Income Elasticity of Rice Demand in Japan and Its Implications: Cross-Sectional Data Analysis

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Abstract

Researchers believe that rice in developed countries such as Japan became an inferior good a few decades ago. This study employs the flexible complete demand system for the recent cross-sectional data in Japan. Our results clearly show that rice in Japan is a normal good contrary to the preceding studies. The objective of this research is to analyze the food consumption patterns and to conduct econometric analysis of food demand structure. We use the monthly basis cross-sectional household data, *Annual Report on the Family Income and Expenditure Survey* (FIES) in 1997. Food items are non-glutinous rice, bread, noodle, fresh fish, and shellfish, fresh meat, milk, eggs, fresh vegetables, fresh fruits, fats and oil, and food away from home. We apply various single equation models: Working-Leser model is estimated by OLS, Heckman's two-step estimator, and Tobit estimator. All coefficients have correct signs and are statistically significant. For the complete demand system analysis, we apply the almost ideal demand (AIDS) system. To correct a censored dependent variable problem, we additionally utilize a censored regression approach. Results from AIDS models show that the expenditure elasticity of rice is positive and close to one. Marshallian and Hicksian own-price elasticities for rice are highly elastic for all models. Fresh meats and rice are mild complements in all models; however, fresh fish and rice show the mixed results.

Key Words: AIDS model, Cross-section, Income Elasticity, Japan, Rice Consumption.

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I. Introduction

The 1994 Marrakech agreements of the General Agreement on Tariff and Trade (GATT) Uruguay Round have started a process of agricultural market liberalization. The new round of World Trade Organization (WTO) negotiations to be launched the year 2000 are expected to bring this process further. The world rice market is a thin market. Ninety percent of production and consumption occurs in Asia. The GATT/WTO decisions will design a new picture of the world agricultural markets, and it is important to understand how this will influence the rice market in the near future.

Japan reached high economic growth earlier than other Asian nations. Recently, the Newly Industrialized Economies (NIEs) have been rapidly catching up and attaining higher per capita income. Many Asian nations may eventually reach the economic standards of Japan, Europe, and the U.S.. Japanese consumption behavior is a key indicator to forecast the future consumption patterns of Asian nations. For example, Korea accepted the same minimum access import requirements in the GATT negotiations, and Taiwan has a very similar agricultural society to Japan. By investigating Japanese consumption behavior as being representative of high-income consumers, this study will shed some light on the future direction of Asian and world rice demand.

In addition to a general concern about Japanese consumption behavior, it is of great interest to ascertain whether rice is a normal or inferior good, i.e. as the income increases, whether rice consumption goes up or down. Since rice is a very important food staple in Asian countries, many domestic agricultural as well as international trade

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policies are centered on rice. Such important agricultural policies would be misdirected if they were based on the belief that rice is an inferior good, without a rigorous and robust estimation of that characteristic.

When assessing food balances, the literature on the rice market is mainly concerned with supply side factors. (See Oniki (1996) and Fujiki (1993, 1998, 1999).) Considering the uncertain environment of the rice market in the future, one cannot neglect demand side study. In order to obtain an accurate forecast of Japanese rice market liberalization, precisely estimated elasticities are necessary.

The main objective of this research is to analyze food consumption patterns and to conduct econometric analysis of food demand structure in Japan. We use the cross-sectional household data from the *Annual Report on the Family Income and Expenditure Survey 1997* (FIES) compiled by the Statistics Bureau, Management and Coordination Agency in Japan. FIES is monthly basis and cross-sectional. The total number of observations used for estimation is 95,223. Food items are non-glutinous rice, bread, noodle, fresh fish, and shellfish, fresh meat, milk, eggs, fresh vegetables, fresh fruits, fats and oil and food away from home. This research is unique in the sense that income elasticities of rice and other related foods are estimated with a large degree of freedom. This kind of cross-sectional survey study is virtually non-existent in regard to Japanese consumption patterns. To our knowledge, these survey data have never been used for estimating a food demand system. Therefore, the results produced in this paper are potentially intriguing to demand analysts and policy makers.

In order to incorporate household-level microdata, we apply various single equation models: Working-Leser model estimated by OLS, Heckman’s sample selection model, and Tobit model. All coefficients have correct signs and are statistically significant. For complete demand system analysis, we apply the linearly approximated almost ideal demand system (LA/AIDS). The concept of a flexible complete demand system yields consumption behavior estimates with many desirable properties: the adding-up, homogeneity, and symmetry conditions can be tested, which preceding demand studies on this topic had rarely imposed. The LA/AIDS poses the unit of measurement problem. In order to obtain more accurate estimation, the LA/AIDS model with two price indexes is compared: the Stone price index and the Laspeyres price index. In order to correct a censored dependent variable problem, we also utilize a censored regression approach.

In section II of the paper, we discuss the background of Japanese consumption behavior. We show the historical path that has led to the recent consumption patterns. In section III, we present the data used for this research. In section IV, the single equation model and complete demand system used in this study are described. In section V, we make estimates with the model using cross-sectional data from section III. Section VI is the summary and conclusion.

II. Background

Japan reached high per capita income much earlier than other Asian nations. As per capita income grew, the consumption pattern changed. Many studies have reported that the Japanese diet has become more westernized; calorie intake is less from rice and more from animal meat, and the fat content of food has increased. Because of

Table 1: Industry Output (1995 Input-Output Data) Unit: Million Yen

Purchased Sector	Output of Rough Rice	
Milling	¥3,232,103	93.21%
Rice Wine	¥195,609	5.64%
Rough Rice	¥28,612	0.83%
Agricultural Services	¥6,690	0.19%
Live Stock	¥3,869	0.11%
Other Food Stuff	¥727	0.02%
Total	¥3,467,610	

Purchased Sector	Output of Milled Rice	
Household Consumption	¥2,604,991	74.38%
Restaurants and Hotels	¥553,485	15.80%
School and Hospital Lunch	¥118,625	3.39%
Rice Powder and Snacks	¥94,771	2.71%
Alcohol Beverages	¥67,076	1.92%
Prepared Instant Food	¥63,038	1.80%
Other (non-food use)	¥499	0.01%
Total	¥3,502,485	

Data Source: 1995 Input-Output Tables
Management and Coordination Agency, Government of Japan

geographical reasons and preferences, calorie intake from fish has a larger share than from meat.

In this study, we estimate the income elasticity from cross-sectional survey data to shed some light on some important questions.

1) Is Japanese rice an inferior good?

Rice is a staple food in Japan, and its great importance in the Japanese diet is well known. In 1995 10,748,000 metric tons of rice were produced domestically, and 10,485,000 metric tons were consumed. Rice is used by a variety of sectors, but mostly by the household. According to the 1995 input-output table (Government of Japan, 1999), 93.21% of rough rice is purchased by the milling sector, and 74.38% of milled rice is consumed by the households. (See **Table 1**.)

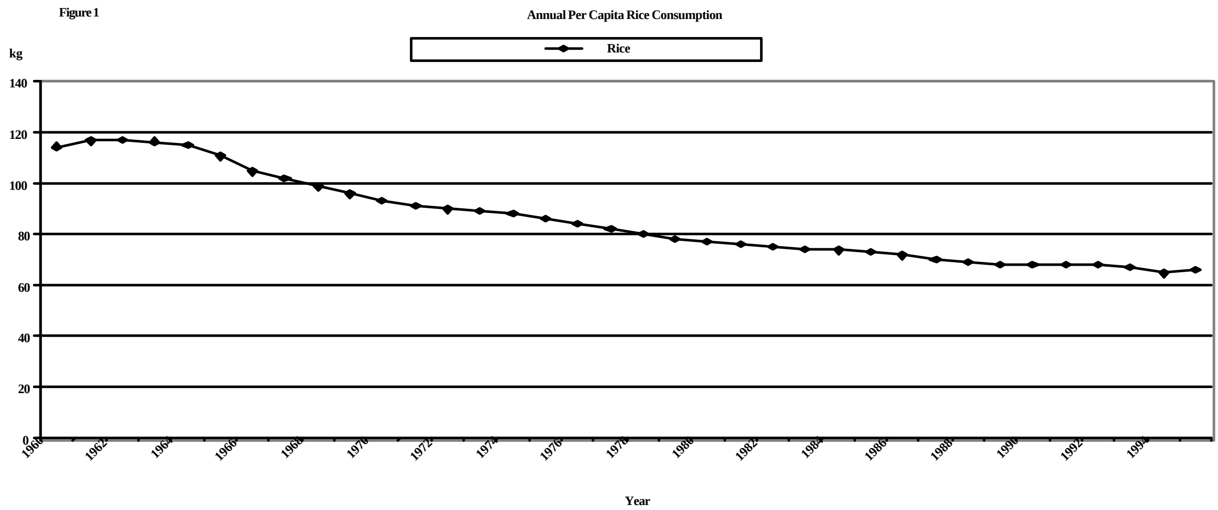
It is important to understand whether rice is a normal or inferior good. Japan has one of the highest per capita GDP in the world. By definition, rice consumption would keep falling with per capita GDP growth, if rice were an inferior good. If that is the case, and if Japan could be considered as the leading case for other Asian countries, we could project lower world rice demand in the future as Asian nations' income increases.

