grain Expenditure Share			
Rice	0.62	0.27	0.00	1.00
Wheat	0.06	0.11	0.00	0.83
Coarse grains	0.03	0.05	0.00	1.00
Grain products	0.30	0.25	0.00	1.00
	Per Capita Consumption (kg/person/year)			
Rice	57.14	47.63	0.00	400.00
Wheat	7.26	17.90	0.00	221.25
Coarse grains	1.86	3.44	0.00	33.85
Grain products	13.15	13.53	0.00	106.25
	Unit Value for Consuming Households (yuan/kg)			
Rice	2.89	0.29	1.80	4.41
Wheat	2.56	0.56	1.52	5.00
Coarse grains	3.41	2.05	1.00	18.19
Grain products	4.73	2.37	1.83	22.24
	Quality-Adjusted Price (yuan/kg)			
Rice	2.78	0.26	1.82	4.24
Wheat	2.72	0.44	0.80	4.98
Coarse grains	2.48	1.66	0.03	16.21
Grain products	3.33	2.19	0.02	19.03
	Socio-Demographic Variables			
Per capita income	10538.50	8193.76	1163.20	116473.00
Per capita grain expenditure	240.23	159.57	0.75	1217.40
South (yes = 1; 0 otherwise)	0.46	0.50	0.00	1.00
Town (yes = 1; 0 otherwise)	0.28	0.45	0.00	1.00
Household size	3.00	0.99	1.00	8.00
Ratio of seniors[b]	0.21	0.35	0.00	1.00
Ratio of children[b]	0.15	0.17	0.00	1.00
College (yes = 1; 0 otherwise)	0.08	0.27	0.00	1.00
FAFH spending ratio[b]	0.14	0.14	0.00	0.85

[a] Statistics refer to food-consumed-at-home data.

[b] Ratio of seniors, ratio of children, and ratio of FAFH spending refer to the ratio of seniors (aged 61 and above) to total household members, the ratio of children (aged 17 and below) to total household members, and the ratio of food-away-from-home spending to total food expenditures, respectively.

Source: Calculated based on the NBS data regarding 920 households in urban Jiangsu, China, 2004.

probability of purchasing a grain commodity. Different from the approach suggested by Shonkwiler and Yen (1999), who employ a univariate probit model in the first step estimation, this study adopts a multivariate probit model so as to account for possible correlation among the four studied commodities (Pan, Monhanty, and Welch, 2008). With the maximum likelihood method, the multivariate probit regression is estimated simultaneously for rice, wheat flour, coarse grains, and grain products using all observations. The explanatory variables used in the estimation are demographic variables that are the same as those used in Equation (4), logarithms of prices for the four studied commodities, and household income. From the multivariate probit estimation, the standard normal cumulative distribution function (cdf) and the standard normal probability density function (pdf) are calculated subsequently for each commodity related to each household. In the second step, the calculated cdf and pdf from the first step multivariate probit regression are augmented in the QUAIDS specification to generate a model that is used in this study. This model is specified as:

$$(7) \qquad s_{ih} = \Phi(\mathbf{z}_h\hat{\boldsymbol{\tau}}_i) \times w_{ih} + \delta_i\varphi(\mathbf{z}_h\hat{\boldsymbol{\tau}}_i) + \zeta_{ih},$$

where s_{ih} is the observed share of total grain expenditure allocated to the ith grain commodity for household h, w_{ih} is the determinant part of Equation (1), $\Phi(\cdot)$ and $\varphi(\cdot)$ are the calculated standard normal cdf and pdf for household h for commodity i from the first-step estimation respectively, $\mathbf{z}_h$ is a vector of explanatory variables in multivariate probit estimation, $\boldsymbol{\tau}_i$ is the vector of associated parameters for the ith commodity in multivariate probit estimation, δ_i represents the covariance between the error term in QUAIDS model and error term of multivariate probit model (Shonkwiler and Yen, 1999) and is also the parameter to be estimated in equation above, and ζ_{ih} is the heteroscedastic error term.[3]

One issue associated with the use of CTS procedure is that the adding-up condition does not hold in the system of Equation (7) [see Yen, Kan, and Su (2002) for a detailed explanation]. To correct for this problem, the approach proposed by Yen, Lin, and Smallwood (2003) is used in this study to treat the nth good as a residual category with no specific demand of its own. More specifically, the first n − 1 equations in the n-good QUAIDS system are estimated along with the following identity (which may be viewed as the adding-up restriction):

$$(8) \qquad s_n = 1 - \sum_{i=1}^{N-1} s_i,$$

where s_n is defined as the budget share of good n as a residual share. A drawback associated with this approach is that the resulting estimates will not be invariant to the residual good selected (Yen, Lin, and Smallwood, 2003). However, "if there is a natural choice for this residual good, invariance is not of primary interest" (Yen, Lin, and Smallwood, 2003, p. 460). For this study, the coarse grains category fits into the residual good category because it only accounts for less than 3% of total grain expenditures in urban Jiangsu. Hence, the four-good augmented QUAIDS system [Equation (7)] is estimated for three grain commodities encompassing rice, wheat flour, and grain products, simultaneously with the grain expenditure equation [Equation (6)], using the full information maximum likelihood estimation method, with homogeneity and symmetry imposed.