It has been considered as the stylized fact among researchers that income elasticities for rice and other food staples decline as per capita income increases. Researchers believe that rice in developed countries such as Japan became an inferior good a few decades ago.

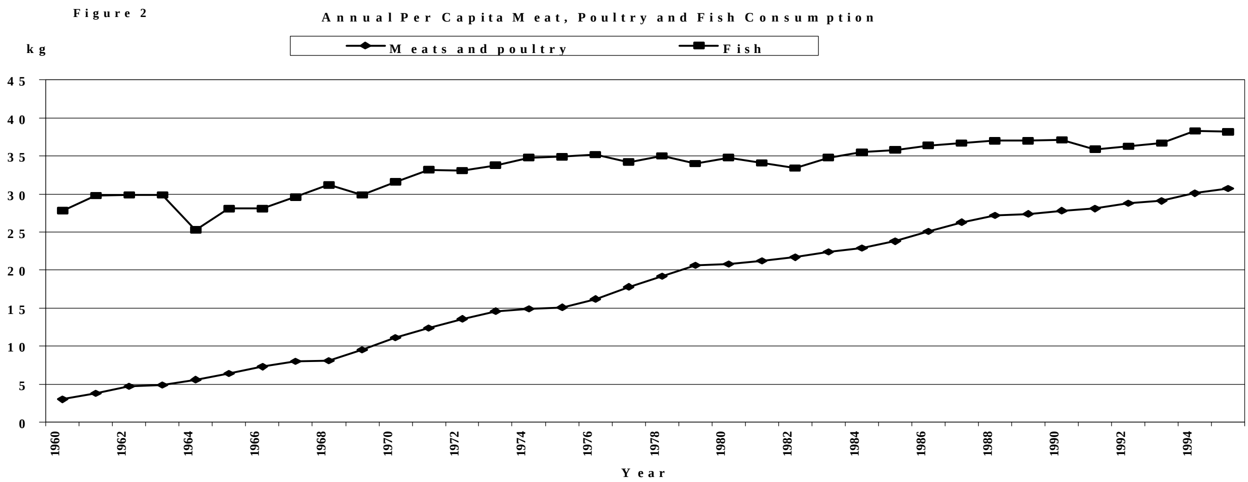
There is conflicting evidence on whether rice is an inferior good. Empirical studies are conducted by Ito el. al. (1989). Ito and colleagues conclude that rice is an inferior good in high-income Asian countries. Kako (1997) projected Japanese rice demand applying log linear function, and estimated it by OLS. They find evidence that rice is an inferior good and meat products are substitutes for rice. Bouis (1991) objects to Ito et al.'s study; the author claims that time-series estimates of grain consumption have a downward bias due to the urban-rural migration pattern and decreasing importance of rice production. From the estimation of calorie-income elasticities, Bouis and Haddad (1992) and Bouis (1994) claim that cross-sectional data estimates of income elasticity are upwardly biased due to leakage from actual consumption, such as meals for guests and animal feeding in developing countries. As Chern (1998) and Huang and Bouis (1986) point out, plotting aggregate consumption against per capita income simply shows the correlation between two variables. It does not necessarily reveal the true consumption behavior. Accurate income elasticity can be obtained from cross-sectional data, and we will estimate income elasticity among various income classes.

2) Is rice a substitute or complement for meat and/or fish?

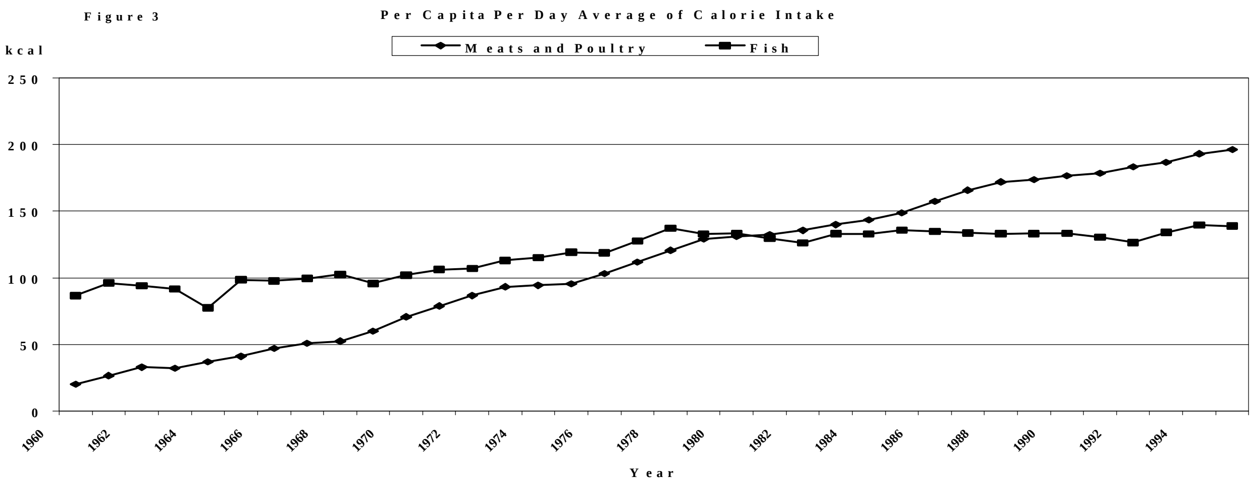
Many time-series studies show that people consume more meat and poultry as per capita income increases. Japan is not an exception: the consumption of meats and poultry has been increasing, while the consumption of rice has been decreasing since the 1960s.



Data Source: Food Balance Sheet (1997)



Data Source: Food Balance Sheet (1997)



Data Source: Food Balance Sheet (1997)

We estimate demand relationships among rice, meats, poultry, fish, and other products, and results are shown in section V.

Figures 1 to **3** show descriptive consumption patterns in Japan. All data are taken from the *Food Balance Sheet* by Japan Ministry of Agriculture, Forestry, and Fisheries (1997). **Figure 1** plots the annual per capita rice consumption in Japan. It is a well-known fact that aggregate rice consumption in Japan has been declining over the years, which is common amongst high-income countries. The peak of the per capita consumption of rice is in 1962. It is almost halved by the end of the 1990s. **Figure 2** shows annual per capita meat (beef and pork), poultry, and fish consumption. In kilogram terms, Japanese consume more fish than meat and poultry. This is one of unique features of the Japanese consumption pattern. **Figure 3** plots the average per capita daily calorie intake from meat, poultry, and fish. Since 1980, meat and poultry have become a larger source of calories compared to fish. In sum, in kilogram terms, Japanese consume more fish; while in nutrition terms, Japanese intake more calories from meat and poultry.

Two considerations should be noted for these figures. First, they provide little information about price and income elasticities of each commodity. Calorie intake is purely a behavioral variable, and it does not reveal any clear price information. Second, the food balance sheet provides macro data; it may not accurately capture individual household consumption patterns. That is, there may be an aggregation problem. For estimating income elasticities, household survey data probably provides a better picture of individual household consumption patterns.

Table 2: Classification of household by income level

Household Class	Annual Income Level
Income Class 1	less than ¥4,020,000
Income Class 2	between ¥4,020,000 and ¥5,680,000
Income Class 3	between ¥5,680,000 and ¥7,450,000
Income Class 4	between ¥7,450,000 and ¥9,900,000
Income Class 5	between ¥9,900,000 and higher

III. Data

To analyze food consumption patterns and to conduct econometric analysis of food demand structure in Japan, we use the cross-sectional household data, *Annual Report on the Family Income and Expenditure Survey 1997* (FIES) compiled by the Statistics Bureau of the Management and Coordination Agency in Japan.

These are monthly and cross-sectional survey data. Amongst all households in Japan, farm, one-person, and non-citizen households are excluded. Participants are asked to keep a *Household Schedule*, *Family Account Book*, and a *Yearly Income Schedule*. The total number of observations in this survey data is 95,225. Food items estimated for this study are non-glutinous rice, bread, noodle, fresh fish and shellfish, fresh meat, milk, eggs, fresh vegetables, fresh fruits, fats and oil, and food away from home.

In order to investigate the differences in demand structure amongst income groups, we divided the sample according to their household head annual income level. (See **Table 2.**)

Table 3 shows the distribution of sample by income and age. Age refers to the household head's age. **Table 4** shows the average household size by income group. In FIES, one-person households are not included. Hence, the minimum number in a household is two people. In addition, if a household has more than eight members, then

Some Selected Sample Descriptive Statistics

Table 3 Distribution of Sample by Income and Age

	Income Level (ten thousand yen)				
	Income 1	Income 2	Income 3	Income 4	Income 5
Age	< 402	402-568	568-745	745-990	990 <
< 35	2,864	4,257	2,745	1,420	502
35-44	2,341	4,125	5,638	4,664	2,854
45-54	2,460	2,797	4,260	6,500	7,496
55-64	4,158	3,686	3,694	3,944	5,691
65 <	8,488	4,684	2,408	1,627	1,922
Total	20,311	19,549	18,745	18,155	18,465

Table 4 Household Size by Income and Age

	Income Level (ten thousand yen)				
	Income 1	Income 2	Income 3	Income 4	Income 5
Age	< 402	402-568	568-745	745-990	990 <
< 35	3.15	3.32	3.28	3.30	3.48
35-44	3.57	4.05	4.04	4.12	4.31
45-54	3.18	3.47	3.76	3.80	3.90
55-64	2.50	2.60	2.87	3.10	3.33
65 <	2.21	2.27	2.68	3.07	3.39

Table 5
Daily Consumption of Non-glutinous Rice (g) per Household by Age and Income

	Income Level (ten thousand yen)					
	Income 1	Income 2	Income 3	Income 4	Income 5	
Age	< 402	402-568	568-745	745-990	990 <	
< 35	137.60	141.45	137.46	146.16	132.72	
35-44	218.24	219.96	235.69	244.63	259.76	
45-54	279.73	293.76	324.71	340.66	332.32	
55-64	302.35	294.68	294.95	330.16	327.50	
65 <	269.05	292.21	285.17	304.05	320.13	
All Ages	258.19	243.15	266.36	307.45	309.34	267.64

Table 6 Price of Non-glutinous Rice (Yen/100g) by Income and Age

	Income Level (ten thousand yen)				
	Income 1	Income 2	Income 3	Income 4	Income 5
Age	< 402	402-568	568-745	745-990	990 <
< 35	44.88	45.84	47.47	47.97	49.59
35-44	46.09	45.53	46.42	47.79	49.82
45-54	46.60	47.08	47.14	47.74	49.10
55-64	48.05	48.46	48.84	48.95	50.77
65 <	49.20	50.20	50.53	50.94	52.49

Table 7 Average Retail Price of Non-glutinous Rice (Yen/100g)

	Voluntary Rice			Government Rice
Year	Superior	Good	Normal	Standard
1992	57.76	50.92	46.47	37.61
1993	59.26	52.79	49.22	38.63
1994	62.53	55.61	52.23	N/A
1995	57.10	51.25	49.39	38.59

Data Source: Rice Wheat Data Book 1998

the demographic variables of ninth or more family members of the young are omitted from the sample. As a result, the maximum household size is eight. It is interesting to see that the higher income households tend to have a larger number of household members.

The FIES contains demographic variables and monthly data on expenditure and the quantity of food items consumed. The monthly data are converted to a daily basis for the estimation in order to correct for different numbers of days in months. **Table 5** shows the daily consumption of non-glutinous rice. There is a tendency for higher-income and more elderly household to consume more rice. **Table 6** shows non-glutinous rice price depending on the age and the income. It indicates that the higher the income is, the more expensive rice the household consumes.

The price used for estimation is obtained by dividing expenditure by the quantity purchased. The zero consumption problem poses a serious estimation flaw; there is no price data for zero consumption household. In order to obtain price data for households with zero consumption, we make the assumption that each household is facing the mean price of each commodity depending on region, month and income class. In FIES, there are ten regions: Hokkaido, Tohoku, Kanto, Hokuriku, Toukai, Kinki, Tyugoku, Shikoku, Kyushu, and Okinawa. There are twelve months in a year, and five income classes defined above. Therefore, there are six hundred price variations according to location, time, and income group for zero consumption samples. Amongst eleven food items, food away from home does not have a quantity unit. We use the Consumer Price Index (CPI) from *Annual Report on the Consumer Price Index*, by Statistics Bureau, Management and Coordination Agency, for food away from home.

Table 7 shows the annual average retail price of non-glutinous rice for different classifications. Data are taken from *Rice Wheat Data Book 1998*. Rice can be categorized by two types according to its distribution system: voluntary rice and government rice. Beginning in 1969, the Japanese government introduced the system of quasi-rationed rice. Japanese rice is categorized as government rice and voluntary rice. At the production level, the agricultural cooperatives collect government rice. The agricultural cooperatives sell either to the Japan Food Agency (JFA) under the Japan Ministry of Agriculture, Forestry, and Fisheries (MAFF) or to licensed wholesalers. Government rice is mainly transferred to storage for food security purposes and for foreign aid. Voluntary rice has more varieties of price and quality as mentioned above. The price of voluntary rice is determined by auction, while the government sets the price for government rice as a price support. **Tables 6** and **7** show that the unit prices from FIES data lie between good and normal criteria.

IV Model

The application of the theory of the household requires a specific model. In general, econometric studies on demand include both single equations and systems of demand equations. The demand functions can be generalized for a consumer or a household buying n goods as:

$$x_i = x_i\,(p_1, p_2, \ldots\, p_j, \ldots\, p_n, I), \qquad i = 1, 2, \ldots, n. \tag{1}$$

where x_i is quantity demanded, p is the price, the subscript i denotes the commodities, and I is income. These n equations can be estimated by single equations or by systems of equations. In this study, equation (1) is estimated in a budget share form.

IV-1: Single Equation Model

The first empirical model applied in this study is the Working-Leser model[1]. In the Working-Leser model, each share of the food item is simply a linear function of the log of prices and of the total expenditure on all food items in question. The Working-Leser food demand function can be expressed as:

$$w_i = a_0 + a_i \log x + \sum_j b_{ij} \log p_j + \sum_k g_{ik} H_k + e_i \qquad (2)$$

where $(i, j) \in$ eleven food items,

w_i = expenditure share of food i among eleven food items,

p_j = price of food j, and

x = total expenditure of all food items included in the model.

H_k includes dummy variables where k $\in$ 25:

AGE = log age of household head,

SIZE = log of household size,

WE = number of wage earners,

BABY = number of children aged 5 or under,

PRIM = number of children aged between 6 and 12,

HIGH = number of children aged between 13 and 18,

M = dummy variables for month (M_1, …, M_{10})[2], and

REG = dummy variables for region (REG_1, …, REG_9).

[1] Original form of Working-Leser was discussed by Working (1943) and Leser (1963). See Intriligator et. al. (1996) and Deaton and Muellbauer (1980b) for a more detailed discussion of this functional form.

[2] Only ten monthly dummies are included in the model, because CPI for food away from home is monthly basis.

ε_i's are random disturbances assumed with zero mean. Each food item is estimated by OLS. Expenditure and uncompensated own-price elasticities are estimated at their sample mean.

IV-2: Elasticity Estimates in Working-Leser model

It is easy to show the elasticity estimates of Working-Leser models. The expenditure elasticity of Working-Leser model e_i as:

$$e_i = 1 + \left(\frac{1}{w_i}\right)\left(\frac{\partial w_i}{\partial \ln(x)}\right). \tag{3}$$

Taking derivative with respect to $\ln(p_j)$ yields uncompensated own ($j = i$) and cross ($j \neq i$) price elasticities, e_{ij}, are as follows:

$$e_{ij} = -1 + \left(\frac{1}{w_i}\right)\left(\frac{\partial w_i}{\partial p_j}\right) \tag{4}$$

In this study, expenditure, own-price, and cross-price elasticities are evaluated at their sample mean.

IV-3: Income Elasticity in Working-Leser model

Since the Working-Leser model uses total expenditures for the group of food items included in the model, it does not provide a direct estimate of income elasticity. In order to estimate income elasticity, we estimate the following Engel function:

$$\log x = a_0 + a_1 \log X + b \log P + \sum_k g_k H_k + e \tag{5}$$

where x = Total expenditures of the food included in the model,

X = Total expenditures of food and non-food consumer goods and services,

P = Laspeyres price index, and

other demographic and dummy variables are the same as previously defined. Remaining variables are the same as equation (2). From equation (2) and equation (5), income elasticity can be estimated. From equation (2), we can estimate expenditure elasticity, $e_i = \frac{\partial q_i}{\partial x}\frac{x}{q_i}$. From equation (5), we can derive the responsiveness of expenditure on food items by income change, $s = \frac{\partial x}{\partial X}\frac{X}{x}$. Hence, income elasticity is estimated as follows:

$$e_{i(income)} = e_i s = \left(\frac{\partial q_i}{\partial x}\frac{x}{q_i}\right)\left(\frac{\partial x}{\partial X}\frac{X}{x}\right) = \frac{\partial q_i}{\partial X}\frac{X}{q_i}. \quad (6)$$

Table 8 Percentage of Households with Zero Consumption Major 11 commodities

Food Variables	%
Non-glutinous Rice	43.75%
Bread	4.15%
Noodle	6.14%
Fresh Fish and Shell Fish	2.45%
Fresh Meat	1.92%
Milk	8.36%
Eggs	5.51%
Fresh Vegetables	0.24%
Fresh Fruits	5.50%
Fats and Oil	42.12%
Food Away From Home	12.65%

IV-4: Tobit Model

In order to estimate income elasticities, household-level micro data are preferable, since one can avoid the aggregation problem by using them. With the use of household micro data for detailed commodities; however, we encounter an econometric problem with some households having zero consumption, as stated before. This problem stems from the fact that some households do not consume some of the items considered. This zero consumption problem is particularly severe for the case of rice, oil and fats, and food away from home in FIES. (See **Table 8**.)