Because common price variables are used in both the multivariate probit and the QUAIDS estimations, the full effects of changes in a price on grain demand should be taken into account. Hence the uncompensated (Marshallian) price elasticities for rice, wheat flour, and grain products are adapted as follows:

$$(9) \qquad e_{ij}^{u} = w_i^{-1}\left\{\gamma_{ij} - \left(\beta_i + \frac{2\lambda_i}{b(p)}\right)\left[\ln\left(\frac{m}{a(p)}\right)\right]\left(\alpha_j + \sum_k^N \gamma_{jk}\ln(p_k)\right) - \frac{\lambda_i\beta_j}{b(p)}\left[\ln\left(\frac{m}{a(p)}\right)\right]^2\right\} \times \Phi_i + \varphi_i\tau_{ij}(1 - \delta_i/w_i) - \delta_{ij},$$

where τ_{ij} denotes the parameter for the price of jth grain commodity in the first-step estimation, and δ_{ij} is the Kronecker delta (1 if $i = j$ and 0 otherwise).[4]

The expenditure elasticity of demand for rice, wheat flour, and grain products is defined as:

$$(10) \qquad e_i = 1 + w_i^{-1}\left[\beta_i + \frac{2\lambda_i}{b(p)}\ln\left(\frac{m}{a(p)}\right)\right] \times \Phi_i.$$

Price and expenditure elasticities for coarse grains category are derived using the adding-up restriction [Equation (8)] specified as:

$$(11) \qquad \sum_{i=1}^{N} w_i e_i = 1,\ \sum_{i=1}^{N} w_i e_{ij}^{u} = -w_j, \text{ and } \sum_{j=1}^{N} e_{ij}^{u} + e_i = 0.$$

The compensated (Hicksian) price elasticity of demand for the studied goods is given by:

[3] The incorporation of cdf and pdf from the first-step probit estimation introduces heteroscedasticity into the second-step estimation, leading to consistent but inefficient parameter estimates (Greene, 2003; Shonkwiler and Yen, 1999). Future econometric research is needed to develop a procedure to address this efficiency issue.

[4] Based on Su and Yen (2000, p.733), the marginal effect of a common variable z_{ik} in $\mathbf{x}_i$ and $\mathbf{z}_i$ is specified as $\frac{\partial E(s_i)}{\partial z_{ik}} = \Phi(\mathbf{z}_i\hat{\boldsymbol{\tau}}_i) \times \frac{\partial w(\mathbf{x}_i\boldsymbol{\beta}_i)}{\partial z_{ik}} + w(\mathbf{x}_i\boldsymbol{\beta}_i)\varphi(\mathbf{z}_i\hat{\boldsymbol{\tau}}_i)\tau_{ik} - \delta_i\varphi(\mathbf{z}_i\hat{\boldsymbol{\tau}}_i)\tau_{ik}$, which is the basis to adapt the price and demographic elasticities for rice, wheat flour, and grain products in this study.

$$e_{ij}^{c} = e_{ij}^{u} + w_j e_i. \tag{12}$$

The income elasticity for the studied goods is given by:

$$e_{y(i)} = e_i e_y, \tag{13}$$

where e_y is the estimated parameter of the household income in the reduced form expenditure equation [Equation (6)].

Similar to the uncompensated price elasticities for rice, wheat flour, and grain products, the demographic elasticity of demand for the three commodities should also reflect the full effect of changes in a common demographic variable on the grain demand. Thus the demographic elasticity for the three commodities is derived as:

$$\begin{aligned} e_{ik}^{d} = w_i^{-1} &\left\{ \rho_{ik} - \left(\sum_{j=1}^{N} \rho_{ij} \ln(p_j) \right) \right. \\ &\left. \times \left[\beta_i + \frac{2\lambda_i}{b(p)} \ln\left(\frac{m}{a(p)} \right) \right] \right\} d_k \Phi_i \\ &+ \varphi_i \tau_{ik} \left(1 - \frac{\delta_i}{w_i} \right), \end{aligned} \tag{14}$$

where τ_{ik} denotes the parameter for the kth demographic variable in the first step estimation, and $d_k = 1$ if d_k is a binary variable (1/0) and the mean of the variable otherwise.

The demographic elasticity for coarse grains category is calculated directly from the parameters of the adding-up restrictions. That is, the demographic elasticity for coarse grains category is given as:

$$\begin{aligned} e_{ik}^{d} = w_i^{-1} &\left\{ \rho_{ik} - \left(\sum_{j=1}^{N} \rho_{ij} \ln(p_j) \right) \right. \\ &\left. \times \left[\beta_i + \frac{2\lambda_i}{b(p)} \ln\left(\frac{m}{a(p)} \right) \right] \right\} d_k. \end{aligned} \tag{15}$$

Empirical Results

Parameter Estimates

Parameter estimates and error correlation matrix from the first-step multivariate probit estimation is presented in Table 3. While many of the parameters in the participation equation (i.e., the multivariate probit model) are statistically insignificant, variables associated with south, city size, household size, ratio of seniors to total household members, ratio of children to total household members, ratio of FAFH spending to total food expenditures, and prices play a role in determining the consumption of grain commodities in urban Jiangsu. It is of interest to note that among all food grains, the household income only has a significant influence on the probability of consumption of coarse grains which consists mainly of corn, millets, and oats. This finding is consistent with the current consumption patterns of urban China consumers and reflects consumers' view of coarse grains as having a higher nutritional value as compared with rice and wheat products (Wang and Zhou, 2005). Additionally, four of the six error correlation parameters are statistically significant (Table 3, last 3 rows), suggesting the correlation among four types of grain commodities.

In this study, the demand system for grain commodities is also estimated using the AIDS specification developed by Deaton and Muellbauer (1980). The parameter estimates and the adjusted R^2 of the QUAIDS and AIDS models for rice, wheat flour, and grain products, as well as the reduced form equation for grain expenditures, are reported in Table 4. The AIDS model is nested within the QUAIDS through the joint hypothesis that $\lambda_i = 0 \forall i$. As shown in Table 4, the estimated value of λ_i is statistically different from zero only for rice, which suggests nonlinear Engel curve with respect to the logarithm of total grain–expenditures on this commodity. However, when the AIDS restriction, as described above, is imposed on the QUAIDS specification, the likelihood ratio statistic of 58 is obtained for the AIDS versus the QUAIDS. This likelihood ratio indicates the rejection, at the 1% significance level, of the null hypothesis that the AIDS and QUAIDS models are the same. From the statistical test results it is concluded that the QUAIDS model is superior to the AIDS specification in this particular application. Additionally, parameter estimates for the standard normal pdf (δ_i) are significant in the equations for rice and grain products respectively, providing evidence that

Table 3. Parameter Estimates of the Multivariate Probit Model, Urban Jiangsu Province, China, 2004[a]

	Rice		Wheat Flour		Coarse Grains		Grain Products	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
Constant	3.884*[b]	1.696	1.702*	0.942	−1.294	0.949	2.541	3.699
South	0.064	0.170	−0.587*	0.094	0.024	0.097	0.467	0.429
Town	−0.778*	0.160	−0.284*	0.100	−0.141	0.101	−0.659*	0.338
Household size	0.205*	0.108	0.080	0.052	−0.037	0.055	−0.185	0.188
Ratio of seniors	1.167*	0.428	0.276*	0.139	0.270*	0.150	0.623	0.616
Ratio of children	−1.301*	0.449	−0.443	0.274	−0.621*	0.282	2.986*	1.580
College	−0.141	0.255	−0.095	0.165	−0.092	0.169	2.924	11.139
FAFH ratio	−1.340*	0.477	−2.239*	0.373	−0.796*	0.343	0.461	1.538
Log of price of rice	−0.747	0.979	−0.856*	0.495	−0.078	0.543	0.556	1.786
Log of price of wheat flour	−0.972	0.599	−0.766*	0.301	−0.035	0.321	0.728	1.098
Log of price of coarse grains	−0.080	0.198	−0.184*	0.079	−0.500*	0.102	0.306	0.317
Log of price of grain products	−0.214*	0.110	−0.203*	0.067	0.194*	0.070	−0.478	0.317
Log of household income	−0.023	0.142	0.100	0.080	0.248*	0.082	−0.084	0.343
Error Correlation Matrix								
Rice	1		0.323*	0.093	0.177*	0.094	0.393*	0.237
Wheat flour			1		0.309*	0.055	0.067	0.189
Coarse grains					1		0.203	0.203
Grain products							1	

[a] Estimated using 2004 China's National Bureau of Statistics (NBS) household survey data.
[b] Single asterisks (*) denote significance at the 10% level.

it is important to account for zero observations in these commodities.

Economic Variable Impacts

Price, grain expenditure, and income elasticities, using both the QUAIDS and the AIDS specifications, are presented in Table 5. All these elasticities are evaluated on the basis of parameter estimates and sample means of explanatory variables. Standard errors for these elasticities are derived using the delta method. Consistent with economic theory, all uncompensated (Marshallian) own-price elasticities are negative and significant at the 5% level. The uncompensated own-price elasticities for rice, wheat flour, coarse grains, and grain products are −0.93, −1.95, −2.16, and −0.79, respectively. Similar to their uncompensated counterparts, all compensated (Hicksian) own-price elasticities are negative and significant at the 5% level. The compensated own-price elasticities for rice, wheat flour, coarse grains, and grain products are −0.30, −1.84, −2.14, and −0.57, respectively. While the uncompensated own-price elasticity for rice from this study is close to those reported by past studies (Table 1), the uncompensated own-price elasticities for wheat flour and coarse grains from this study are notably larger in absolute terms than those found by past studies.

With the positive signs, the compensated cross-price elasticity estimates show that all the grain commodities are net substitutes. As shown in Table 5, the cross-price elasticity of wheat flour with respect to the price of coarse grains is 1.41, and the cross-price elasticity of coarse grains with respect to the price of grain products 3.03. Consequently, the demand for wheat flour is expected to rise markedly as coarse grains category becomes more expensive relative to wheat flour. A similar situation holds for the consumption of coarse grains as grain products category become more expensive relative to coarse grains. Additionally, while six uncompensated cross-price effects are negative, all the compensated cross-price

Table 4. Parameter Estimates of the Expenditure Function, the QUAIDS Model, and the AIDS Model, Urban Jiangsu Province, China, 2004[a]