It is known that using only observed positive purchase data to estimate consumption behavior by OLS regression produces inconsistent estimates of coefficients. The dependent variables, which are the budget shares for the eleven food items specified, are zero if a household does not purchase a food item and positive if one does purchase the food item. Zero shares are censored by an unobservable latent variable. This zero consumption stems from the decision not to purchase the particular item in the month-long survey period. Because rice is a staple food, it is unlikely that people consume it infrequently in Japan. However, some people might not purchase it as frequently as they consume it.

In order to correct the sample bias problem on rice consumption, we applied Heckman's two-step estimation (Heckit) procedure suggested by Heckman (1978). In the first stage, a probit regression is computed in order to estimate the probability that a given household consumes the food item in question. This regression is used to estimate the inverse Mills ratio (λ) for each household, which is used as an instrument in the second regression. In the second stage, the initial Working-Leser model (equation (2)) and the inverse Mills ratio are estimated.

In the first stage, the decision for the household is modeled as a dichotomous choice problem;

$$Y_i = a_0 + a_i \log x + \sum_j b_{ij} \log p_j + \sum_k g_{ik} H_k + e_i \qquad (7)$$

where Y_i is one if a household consumes *i*th food item (i.e., $w_i > 0$), and zero otherwise. Other variables were defined previously. From equation (7), the inverse Mills ratio (λ) for every household can be computed as:

$$l = \frac{f(P)}{\Phi(P)} \qquad (8)$$

where P is a vector of prices for the household. ϕ is the density probability function, and Φ is the cumulative probability function.

In the second step, the following Working-Leser demand function, in addition to the computed inverse Mills ratio as an instrument variable is estimated:

$$w_i = a_0 + a_i \log x + \sum_j b_{ij} \log p_j + \sum_k g_{ik} H_k + l + e_i \qquad (9)$$

Censored and uncensored models are estimated for the whole sample. For comparison, the uncensored models are also estimated using every household with non-zero consumption.

IV-5: Elasticity Estimates of Tobit Model

This section describes the elasticity calculation of Tobit estimator. There are many studies cited on this topic. Notation mainly follows Amemiya (1985) and Maddala (1983).

The Tobit model is defined as follows;

$$\begin{cases} y_i = y^* = x_i b + u_i \text{ if } y^*_i > 0 \quad y^* \sim N(m, s^2) \\ y_i = 0 \text{ otherwise} \end{cases} \tag{10}$$

β is a k × 1 vector of unknown parameters; x_i is a k × 1 vector of known constants; u_i are residuals that are independently and normally distributed, with mean zero and a common variance σ^2.

In our study, Working-Leser Model is denoted as follows:

$$w_i^* = a_0 + a_i \log x + \sum_j b_{ij} \log p + \sum_k g_{ik} H_k + e_i \qquad i \in 1, \dots, n$$

(11)

$$\begin{cases} w_i = w_i^* \quad if \quad w_i > 0 \\ w_i = 0 \quad if \quad w_i \le 0 \end{cases} \text{ and } e_i \sim N(0, s^2)$$

where subscript *i* denotes a good in question. *x* denotes total expenditure on eleven commodities. p_i and q_i denote price and quantity for *ith* commodity, respectively. w_i denotes budget share of *ith* good, $w_i = \frac{p_i q_i}{x}$.

McDonald (1980) describes that total change in y can be disaggregated into two parts: the change in y above the threshold, weighted by the probability of being above the threshold; and the change in the probability of being above the threshold, weighted by the expected vale of y. Unconditional elasticity describes the elasticity of y from the mean of all observed y's. Conditional elasticity is the elasticity measure conditional on the consumer's choice of non-zero quantity purchase of the good.

Considering the model given above, and the non-zero observations y_i we get

$$E(y_i \mid y_i > 0) = x_i b + E(u_i \mid u_i > -x_i b) = x_i b + s \frac{f_i}{\Phi_i} \qquad (12)$$

where ϕ_i and Φ_i are the density function and distribution function of the standard normal evaluated at $\frac{x_i b}{s}$. Define z as $z_i \equiv \frac{x_i b}{s}$ for notational convenience.

In order to obtain prediction values using all the observations, we have:

$$\begin{aligned} E(y_i) &= P(y_i > 0)E(y_i \mid y_i > 0) + P(y_i = 0)E(y_i \mid y_i = 0) \\ &= \Phi_i (x_i b + s \frac{f_i}{\Phi_i}) + (1 - \Phi_i)0 \qquad (13) \\ &= \Phi_i x_i b + s f_i \end{aligned}$$

Unconditional and conditional elasticity can be obtained as follows:

Unconditional elasticity $e_{i,unconditional} = \frac{\partial E[y_i]}{\partial x} \frac{x}{E[y_i]}$ (14)

Conditional elasticity $e_{i,conditional} = \frac{\partial E[y_i \mid y_i > 0]}{\partial x} \frac{x}{E[y_i \mid y_i > 0]}$ (15)

In this study, we apply two different models to obtain Tobit estimator: Heckman's two-step model and standard Tobit estimator. This is the derivation of elasticity measure for each model.

The prediction of y_i, given x_i, can be obtained from the different expectations functions: unconditional and conditional expectations. We follow Maddala (1983) and McDonald (1980). In order to obtain unconditional expectation, we take derivative of the second equation (Equation (12) with $\hat{O}_i$ and $\hat{f}_i$). We drop subscript *i*, which denotes observation.

$$\frac{\partial E(y)}{\partial x} = \frac{b}{s} f(z) xb + \Phi(z) - s \; \frac{xb}{s} f(z)$$
$$= b\,(f(z) + \Phi(z) - f(z)) \tag{16}$$
$$= b\,\Phi(z)$$

From equation (12), partial derivative calculates:

$$\frac{\partial E(y \mid y^* > 0)}{\partial x} = b\left[1 - z\frac{f(z)}{\Phi(z)} - \left(\frac{f(z)}{\Phi(z)}\right)^2\right] \tag{17}$$

See McDonald (1980) for the detailed derivation.

From these general formulas for elasticity estimation, we can derive the estimation measures for Leser-Working model.

1) Estimation on expenditure elasticity

$$E(w_i) = \frac{p_i E(q_i)}{x}$$

$$E(q_i) = \frac{E(w_i)x}{p_i}$$

$$\frac{\partial E(q_i)}{\partial x}\frac{x}{E(q_i)} = \frac{E(w_i)}{p_i}\frac{x}{E(q_i)} + \frac{\frac{\partial E(w_i)}{\partial x}x}{p_i}\frac{x}{E(q_i)}$$
$$= 1 + \frac{\frac{\partial E(w_i)}{\partial \log x}}{E(w_i)} \tag{18}$$

We can apply this formula for equation (14) evaluated at the sample mean. Hence, unconditional expenditure elasticity is:

$$\hat{e}_{i,unconditional} = \frac{\partial E[q_i]}{\partial x}\frac{x}{E[q_i]} = 1 + \frac{\Phi(\hat{z}_i)\hat{a}_i}{\Phi(\hat{z}_i)\bar{x}\hat{b}_i + \hat{s}_i f(\hat{z}_i)} \tag{19}$$

where upper bar denotes sample mean.

Conditional expenditure elasticity is

$$\hat{e}_i = \frac{\partial E[q_i \mid q^*_i > 0]}{\partial x}\frac{x}{E[q_i \mid q^*_i > 0]} = 1 + \frac{\hat{a}_i\left[1 - \hat{z}_i\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)} - \left(\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)}\right)^2\right]}{\bar{x}\hat{b}_i + \hat{s}_i\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)}} \tag{20}$$

where ϕ and Φ are the density function and cumulative density function of the standard normal evaluated at z_i, respectively.