	QUAIDS				AIDS			
	Ln(m)	Rice	Wheat Flour	Grain Products	Ln(m)	Rice	Wheat Flour	Grain Products
Intercept	5.2867**[b]	0.1925	−0.3371**	0.8061**	5.1535**	0.6522**	−0.2565**	0.6018**
South	−0.0201	0.1069**	−0.0848**	−0.0264**	−0.0235	0.1141**	−0.0897**	−0.0258**
Town	−0.3772**	−0.0609**	0.0860**	0.0031	−0.3838**	−0.0767**	0.0860**	0.0145
Household size	0.2171**	0.0312**	−0.0114**	−0.0192*	0.2176**	0.0356**	−0.0126**	−0.0236**
Ratio of seniors	0.3791**	0.1071**	−0.0492**	−0.0794**	0.3750**	0.1164**	−0.0468**	−0.0875**
Ratio of children	−0.6785**	−0.2871**	0.0422	0.2477**	−0.6920**	−0.3052**	0.0368	0.2647**
College	−0.1316	−0.0373	0.0208	0.0200	−0.1215	−0.0328	0.0199	0.0191
Ratio of FAFH spending	−1.7876**	−0.4023**	0.1522**	0.2680**	−1.7741**	−0.4216**	0.1692**	0.2880**
Log of price of rice	−0.4308*	−0.0051	−0.0276	−0.0138	−0.4251**	0.0449	0.0180	−0.0684**
Log of price of wheat flour	−0.3424**	−0.0276	−0.0809**	0.0658**	−0.3863*	0.0180	−0.0535	0.0369**
Log of price of coarse grains	−0.0212	0.0465**	0.0427**	−0.0410**	−0.0222	0.0055	−0.0014**	0.0022
Log of price of grain products	0.0019	−0.0138	0.0658**	−0.0110	0.0074	−0.0684**	0.0369**	0.0292
ln(m)	—	0.1455**	0.1038**	−0.1134**	—	−0.0203	0.0780**	−0.0550*
$[\ln(m)]^2$	—	−0.0148**	−0.0019	0.0035	—	—	—	—
φ[c]	—	0.4192**	−0.0563	0.2052*	—	0.4386**	−0.0466	0.2062**
ln(y)	0.1499**	—	—	—	0.1665**	—	—	—
Adjusted R^2	0.2261	0.1557	0.1614	0.3014	0.2243	0.0668	0.1770	0.2622

[a] Estimated using 2004 China's National Bureau of Statistics (NBS) household survey data.

[b] Single and double asterisks (*) denote significance at the 10% and 5% levels, respectively.

[c] φ indicates the standard normal pdf estimated in the first-step multivariate probit regression.

Table 5. Uncompensated and Compensated Price, Expenditure, and Income Elasticities, Urban Jiangsu Province, China, 2004 (Standard Error in Parentheses)[a]

	QUAIDS Model				AIDS Model			
	Price of				Price of			
	Rice	Wheat Flour	Coarse Grains	Grain Products	Rice	Wheat Flour	Coarse Grains	Grain Products
				Marshallian Price Elasticities				
Rice	−0.927**[b]	0.024	−0.009	−0.108	−0.904**	0.015	0.016	−0.095**
	(0.061)	(0.038)	(0.019)	(0.023)	(0.071)	(0.041)	(0.020)	(0.024)
Wheat flour	−1.075**	−1.952**	1.348**	−0.236**	−1.066**	−1.830**	1.234**	−0.164
	(0.378)	(0.356)	(0.573)	(0.115)	(0.381)	(0.380)	(0.578)	(0.109)
Coarse grains	−0.700	0.242	−2.165**	2.566**	−1.206	0.334	−2.616**	2.199**
	(1.287)	(0.792)	(0.860)	(0.459)	(1.496)	(0.814)	(0.791)	(0.488)
Grain products	−0.028	0.062*	0.030	−0.787**	−0.078	0.068*	0.005	−0.809**
	(0.087)	(0.037)	(0.034)	(0.036)	(0.098)	(0.036)	(0.026)	(0.037)
				Hicksian Price Elasticities				
Rice	−0.297**	0.083**	0.020	0.195**	−0.307**	0.072**	0.042**	0.192**
	(0.051)	(0.038)	(0.019)	(0.026)	(0.058)	(0.041)	(0.020)	(0.030)
Wheat flour	0.096	−1.838**	1.411**	0.332**	0.061	−1.723**	1.285**	0.378**
	(0.377)	(0.355)	(0.571)	(0.119)	(0.381)	(0.380)	(0.578)	(0.117)
Coarse grains	0.287	0.362	−2.140**	3.033**	0.010	0.449	−2.562**	2.783**
	(1.335)	(0.802)	(0.851)	(0.513)	(1.485)	(0.823)	(0.786)	(0.523)
Grain products	0.420**	0.105**	0.049	−0.573**	0.425**	0.115**	0.028	−0.568**
	(0.056)	(0.037)	(0.034)	(0.042)	(0.060)	(0.036)	(0.026)	(0.050)
				Expenditure and Income Elasticities				
Expenditure	1.019**	1.916**	1.588**	0.724**	0.967**	1.825**	1.969**	0.815**
	(0.036)	(0.116)	(0.555)	(0.080)	(0.040)	(0.095)	(0.589)	(0.083)
Income	0.152**	0.286**	0.238**	0.108**	0.161**	0.305**	0.329**	0.136**
	(0.039)	(0.073)	(0.096)	(0.031)	(0.034)	(0.063)	(0.104)	(0.032)

[a] Estimated using 2004 China's National Bureau of Statistics (NBS) household survey data.

[b] Single and double asterisks (*) denote significance at the 10% and 5% levels, respectively.

effects are positive, indicating that the income effect outweighs the substitution effect in 6 of the 12 cases (Table 5).

Grain expenditure elasticities indicate the percentage change in quantity demanded of a grain commodity in response to a 1% change in total grain expenditures. The expenditure elasticities for rice, wheat flour, coarse grains, and grain products are 1.02, 1.92, 1.59, and 0.72, respectively (Table 5). The relatively low expenditure elasticities for rice and grain products in this study are consistent with the dietary habits of consumers in Jiangsu who use rice and grain products as their main staple grain commodities (accounting for 60% and 30% of total grain expenditures respectively) and consider these grain commodities as being more important as compared with other grain commodities.