2) Own-price elasticity

$$\frac{\partial E(q_i)}{\partial p_i} = \frac{\frac{\partial E(w_i)}{\partial p_i}x - E(w_i)x}{p_i^2}$$

$$\frac{\partial E(q_i)}{\partial p_i}\frac{p_i}{q_i} = \frac{p_i}{q_i}\frac{\frac{\partial E(w_i)}{\partial p_i}x - E(w_i)x}{p_i^2} = -1 + \frac{\frac{\partial E(w_i)}{\partial \log p_i}}{E(w_i)} \tag{21}$$

Unconditional own-price elasticity is

$$\hat{e}_{ii,unconditional} = -1 + \frac{\Phi(\hat{z}_i)\hat{b}_{ii}}{\Phi(\hat{z}_i)\bar{x}\hat{b}_i + \hat{s}_i f(\hat{z}_i)} \tag{22}$$

Conditional own-price elasticity is

$$\hat{e}_{ii,conditional} = -1 + \frac{\hat{b}_{ii}\left[1 - \hat{z}_i\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)} - \left(\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)}\right)^2\right]}{\bar{x}\hat{b}_i + \hat{s}_i\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)}} \tag{23}$$

3) Cross-price elasticity

$$\frac{\partial E(q_i)}{\partial p_j} = \frac{\frac{\partial E(w_i)}{\partial p_j}x}{p_j}$$

$$\frac{\partial E(q_i)}{\partial p_j}\frac{p_j}{q_i} = \frac{p_j}{q_i}\frac{\frac{\partial E(w_i)}{\partial p_j}x}{p_j} = \frac{\frac{\partial E(w_i)}{\partial \log p_i}}{E(w_i)} \tag{24}$$

Unconditional cross-price elasticity is

$$\hat{e}_{ij,unconditional} = \frac{\Phi(\hat{z}_i)\hat{b}_{ij}}{\Phi(\hat{z}_i)\overline{x}\hat{b}_i + \hat{s}_i f(\hat{z}_i)} \tag{25}$$

Conditional own-price elasticity is

$$\hat{e}_{ij,conditional} = \frac{\hat{b}_{ij}\left[1 - \hat{z}_i\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)} - \left(\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)}\right)^2\right]}{\overline{x}\hat{b}_i + \hat{s}_i\frac{f(\hat{z}_i)}{\Phi(\hat{z}_i)}} \tag{26}$$

IV-6: Heckman's Two-stage (Sample Selection) model

In order to correct the sample bias problem, we applied Heckman's two-step estimation procedure (Heckman, 1978). This procedure involves two steps. In the first stage, the decision for the household is modeled as a dichotomous choice problem, which is estimated as a probit model.

In order to obtain consistent estimate, we set dummy variable for equation (11):

$$\begin{cases} I_i = 1 \text{ if } y_i > 0 \\ I_i = 0 \text{ otherwise} \end{cases} \tag{27}$$

Replacing dependent variables of equation (11) by (27), we get estimates of $\frac{b}{s}$. Using these values, we get estimates values of $f(z_i)$ and $\Phi(z_i)$ for each observation. At the second stage, we estimate equation (11) by OLS using $\hat{\text{Ô}}_{\text{i}}$ and $\hat{f}_{\text{i}}$ in place of with Ö$_{\text{i}}$ and f_{i}.

IV-7: Standard (Type 1) Tobit Model

We estimate the equation (11) as a censored normal regression model.

We apply the same elasticity formulas for both Heckman's Two-step and standard Tobit model.

IV-8: Complete Demand System

Deaton and Muellbauer (1980a, 1980b) developed a flexible demand system called the almost ideal demand system (AIDS). The concept of a flexible demand system is extremely useful for estimating a demand system with many desirable properties. As Moschini (1998) pointed out, the AIDS model automatically satisfies the adding-up restriction, and with simple parametric restrictions, homogeneity and symmetry are handled. In addition, the non-linear Engel curves of the AIDS model imply that an increase in income will decrease the share of income allocated on the particular commodity as well as the income elasticity of that good if the income elasticity of the good is less than one. However, the AIDS model may be difficult to estimate because the price index is not linear in parameters estimated. Due to the simplicity, the linear approximated almost ideal demand system (LA/AIDS) is popular amongst empirical studies. Therefore, both LA/AIDS and AIDS models are applied in this study.

The AIDS model can be estimated as follows:

$$w_i = a_i + \sum_j g_{ij} \ln(p_j) + b_i \ln(x/P) + m_i \qquad \text{i = 1, …, 11} \qquad (28)$$

where w_i is the budget share of good i, p_j is the price of good j, x is the total expenditure of the goods in question, μ_i's are random disturbances assumed with zero mean, and P is a translog price index defined by:

$$\log P = a_0 + \sum_k a_k \log p_k + \frac{1}{2}\sum_k \sum_l g^*_{kl} \log p_k \log p_l \qquad (29)$$

k = 1, …, 11   l = 1, …, 11

and the parameters γ are defined as follows:

$$g_{ij} = \frac{1}{2}(g^*_{ij} + g^*_{ji}) = g_{ji} \qquad j = 1, \ldots, 11 \qquad (30)$$

The model defined by the equations (28) to (30) is called the AIDS model.

It is easy to check that the adding-up restriction is satisfied with given $\sum_i w_i = 1$ for all j;

$$\sum_i a_i = 1,\ \sum_i b_i = 0, \text{ and } \sum_k g_{kj} = 0 \qquad (31)$$

The homogeneity restriction is satisfied for the AIDS model if and only if, for all j;

$$\sum_k g_{jk} = 0 \qquad (32)$$

The symmetry is satisfied by:

$$g_{ij} = g_{ji} \qquad (33)$$

Using the price index in equation (29) raises the estimation difficulties due to non-linearity in parameters. In addition, the theory of the household does not provide any empirically plausible value for α_0[3].

[3] The minimum expenditure on the commodity is widely used for the value of α_0 in order to overcome empirical difficulties. The interpretation and rational is that α_0 represents a subsistence good.

For the empirical tractability, approximation of price index is applied. In this study, we apply two different types of price index approximations. First, the Stone price index P* is used, and then the log-linear analogue of the Laspeyres price index is used.

As Asche (1997) pointed out, the Stone index is widely used for LA/AIDS estimation.

$$\ln(P^*) = \sum_i w_i \ln(p_i) \qquad \text{i = 1, …, 11} \tag{34}$$

where w is budget share among eleven commodities. The Stone index is an approximation proportional to the translog. P = φ P* where E(ln(φ)) = α_0. The LA/AIDS model with the Stone index can be seen as follows:

$$w_i = a^*_i + \sum_j g_{ij} \ln(p_j) + b_i \ln(x / P^*) + m^*_i \tag{35}$$

where $a_i^* = a_i - b_i a_i$ and $m_i^* = m_i - b_i(\ln(j) - E(\ln(j)))$.

Since prices will never be perfectly collinear, it is widely cited that applying the Stone index will introduce the units of measurement error. (See Alston (1994), Asche (1997), and Moschini (1995).) The Stone index does not satisfy the fundamental property of index numbers, because the Stone index is variant to changes in the units of measurement of prices. One of the solutions to correct the units of measurement error is that prices are scaled by their sample mean. Following Moschini's suggestion (1995) we created the Laspeyres price index in order to overcome this measurement error. The log-linear analogue of the Laspeyres price index is obtained by replacing w_i in equation (34) with w_i^0, which is a mean budget share. Hence, the Laspeyres price index becomes a geometrically weighted average of prices:

$$\ln(P^L) = \sum_i w_i^0 \ln(P_i) \tag{36}$$

Substitution of (36) into (35) will yield a LA/AIDS model with the Laspeyres price index as follows:

$$w_i = a_i^{**} + \sum_j g_{ij} \ln(p_j) + b_i(\ln(x) - \sum_j w_j^0 \ln(p_j)) + m_i^{**} \tag{37}$$

where $a_i^{**} = a_i - b_i(a_0 - \sum_j w_j^0 \ln(p_j^0))$.

Following Pollak and Wales (1981, 1978), we applied linear demographic translating, $D^i(h) = \sum_{r=1}^{N} d_{ir} h_r$, where δ's and η's are associated parameters and the demographic variables, respectively. In this study, the linear demographic translating replaces equation (28) as follows:

$$w_i = a_i^{***} + \sum_k d_{ik} h_k + \sum_j g_{ij} \ln(p_j) + b_i(\ln(x) - \sum_j w_j^0 \ln(p_j)) + m_i^{***} \tag{38}$$

where $a_i^{***} = a_i^{**} - \sum_k d_{ik} h_k$. Demographic and dummy variables used in the complete demand system are the same as the ones used in single equation models.

The adding-up restriction requires

$$\sum_i a^{***} = 1, \text{ and } \sum_i d_{ik} = 0, \qquad k = 1, \ldots, m \tag{39}$$

where m is the number of demographic and other dummy variables.

In order to correct the zero consumption problem, we applied the generalized Amemiya's two-stage estimators to a simultaneous-equation model. (See Amemiya (1974), Lee and Pitt (1986), and Heinen and Wessels (1990).) In the first stage, the probit model of the dichotomous choice model is estimated. From the regression results, we derive the inverse Mills ratio. For the LA/AIDS model, we only use the inverse Mills ratio of rice, fats and oil, and food away from home. These three inverse Mills ratios are used as an instruments in the second stage. Similar arguments are applied from the Heckman's two-step estimator section.

IV-9: Elasticity Estimates in the AIDS model

The elasticity measures of the AIDS and the LA/AIDS model are widely investigated and well documented. Following Bues (1994) and Green and Alston (1990), taking the derivative of equation (35) with respect to ln(x), we can obtain the expenditure elasticity e_i as follows:

$$e_i = 1 + \left(\frac{1}{w_i}\right)\left(\frac{\partial w_i}{\partial \ln(x)}\right) = 1 + \left(\frac{b_i}{w_i}\right). \qquad (40)$$

Taking the derivative with respect to $ln(p_j)$, uncompensated own ($j=i$) and cross ($j\,{}^{1}\,i$) price elasticities, e_{ij}, become as follows:

$$\begin{aligned} e_{ij} &= -d_{ij} + \left(\frac{1}{w_i}\right)\left(\frac{\partial w_i}{\partial \ln\left(p_j\right)}\right) \\ &= -d_{ij} + \left(\frac{g_{ij}}{w_i}\right) - \left(\frac{b_i}{w_i}\right) w_j^0 \qquad \forall i, j = 1, \ldots, n, \end{aligned} \qquad (41)$$

where d_{ij} is the Kronecker delta that is unity if $i = j$ and zero otherwise.

We can derive the Hicksian compensated price elasticities for the AIDS and the LA/AIDS model. The compensated price elasticities s_{ij}^* at the point of normalization becomes as follows:

$$\begin{aligned} s_{ij}^* &= e_{ij} + e_i w_j \\ &= -d_{ij} + \left(\frac{g_{ij}}{w_i^0}\right) + w_j^0 \qquad \forall i, j = 1, \ldots, n. \end{aligned} \qquad (42)$$

V Empirical Results

The original data consist of 95,225 observations. When only non-zero consumption data are utilized, the number of observations drops to 21,496 in the whole sample case, 3173 in income class 1, 4007 in income class 2, 4436 in income class 3, 4875 in income class 4, and 5005 in income class 5. When the Working-Leser model is estimated with the price data constructed above, zero consumption households with a zero budget share are assumed to be facing the mean price for the particular geographic location, month, and income level. In the censored regression, data are corrected by Heckman's two-step procedure.

The estimates of expenditure and income elasticities from whole-sample working-Leser model are shown in **Table 9.** First of all, the results indicate that rice is not an inferior good from this estimation. Expenditure elasticity exceeds one. Other commodities are relatively expenditure elastic. Only rice and food away from home exceeds the expenditure elasticity of one. It is noteworthy that own-price elasticity for rice is very elastic. This indicates that Japanese consumers are sensitive for the price change. If this estimate represents consumers' behavior correctly, then rice imports, which lead to the reduction of price, might benefit not only consumers but also rice farmers. The same estimation has divided into income levels in the **Tables 10** and **11**. **Table 10** shows the expenditure elasticities by income bracket. All estimates are invariant with income level. Fresh fish and meat show that lower income consumers' demands tend to be expenditure elastic, while higher income consumers are inelastic. **Table 11** shows the own-price elasticities by income bracket. There are no significant variations of elasticity estimates by income level.

The parameters of the LA/AIDS and AIDS model with demographic and seasonal dummy variables are estimated by dropping one equation, which is food away from home. We apply for the iterative seemingly unrelated regression procedure (ITSUR) in

Table 9: Whole Sample Elasticity Estimates for Major 11 Products (OLS)

Food Items	Mean Budget Share	Own Price Elasticity	Expenditure Elasticity
Non-glutinous Rice	**8.05%**	**-1.824**	**1.076**
		(0.029)	**(0.009)**
Bread	**5.56%**	**-0.706**	**0.474**
		(0.003)	**(0.005)**
Noodle	**3.83%**	**-0.607**	**0.493**
		(0.008)	**(0.007)**
Fresh Fish	**13.14%**	**-0.703**	**0.843**
		(0.005)	**(0.005)**
Fresh Meat	**12.43%**	**-0.518**	**0.713**
		(0.006)	**(0.004)**
Milk	**4.71%**	**-0.106**	**0.569**
		(0.012)	**(0.007)**
Eggs	**1.89%**	**-0.433**	**0.411**
		(0.006)	**(0.005)**
Fresh Vegetables	**14.30%**	**-0.770**	**0.682**
		(0.005)	**(0.003)**
Fresh Fruits	**7.94%**	**-0.660**	**0.960**
		(0.006)	**(0.006)**
Fats and Oil	**0.86%**	**-0.925**	**0.778**
		(0.014)	**(0.016)**
Food Away from Home	**27.29%**	**-2.523**	**1.655**
		(0.171)	**(0.005)**

Notes: The numbers in parentheses below the elasticity estimation are standard error. All estimates are statistically significant at 5% level.

Table 10: Expenditure Elasticity for Major 11

	Income Level (thousand yen)									
	Income 1 < 402		Income 2 402 - 568		Income 3 568 - 745		Income 4 745 - 990		Income 5 990 <	
Food Items	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate
Non-glutinous Rice	10.21%	1.109	8.06%	1.185	7.45%	1.168	7.47%	1.178	6.84%	1.157
		(0.017)		(0.020)		(0.021)		(0.022)		(0.021)
Bread	5.66%	0.502	5.85%	0.468	5.75%	0.450	5.61%	0.451	4.92%	0.445
		(0.012)		(0.013)		(0.012)		(0.013)		(0.012)
Noodle	4.16%	0.525	4.11%	0.536	4.00%	0.535	3.71%	0.493	3.14%	0.485
		(0.015)		(0.015)		(0.016)		(0.016)		(0.017)
Fresh Fish	14.33%	0.948	12.75%	0.878	12.42%	0.846	12.78%	0.806	13.31%	0.714
		(0.010)		(0.011)		(0.012)		(0.012)		(0.011)
Fresh Meat	11.88%	0.797	12.39%	0.708	12.61%	0.673	12.72%	0.682	12.58%	0.666
		(0.010)		(0.009)		(0.010)		(0.010)		(0.009)
Milk	5.00%	0.610	4.98%	0.536	4.75%	0.492	4.53%	0.540	4.23%	0.495
		(0.015)		(0.015)		(0.016)		(0.016)		(0.015)
Eggs	2.05%	0.406	1.96%	0.427	1.91%	0.413	1.83%	0.404	1.68%	0.393
		(0.012)		(0.012)		(0.013)		(0.012)		(0.013)
Fresh Vegetables	15.92%	0.719	14.47%	0.685	13.72%	0.674	13.58%	0.657	13.65%	0.618
		(0.007)		(0.008)		(0.008)		(0.008)		(0.008)
Fresh Fruits	9.08%	0.982	7.70%	0.919	7.40%	0.923	7.39%	0.931	8.02%	0.947
		(0.013)		(0.015)		(0.016)		(0.016)		(0.016)
Fats and Oil	0.99%	0.839	0.91%	0.824	0.84%	0.802	0.83%	0.775	0.74%	0.770
		(0.035)		(0.037)		(0.036)		(0.039)		(0.040)
Food Away from Home	20.73%	1.698	26.82%	1.645	29.14%	1.630	29.54%	1.625	30.89%	1.644
		(0.013)		(0.011)		(0.011)		(0.011)		(0.010)

Notes: The numbers in parentheses below the elasticity estimation are standard error.
All estimates are statistically significant at 5% level.

Table 11: Own Price Elasticity for Major 11

	Income Level (thousand yen)									
	Income 1 < 402		Income 2 402 - 568		Income 3 568 - 745		Income 4 745 - 990		Income 5 990 <	
Food Items	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate	Mean Budget Share	Elasticity Estimate
Non-glutinous Rice	10.21%	-1.551	8.06%	-1.906	7.45%	-1.865	7.47%	-1.751	6.84%	-1.886
		(0.058)		(0.067)		(0.069)		(0.066)		(0.065)
Bread	5.66%	-0.710	5.85%	-0.683	5.75%	-0.706	5.61%	-0.717	4.92%	-0.721
		(0.008)		(0.007)		(0.007)		(0.007)		(0.007)
Noodle	4.16%	-0.647	4.11%	-0.616	4.00%	-0.614	3.71%	-0.557	3.14%	-0.587
		(0.017)		(0.016)		(0.017)		(0.017)		(0.018)
Fresh Fish	14.33%	-0.71151	12.75%	-0.70396	12.42%	-0.67464	12.78%	-0.71957	13.31%	-0.70544
		(0.010)		(0.011)		(0.011)		(0.011)		(0.011)
Fresh Meat	11.88%	-0.571	12.39%	-0.551	12.61%	-0.498	12.72%	-0.503	12.58%	-0.4535
		(0.013)		(0.012)		(0.013)		(0.012)		(0.012)
Milk	5.00%	-0.025	4.98%	-0.152	4.75%	-0.094	4.53%	-0.182	4.23%	-0.073
		(0.027)		(0.026)		(0.027)		(0.026)		(0.025)
Eggs	2.05%	-0.433	1.96%	-0.441	1.91%	-0.455	1.83%	-0.436	1.68%	-0.409
		(0.013)		(0.012)		(0.012)		(0.012)		(0.013)
Fresh Vegetables	15.92%	-0.790	14.47%	-0.782	13.72%	-0.787	13.58%	-0.733	13.65%	-0.754
		(0.010)		(0.011)		(0.012)		(0.012)		(0.012)
Fresh Fruits	9.08%	-0.662	7.70%	-0.678	7.40%	-0.675	7.39%	-0.655	8.02%	-0.628
		(0.013)		(0.014)		(0.014)		(0.014)		(0.015)
Fats and Oil	0.99%	-0.891	0.91%	-0.972	0.84%	-0.946	0.83%	-0.863	0.74%	-0.928
		(0.031)		(0.030)		(0.028)		(0.030)		(0.032)
Food Away from Home	20.73%	-3.511	26.82%	-2.525	29.14%	-1.721	29.54%	-1.933	30.89%	-2.973
		(0.486)		(0.393)		(0.360)		(0.354)		(0.344)

Note: The numbers in parentheses below the elasticity estimation are standard error.
All estimates but the lowest income class milk are statistically significant at 5% level.