Wheat flour and coarse grains in this study have relatively higher own-price and expenditure elasticities in absolute values as compared with rice and grain products. This finding seems to be contradictory to the fact that wheat flour and coarse grains only account for a marginal share of total food grain expenditures spent in urban Jiangsu (6% and 3%, respectively). However, a careful examination of the data used in this study reveals that these elasticity estimates may be reasonable. Wheat flour is consumed mainly by relatively low-income households in the north of Jiangsu province. Given that the unit value of wheat flour for consuming households is the lowest in the four studied commodities (Table 2), these low-income consumers in urban Jiangsu, who have been with wheat products as their staple grain commodity, might be highly responsive to changes in own-price and grain expenditure. In contrast to the case of wheat flour, the coarse grains category is mainly consumed by high-income consumers. Considering that coarse grains in urban Jiangsu serves as a complement to rice and grain products in consumers' diets and the consumption of coarse grains has a positive relationship with per capita disposable incomes, the own-price and expenditure elasticities for coarse grains category is expected to be higher in absolute terms than those for rice and grain products.[5] Nevertheless, more research is needed for confirming this finding in other southern urban provinces of China.

The income elasticities for rice, wheat flour, coarse grains, and grain products are 0.15, 0.29, 0.24, and 0.11, respectively. Contrary to the studies by Peterson, Jin, and Ito (1991) and Carter and Zhong (1999) that indicate rice and wheat are inferior goods in China and in rural Jiangsu, respectively, the results from this study support the findings from Fan, Wailes, and Cramer (1995); Gould and Villarreal (2006); Huang, David, and Duff (1991); Liu and Chern (2003); Wu, Li, and Samuel (1995); and Zhuang and Abbott (2007) that rice, wheat, and coarse grains are normal goods in urban Jiangsu. Moreover, these income elasticity estimates are relatively lower as compared with those found by past studies (Table 1). This study uses the most recent urban household survey data that show consumers in urban Jiangsu earn more income on a per capita basis now than the periods covered by past studies. Consequently, the relatively low income elasticities for grain products from this study suggest that urban consumers in Jiangsu may have become less responsive to per capita income changes as household incomes have increased.

[5] According to the data used in this study, 158 households (146 in the north and 12 in the south), with per capita consumption at 10 kg and more, purchased approximately 86% of the total amount of wheat flour; whereas 107 households (103 in the north and 4 in the south), with per capita consumption at 20 kg and more, consumed about 76% of the total amount of wheat flour. Additionally, the average per capita income for the former is 8,669 yuan while the income for the latter is 8,124 yuan. These per capita income figures are much lower than the provincial average (10,538 yuan). For coarse grains, 88 households consumed 50% of total amount of coarse grains where the per capita consumption is at 5 kg and more; while 26 households consumed 26% of total amount of coarse grains where the per capita consumption is at 10 kg and more. In addition, the former has an average income of 13,180 yuan, while the latter has an income of 14,896 yuan. These averages are much higher than the provincial average.

Demographic Variable Impacts

The effects of demographic variables on the demand for grain commodities, as measured by the estimated demographic elasticities of demand, are presented in Table 6. According to the results in Table 6, households living in the south of the Yangtze River tend to purchase more rice but less wheat flour, coarse grains, and grain products. The finding is consistent with consumers' general food preferences in urban Jiangsu that for consumers living to the south of the Yangtze River rice is preferred to wheat products. City size shows as having a significant impact on the consumption of rice and wheat flour. Relative to households living in a city, households living in a town tend to consume more wheat flour and less rice. Because, based on the data used in the study, two-thirds of households living in towns are located in the north of the Yangtze River, the results may also reflect consumers' food preferences in urban Jiangsu that for consumers living to the north of the Yangtze River wheat products is preferred to rice.

Household size has a positive relationship on the demand for rice, but a negative relationship on the demand for wheat flour and grain products. Households with more seniors (aged 61 and above, ratio of seniors in Table 6) tend to consume more rice but less grain products. In contrast to the variable related to the ratio of seniors to total household members, households with more children (aged 17 and below, ratio of children in Table 6) tend to consume more grain products but less rice and wheat flour. Thus, the change of the household size and the population age structure that is currently taking place in China is expected to have a notable effect on the composition and quantity of food grains consumed.

Results from this study show that variables related to educational levels of household heads do not have a significant effect on the consumption of food grain commodities in urban Jiangsu, although they show as having an impact on the broad category of food grains in urban China (Yen, Fang, and Su, 2004; Zheng and Henneberry, 2009). The ratio of FAFH spending to total food expenditures has a positive effect on the consumption of grain products, but a negative impact on consumption of rice and wheat flour. Therefore, as urban consumers in Jiangsu consume more of their food away from home, per capita consumption of grain products is expected to increase; while the per capita consumption of rice and wheat flour is expected to decrease. This is expected as rice and wheat flour purchases by the end consumer are basically for at-home food preparation.

Table 6. Demographic Elasticities Using the QUAIDS Model, Urban Jiangsu Province, China, 2004 (Standard Error in Parentheses)[a]

	Quantity of			
With Respect to:	Rice	Wheat Flour	Coarse Grains	Grain Products
South (yes = 1; 0 otherwise)	0.172**[b]	−1.387**	−1.039**	−0.072
	(0.032)	(0.220)	(0.391)	(0.047)
Town (yes = 1; 0 otherwise)	−0.101**	0.708**	0.152	0.006
	(0.033)	(0.114)	(0.382)	(0.058)
Household size	0.150**	−0.366**	−0.570	−0.174*
	(0.060)	(0.184)	(0.458)	(0.109)
Ratio of seniors	0.041**	0.084	0.017	−0.051**
	(0.011)	(0.082)	(0.090)	(0.018)
Ratio of children	−0.074**	−0.235*	0.092	0.121**
	(0.014)	(0.132)	(0.108)	(0.024)
College (yes = 1; 0 otherwise)	−0.060	0.173	0.164	0.043
	(0.048)	(0.202)	(0.431)	(0.047)
Ratio of FAFH spending	−0.095**	−1.417**	0.216	0.116**
	(0.017)	(0.622)	(0.177)	(0.028)

[a] Estimated using 2004 China's National Bureau of Statistics (NBS) household survey data.

[b] Single and double asterisks (*) denote significance at the 10% and 5% levels, respectively.

Because rice is an important component of food grain demand in China, accounting for over 60% of grain consumption and over 25% of land under food grain production during the past decade, the following section will focus on the analysis of rice demand.

An Analysis of Rice Consumption over the Period of 1995–2007

Similar to the trend in the national average, the average per capita at-home consumption of rice in urban Jiangsu province has been declining over the past decade. The average annual per capita at-home rice consumption decreased from 71.3 kg in 1995 to 56.2 kg in 2000 and to 50.2 kg in 2007. This section quantifies the contribution of prices, grain expenditures, and demographic variables to the decline in rice consumption over the 1995–2007 period, using the estimated structure with the cross-sectional data in 2004 which is presented in the previous section. The factors affecting the decrease in consumption are classified into three groups each of economic effects and demographic effects through a decomposition analysis.

Based on work of Heien and Wessells (1988) and Henneberry and Mutondo (2009), a double-log functional form used for the prediction can be expressed as $\ln \hat{q}_t = \sum_j e^u_{ij} \ln p_{jt} + \sum_k e^d_{ik} \ln d_{kt} + e_i \ln m_t$. Thus, the percentage change in the dependent variable is the elasticity-weighted sum of the percentage changes in the independent variables. Since the annual compound rate of growth between two points T years apart is given by $\frac{1}{T}(\ln \hat{q}_t - \ln \hat{q}_{t-T})$ (Heien and Wessells, 1988, p. 225), the annual rate of change in the demand for rice can be calculated as the elasticity-weighted sum of the annual rates of change in prices, grain expenditures, and demographic effects. That is,

$$
\begin{aligned}
&\frac{1}{T}\sum\nolimits_j e^u_{ij}\left(\ln p_{jt} - \ln p_{jt-T}\right) \\
&\quad + \frac{1}{T}\sum\nolimits_k e^d_{ik}(\ln d_{kt} - \ln d_{kt-T}) \\
&\quad + \frac{1}{T} e_i(\ln m_t - \ln m_{t-T}),
\end{aligned} \tag{16}
$$

where t denotes the last year of the study period, T refers to the number of years of the study period, i refers only to rice, j denotes rice, wheat flour, coarse grains, and grain products, and k refers to demographic variables used in this analysis. Note that this analysis is on a per household basis.

Data used for the decomposition analysis are from Jiangsu Statistical Bureau. Nominal prices (p_j) for rice, wheat flour, coarse grains, and grain products are calculated based on the quality-adjusted prices computed in this study and grain-price indexes for urban Jiangsu during 1995–2007. Nominal urban household grain expenditures (m) are calculated based on per capita grain expenditures and urban household sizes from 1995–2007. The demographic variables used in this decomposition analysis include household size, ratio of seniors to total household members, ratio of children to total household members, and ratio of FAFH spending to total food expenditures. Values for household size are directly obtained from the published urban household surveys in Jiangsu. Values for the ratio of seniors to total household members and for the ratio of children to total household members are computed from the statistics related to the number of household members by age-group, which is derived on the basis of the population age distribution and the average household size in Jiangsu. Data on Jiangsu population age distribution come from the 1% population sample surveys for 1995, 1999, and 2007, respectively. Of which, data for the year 1999 are used for the year 2000 due to unavailability of data for the year 2000. Values for the ratio of FAFH spending to total food expenditures are directly computed from the published urban household consumption statistics in Jiangsu (NBS, 1996–2005). The variables described above are presented in Table 7.

The impacts of changes in demographic and economic effects on the demand for rice are reported in Table 8. As was described above, the demographic impacts are decomposed into the impacts related to changes in the household composition (i.e., combining the ratio of seniors, the ratio of children, and the household size together) and those related to the changes in the ratio of FAFH spending to total food expenditures. The results show that the changes in the household composition (column 1),

Table 7. Variables Used for the Analysis of Rice Consumption over the 1995–2007 Period

Variables	Year 1995	2000	2007
Grain expenditure (yuan)	660.81[a]	481.59	609.72
Price of rice (yuan/kg)	2.74	2.03	3.06
Price of wheat flour (yuan/kg)	2.41	1.78	2.48
Price of coarse grains (yuan/kg)	2.73	2.02	2.81
Price of grain products (yuan/kg)	3.73	2.76	3.84
Household size	3.19	3.07	2.84
FAFH spending ratio	0.09	0.15	0.21
Ratio of seniors	0.26	0.27	0.35
Ratio of children	0.73	0.61	0.44

[a] Numerical values refer to mean values of variables.

which is the elasticity-weighted sums of ratio of seniors to total household members, the ratio of children to total household members, and the household size, caused annual rates of growth of 0.26% per year for rice consumption during the period 1995–2007; whereas the changes in the ratio of FAFH spending to total food expenditures (column 2) was responsible for annual rates of decline of 0.65% per year for rice consumption for the same period. Hence, the changes in these four demographic variables explain an important part of the decline in rice consumption over the past decade.