SAS. ITSUR runs less than 15 iterations to meet the convergence criteria of 1e-4 for all models. The regression results summarized in appendix show the values of the estimated coefficients and their absolute t-values except demographic and seasonal dummy variables. The last column in appendix represents the parameters of food away from home is obtained by using adding-up condition in equation (31). The row of g_{i11} can be generated by the homogeneity restriction in equation (32), and the blank cells can be recovered by using symmetry condition in equation (33). Heckman's two-step, Tobit estimator, and inverse Mills ratio are estimated by LIMDEP version 7.0.

Tables 12 and **13** show the elasticity estimates from AIDS model with inverse Mills ratio of rice, fats and oil, and food away from home. **Table 12** shows the results of uncompensated price elasticity and expenditure elasticity. Expenditure elasticity of rice indicates that rice is normal good, and it exceeds one. Rice is mild complement with all commodities but food away from home. Particularly, the estimated cross price elasticities between rice and both fish and meat carry negative signs. Thus, we may conclude that fish and meat are complements to rice.

In **Table 13**, compensated price elasticity shows the mixed results. Rice is substitutes with fresh fish, while it is complements with fresh meat.

Table 14 compares the own-price elasticity estimates from all models. It is surprising that uncompensated own-price elasticity for rice exceeds 1.7 in absolute term. High own price elasticity of rice is robust across models. The lowest estimate of own-price elasticity for rice is 1.2 in conditional estimates of Heckman's two-step and Tobit estimators.

Table 15 is the comparison table of expenditure elasticity estimates. All expenditure elasticity estimates are transferred to the income elasticity using the formula in equation (6)[4]. **Table 16** shows the income elasticity from all models. In all estimation, it turns out that Japanese rice is normal good. This result is robust across models.

VI. Conclusion

In the consumption literature, grains in developed countries are considered as an inferior good. Based on that, it would be natural to assume that rapid economic growth of Asian countries should result in lower rice demand. This brief survey strongly contradicts these assumptions for rice in Japan. Rice consumed in Japan is a normal good, although the income elasticity does not exceed unity. Marshallian and Hicksian own-price elasticities for rice are highly elastic for all models; on the other hand, the own price elasticity for meat is relatively price inelastic. From the results of the AIDS model, we show that rice in Japan is a mild complement with fresh meat and fish.

[4] Engel function is estimated; however, the estimation results are not shown in this study. Results are provided by the author upon request. All coefficients are statistically significant and correct signs.

Table 12: Elasticity for Major 11 Products: AIDS model with Inverse Mills Ratio

Food Items	Mean Budget Share	Uncompensated Price Elasticity											Expenditure Elasticity
		Rice	Bread	Noodle	Fish	Meat	Milk	Eggs	Vegt.	Fruits	Oil	FAFH	
Non-glutinous Rice	8.05%	-1.736	-0.050	-0.046	-0.089	-0.172	-0.006	-0.007	-0.137	-0.048	-0.030	1.256	1.065
Bread	5.56%	-0.106	-0.708	0.003	-0.052	-0.018	-0.080	-0.016	-0.077	-0.077	-0.012	0.639	0.503
Noodle	3.83%	-0.131	0.007	-0.618	-0.085	-0.078	-0.066	-0.019	-0.096	-0.073	-0.012	0.657	0.513
Fresh Fish	13.14%	-0.075	0.034	0.012	-0.705	0.049	0.002	0.011	-0.007	-0.060	-0.005	-0.111	0.855
Fresh Meat	12.43%	-0.125	-0.034	-0.043	-0.038	-0.519	-0.082	-0.025	-0.089	-0.029	-0.016	0.272	0.728
Milk	4.71%	-0.046	-0.060	-0.032	-0.085	-0.124	-0.111	-0.009	-0.059	-0.110	0.006	0.060	0.569
Eggs	1.89%	-0.072	-0.035	-0.032	-0.070	-0.080	-0.047	-0.438	-0.011	-0.064	-0.011	0.435	0.424
Fresh Vegetables	14.30%	-0.101	-0.014	-0.016	-0.076	-0.021	-0.025	0.002	-0.765	-0.069	0.009	0.383	0.694
Fresh Fruits	7.94%	-0.063	-0.001	0.000	-0.076	0.025	-0.030	0.005	-0.046	-0.677	0.000	-0.087	0.948
Fats and Oil	0.86%	-0.293	-0.094	-0.062	-0.139	-0.233	0.012	-0.032	0.103	-0.030	-0.914	0.874	0.809
Food Away from Home	27.29%	0.443	-0.023	-0.009	0.010	-0.139	-0.065	-0.025	0.011	0.049	0.015	-1.907	1.640

Table 13: Elasticity for Major 11 Products: AIDS model with Inverse Mills Ratio

Food Items	Mean Budget Share	Hicksian Compensated Price Elasticity										
		Rice	Bread	Noodle	Fish	Meat	Milk	Eggs	Vegt.	Fruits	Oil	FAFH
Non-glutinous Rice	8.05%	-1.661	0.011	-0.004	0.028	-0.033	0.042	0.013	0.009	0.022	-0.021	1.594
Bread	5.56%	0.016	-0.693	0.016	0.183	-0.003	-0.034	-0.009	0.042	0.072	-0.008	0.418
Noodle	3.83%	-0.009	0.023	-0.605	0.148	-0.060	-0.020	-0.012	0.024	0.074	-0.008	0.445
Fresh Fish	13.14%	0.017	0.078	0.043	-0.544	0.142	0.049	0.026	0.130	0.040	0.002	0.018
Fresh Meat	12.43%	-0.021	-0.001	-0.019	0.150	-0.454	-0.036	-0.012	0.041	0.088	-0.010	0.275
Milk	4.71%	0.071	-0.040	-0.016	0.136	-0.094	-0.065	0.000	0.064	0.029	0.011	-0.096
Eggs	1.89%	0.056	-0.026	-0.024	0.181	-0.081	-0.001	-0.432	0.105	0.096	-0.008	0.135
Fresh Vegetables	14.30%	0.005	0.016	0.006	0.119	0.036	0.021	0.014	-0.636	0.053	0.014	0.352
Fresh Fruits	7.94%	0.022	0.051	0.036	0.066	0.138	0.017	0.023	0.095	-0.591	0.008	0.134
Fats and Oil	0.86%	-0.196	-0.054	-0.034	0.032	-0.151	0.059	-0.018	0.237	0.076	-0.907	0.957
Food Away from Home	27.29%	0.470	0.085	0.063	0.009	0.125	-0.016	0.009	0.184	0.039	0.030	-0.998

Table 14: Elasticity Comparison: Own-Price Elasticity

Food Items	Mean Budget Share	% of zero Cons	Working Leser (OLS)	Heckit		Tobit	
				Un-conditional	Conditional	Un-conditional	Conditional
Non-glutinous Rice	8.05%	43.75%	-1.824 (0.029)	-1.845	-1.234	-1.705	-1.286
Bread	5.56%	4.15%	-0.706 (0.003)	-0.721	-0.791	-0.751	-0.825
Noodle	3.83%	6.14%	-0.607 (0.008)	-0.664	-0.774	-0.702	-0.816
Fresh Fish	13.14%	2.45%	-0.703 (0.005)	-0.694	-0.764	-0.734	-0.797
Fresh Meat	12.43%	1.92%	-0.518 (0.006)	-0.546	-0.628	-0.542	-0.623
Milk	4.71%	8.36%	-0.106 (0.012)	-0.389	-0.683	-0.296	-0.565
Eggs	1.89%	5.51%	-0.433 (0.006)	-0.632	-0.812	-0.509	-0.657
Fresh Vegetables	14.30%	0.24%	-0.770 (0.005)	-0.781	-0.811	-0.776	-0.799
Fresh Fruits	7.94%	5.50%	-0.660 (0.006)	-0.685	-0.783	-0.739	-0.834
Fats and Oil	0.86%	42.12%	-0.925 (0.014)	-0.782	-0.867	-1.157	-1.055
Food Away from Home	27.29%	12.65%	-2.523 (0.171)	-2.766	-2.090	-2.585	-2.130

Notes: The numbers in parentheses below the elasticity estimation are standard error. All estimates are statistically significant at 5% level.