Economic impacts are decomposed into the impacts of the changes in own-price, cross-price, and household grain expenditures (Table 8). The decomposition results show that cross-price impacts are relatively smaller in absolute values as compared with own-price and household grain expenditure impacts. This was caused by the offsetting impacts of positive and negative price effects and the very small size of the cross-price impacts. Own-price and household grain expenditure impacts together were responsible for annual rates of reduction of 1.52% per year for rice consumption during the period 1995–2007. During the period 1995–2000, own-price impacts had a substantial positive effect on demand (5.56%) while household grain expenditure impacts had a slightly large negative effect on demand (−6.45%). During

Table 8. Decomposition of Demand for Rice by Demographic and Economic Impacts: 1995–2007, Annual Rates of Changes (%) (Standard Error in Parentheses)[a]

	Demographic Impacts		Economic Impacts			Predicted:	
	Household Composition	FAFH	Own-Price	Cross-Price	Exp.	Sum of (1)–(5)	Actual
Period	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1995–2000	0.17 (0.01)	−0.85 (0.01)	5.56 (0.34)	0.56 (0.02)	−6.45 (0.23)	−1.01 (2.41)	−5.54
2000–2007	0.33 (0.01)	−0.50 (0.01)	−5.40 (0.33)	−0.54 (0.02)	3.43 (0.12)	−2.68 (1.83)	−2.71
1995–2007	0.26 (0.01)	−0.65 (0.01)	−0.83 (0.05)	−0.08 (0.01)	−0.68 (0.03)	−1.98 (0.05)	−3.89

[a] Approximated by the delta method with the assumption that variables are independent.

the period from 2000 to 2007, own-price impacts had a substantially depressing effect on demand (−5.40%) while household grain expenditure impacts had a considerably positive effect (3.43%). Therefore, the decline in the demand for rice in urban Jiangsu during the three studied periods was mainly attributable to own-price as well as household grain expenditure impacts. Notice that the opposite impacts of own-prices and household grain expenditures on rice consumption during the two periods (1995–2000 versus 2000–2007) are due to an opposite trend of variation in grain prices over these two periods (Table 7).

Column (6) of Table 8 gives the predicted rates of decline in quantity consumed per household during the periods of 1995–2000, 2000–07, and 1995–2007; and column (7) gives the actual growth rates. The discrepancy between the two figures can arise from normal equation error and/or changes in the structure of demand (Heien and Wessells, 1988). This particularly applies to the situation during the period 1995–2000. Rapid income growth, aging of the population, and an increase in food away from home, etc., might have led to a change in the demand for food grain commodities. However, for the period of 2000–2007, the actual and predicted rates of decline in rice consumption are very close.

Conclusions and Policy Implications

A complete demand system of urban households for food grain commodities is estimated using the QUAIDS and AIDS specifications. All grain commodities are normal goods. Wheat flour and coarse grains are price elastic, while rice and grain products are price inelastic. All goods are net substitutes. The most significant demographic effects on the demand for grain commodities come from variables related to region, city size, household size, ratio of seniors to total household members, ratio of children to total household members, and ratio of expenditures for food-away-from-home to total food expenditures. Educational levels of household heads do not significantly influence the demand for food grain commodities in urban Jiangsu.

The causes of changes in the demand for rice in urban Jiangsu during the period 1995–2007 are decomposed into economic and demographic effects, based on the estimated demand structure. While demographic impacts relating to the changes in the household composition and in the ratio of FAFH spending to total food expenditures are shown as having an important impact on the annual change in rice consumption, economic impacts associated with the changes in own-price, cross-price, and household grain expenditure are mainly responsible for the annual change in the demand for rice. In particular, the decline in the demand for rice in urban Jiangsu over the past decade is largely caused by own-price and household grain expenditure impacts.

The decreasing trend of food grain consumption has significant implications regarding demand for food grains as well as feed grains. The change in dietary patterns away from rice and wheat coupled with the slowing of population growth rate because of the 30-years family planning policy is expected to decrease total demand for food grain commodities. It is therefore expected that China would be able to maintain its national policy goal of self-sufficiency for rice and wheat until 2020. Moreover, because more cropland is expected to be allocated to planting feed grains due to the decrease in the demand for food grains, China may import less feed grains in the future than has been anticipated.

[Received April 2009; Accepted January 2010.]

References

Banks, J., R. Blundell, and A. Lewbel. "Quadratic Engel Curves and Consumer Demand." *The Review of Economics and Statistics* 79(1997): 527–39.

Blundell, R., P. Pashardes, and G. Weber. "What Do We Learn About Consumer Demand Patterns from Micro Data?" *The American Economic Review* 83(1993):570–97.

Blundell, R., and J.M. Robin. "Estimation in Large and Disaggregated Demand Systems: An Estimator for Conditionally Linear Systems." *Journal of Applied Econometrics* 14(1999): 209–32.

Carter, C.A., and F. Zhong. "Rural Wheat Consumption in China." *American Journal of Agricultural Economics* 81(1999):582–92.

China's National Bureau of Statistics (NBS). *China Price and Urban Household Income and Expenditure Survey Statistical Yearbook*. Beijing: China Statistical Press, 1996–2005.

Christensen, L.R., D.W. Jorgenson, and L.J. Lau. "Transcendental Logarithmic Utility Functions." *The American Economic Review* 65(1975):367–83.

Cox, T.L., and M.K. Wohlgenant. "Prices and Quality Effects in Cross-Section Demand Analysis." *American Journal of Agricultural Economics* 68(1986):908–19.

Deaton, A., and J. Muellbauer. "An Almost Ideal Demand System." *The American Economic Review* 70(1980):312–26.

Dhar, T., J. Chavas, and B. Gould. "An Empirical Assessment of Endogeneity Issues in Demand Analysis for Differentiated Products." *American Journal of Agricultural Economics* 85(2003):605–17.

Fan, S., E.J. Wailes, and G.L. Cramer. "Household Demand in Rural China: A Two-Stage LES-AIDS Model." *American Journal of Agricultural Economics* 77(1995):54–62.

Gao, X., E.J. Wailes, and G.L. Cramer. "A Synthetic Demand System: An Application to U.S. Consumer Demand for Rice and Selected Rice Substitutes." *Review of Agricultural Economics* 16(1994):27–38.

Gould, B.W., and H.J. Villarreal. "An Assessment of the Current Structure of Food Demand in Urban China." *Agricultural Economics* 34(2006):1–16.

Greene, W.H. *Econometric Analysis*. Delhi, India: Pearson Education, Inc., 2003.

Heckman, J.J. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1979):153–61.

Heien, D.M., and C.R. Wessells. "The Demand for Dairy Products: Structure, Prediction, and Decomposition." *American Journal of Agricultural Economics* 70(1988):219–28.

Henneberry, S.R., and J.E. Mutondo. "Agricultural Trade Among NAFTA Countries: A Case Study of U.S. Meat Exports." *Review of Agricultural Economics* 31(2009):424–45.

Henneberry, S.R., K. Piewthongngam, and H. Qiang. "Consumer Food Safety Concerns and Fresh Produce Consumption." *Journal of Agricultural and Resource Economics* 24(1999): 98–113.

Hsu, H., W.S. Chern, and F. Gale. "How Will Rising Income Affect the Structure of Food Demand?" *China's Food and Agriculture: Issues for the 21st Century*. F. Gale, ed., pp. 10–13. Washington, DC: U.S. Department of Agriculture, ERS, AIB-775, 2002.

Huang, J., C.C. David, and B. Duff. "Rice in Asia: Is It Becoming An Inferior Good? Comment." *American Journal of Agricultural Economics* 73(1991):10–13.

Jiangsu Statistical Bureau. *Jiangsu Statistical Yearbook*. Beijing: China Statistical Press, 1996–2008. Internet site: http://www.jssb.gov.cn/jstj/index.htm (Accessed September 2009).

Liu, K.E., and W.S. Chern. "Food Demand in Urban China: An Application of a Multi-Stage Censored Demand System." Paper presented at AAEA annual meeting, Montreal, Canada, July 27–30, 2003.

Lohmar, B. "China's Wheat Economy: Current Trends and Prospects for Imports." Economic Research Service/U.S. Agricultural Department. WHS 04D-01 (May 2004).

Mid-Long-Term National Grain Security Plan (2008–2020). Beijing: State Council of People's Republic of China, November 13, 2008 (issue by the Xinhua News Agency).

Pan, S., S. Monhanty, and M. Welch. "India Edible Oil Consumption: A Censored Incomplete Demand Approach." *Journal of Agricultural and Applied Economics* 40(2008):821–35.

Peterson, E.F., L. Jin, and S. Ito. "An Econometric Analysis of Rice Consumption in the People's Republic of China." *Agricultural Economics* 6(1991):67–78.

Shonkwiler, J.S., and S.T. Yen. "Two-Step Estimation of a Censored System of Equations." *American Journal of Agricultural Economics* 81(1999):972–82.

Su, S., and S.T. Yen. "A Censored System of Cigarette and Alcohol Consumption." *Applied Economics* 32(2000):729–37.

Wang, J., and Z. Zhou. "Animal Product Consumption." *Grains in China*. Z. Zhou and W. Tian, eds. Burlington: Ashgate Publishing Company, 2005.

Wu, Y., E. Li, and S.N. Samuel. "Food Consumption in Urban China: An Empirical Analysis." *Applied Economics* 27(1995):509–15.

Yen, S.T., C. Fang, and S. Su. "Household Food Demand in Urban China: A Censored System Approach." *Journal of Comparative Economics* 32(2004):564–85.

Yen, S.T., K. Kan, and S. Su. "Household Demand for Fats and Oils: Two-Step Estimation

of a Censored Demand System." *Applied Economics* 14(2002):1799–806.

Yen, S.T., B. Lin, and D.M. Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." *American Journal of Agricultural Economics* 85(2003):458–78.

Yu, X., and D. Abler. "The Demand for Food Quality in Rural China." *American Journal of Agricultural Economics* 91(2009):57–69.

Zheng, Z., and S.R. Henneberry. "An Analysis of Food Demand in China: A Case Study of Urban Households in Jiangsu Province." *Review of Agricultural Economics* 34(2009):873–93.

———. "The Impact of Changes in Income Distribution on Current and Future Food Demand in Urban China." *Journal of Agricultural and Resource Economics* (in press).

Zhuang, R., and P. Abbott. "Price Elasticities of Key Agricultural Commodities in China." *China Economic Review* 18(2007):155–69.