Table 14 (contd.) Elasticity Comparison: Own-Price Elasticity

Food Items	Mean Budget Share	% of zero Cons	LA/AIDS								AIDS			
			Stone Price Index				Laspeyres Price Index							
			without IMRs		with IMRs		without IMRs		with IMRs		without IMRs		with IMRs	
			Uncom-pensated	Com-pensated	Uncom-pensated	Com-pensated	Uncom-pensated	Com-pensated	Uncom-pensated	Com-pensated	Uncom-pensated	Com-pensated	Uncom-pensated	Com-pensated
Non-glutinous Rice	8.05%	43.75%	-1.801	-1.682	-1.781	-1.681	-1.792	-1.705	-1.769	-1.683	-1.769	-1.693	-1.736	-1.661
			(0.028)	(0.028)	(0.020)	(0.020)	(0.028)	(0.028)	(0.020)	(0.020)				
Bread	5.56%	4.15%	-0.721	-0.695	-0.721	-0.696	-0.706	-0.680	-0.706	-0.680	-0.707	-0.678	-0.708	-0.693
			(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)				
Noodle	3.83%	6.14%	-0.620	-0.597	-0.618	-0.596	-0.615	-0.596	-0.614	-0.595	-0.617	-0.595	-0.618	-0.605
			(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)				
Fresh Fish	13.14%	2.45%	-0.670	-0.583	-0.674	-0.587	-0.670	-0.559	-0.673	-0.562	-0.706	-0.541	-0.705	-0.544
			(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)				
Fresh Meat	12.43%	1.92%	-0.538	-0.460	-0.534	-0.457	-0.543	-0.454	-0.539	-0.450	-0.519	-0.444	-0.519	-0.454
			(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)				
Milk	4.71%	8.36%	-0.129	-0.087	-0.129	-0.087	-0.101	-0.075	-0.101	-0.074	-0.111	-0.055	-0.111	-0.065
			(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)				
Eggs	1.89%	5.51%	-0.448	-0.438	-0.448	-0.437	-0.445	-0.437	-0.444	-0.436	-0.438	-0.426	-0.438	-0.432
			(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)				
Fresh Vegetables	14.30%	0.24%	-0.789	-0.668	-0.786	-0.666	-0.770	-0.672	-0.769	-0.671	-0.765	-0.622	-0.765	-0.636
			(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)				
Fresh Fruits	7.94%	5.50%	-0.657	-0.565	-0.657	-0.564	-0.648	-0.572	-0.648	-0.572	-0.679	-0.593	-0.677	-0.591
			(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)				
Fats and Oil	0.86%	42.12%	-0.901	-0.894	-0.912	-0.905	-0.902	-0.895	-0.912	-0.905	-0.900	-0.893	-0.914	-0.907
			(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)				
Food Away from Home	27.29%	12.65%	-1.909	-1.515	-1.951	-1.535	-1.895	-1.443	-1.900	-1.448	-1.889	-0.872	-1.907	-0.998

Note: The numbers in parentheses below the elasticity estimation are standard error. All estimates are statistically significant at 5% level.

Table 15: Elasticity Comparison: Expenditure Elasticity

Food Items	Mean Budget Share	% of zero Cons	Working Leser (OLS)	Heckit		Tobit		LA/AIDS				AIDS	
								Stone		Laspeyres			
				Un-cond.	Cond.	Un-cond.	Cond.	without IMRs	with IMRs	without IMRs	with IMRs	without IMRs	with IMRs
Non-glutinous Rice	8.05%	43.75%	1.076 (0.009)	1.436	1.121	1.318	1.129	1.472 (0.008)	1.249 (0.006)	1.080 (0.009)	1.078 (0.006)	1.068	1.065
Bread	5.56%	4.15%	0.474 (0.005)	0.486	0.614	0.545	0.679	0.460 (0.005)	0.452 (0.005)	0.475 (0.005)	0.475 (0.005)	0.502	0.503
Noodle	3.83%	6.14%	0.493 (0.007)	0.536	0.688	0.608	0.758	0.583 (0.007)	0.573 (0.007)	0.495 (0.007)	0.495 (0.007)	0.513	0.513
Fresh Fish	13.14%	2.45%	0.843 (0.005)	0.766	0.820	0.867	0.899	0.660 (0.004)	0.658 (0.004)	0.843 (0.005)	0.843 (0.005)	0.856	0.855
Fresh Meat	12.43%	1.92%	0.713 (0.004)	0.656	0.718	0.733	0.780	0.629 (0.004)	0.623 (0.004)	0.717 (0.004)	0.717 (0.004)	0.728	0.728
Milk	4.71%	8.36%	0.569 (0.007)	0.724	0.856	0.678	0.801	0.883 (0.007)	0.888 (0.007)	0.567 (0.007)	0.567 (0.007)	0.570	0.569
Eggs	1.89%	5.51%	0.411 (0.005)	0.642	0.816	0.496	0.648	0.570 (0.005)	0.556 (0.005)	0.416 (0.005)	0.416 (0.005)	0.425	0.424
Fresh Vegetables	14.30%	0.24%	0.682 (0.003)	0.678	0.722	0.690	0.722	0.851 (0.003)	0.836 (0.003)	0.689 (0.003)	0.688 (0.003)	0.696	0.694
Fresh Fruits	7.94%	5.50%	0.960 (0.006)	0.864	0.906	0.999	0.999	1.163 (0.006)	1.175 (0.006)	0.960 (0.006)	0.960 (0.006)	0.950	0.948
Fats and Oil	0.86%	42.12%	0.778 (0.016)	0.652	0.788	1.077	1.027	0.904 (0.016)	0.862 (0.015)	0.799 (0.016)	0.795 (0.015)	0.816	0.809
Food Away from Home	27.29%	12.65%	1.655 (0.005)	1.830	1.513	1.716	1.511	1.446	1.524	1.655	1.656	1.637	1.640

Note: The numbres in parentheses below the elasticity estimation are standard error. All estimates are statistically significant at 5% level.

Table 16: Estimated Income Elasticity Comparison

Food Items	Working Leser (OLS)	Heckit		Tobit		LA/AIDS				AIDS	
		Un-cond.	Cond.	Un-cond.	Cond.	Stone		Laspeyres			
						without IMRs	with IMRs	without IMRs	with IMRs	without IMRs	with IMRs
Non-glutinous Rice	0.311	0.416	0.324	0.382	0.327	0.426	0.362	0.312	0.312	0.309	0.308
Bread	0.137	0.141	0.178	0.158	0.197	0.133	0.131	0.137	0.137	0.145	0.146
Noodle	0.143	0.155	0.199	0.176	0.219	0.169	0.166	0.143	0.143	0.148	0.148
Fresh Fish	0.244	0.222	0.237	0.251	0.260	0.191	0.190	0.244	0.244	0.248	0.248
Fresh Meat	0.206	0.190	0.208	0.212	0.226	0.182	0.180	0.207	0.207	0.211	0.211
Milk	0.165	0.209	0.248	0.196	0.232	0.256	0.257	0.164	0.164	0.165	0.165
Eggs	0.119	0.186	0.236	0.144	0.188	0.165	0.161	0.120	0.120	0.123	0.123
Fresh Vegetables	0.197	0.196	0.209	0.200	0.209	0.246	0.242	0.199	0.199	0.201	0.201
Fresh Fruits	0.278	0.250	0.262	0.289	0.289	0.337	0.340	0.278	0.278	0.275	0.274
Fats and Oil	0.225	0.189	0.228	0.312	0.297	0.262	0.249	0.231	0.230	0.236	0.234
Food Away from Home	0.479	0.530	0.438	0.497	0.437	0.418	0.441	0.479	0.479	0.474	0.475

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Appendix

This appendix shows the parameter estimates of LA/AIDS with Laspeyres price index and inverse Mill ratio and AIDS with inverse Mills ratio. Demographic and seasonal dummy variable estimates are omitted due to the limitation of space.

Appendix 1: Parameter Estimates of the LA/AIDS with Laspeyres Price Index and Inverse Mills Ratio (Iterative SUR model)

Parameter	Non-glutinou Rice	Bread	Noodle	Fresh Fish	Fresh Meat	Milk	Eggs	Fresh Vegetables	Fresh Fruits	Fats and Oil	Food Away from Home
a_i	-0.190	0.247	0.163	-0.189	0.357	0.182	0.097	0.297	-0.158	0.024	0.169
	(35.99)	(79.84)	(58.90)	(29.99)	(67.99)	(53.69)	(87.39)	(58.58)	(29.78)	(17.55)	
b_i	0.006	-0.029	-0.019	-0.021	-0.035	-0.020	-0.011	-0.045	-0.003	-0.002	0.179
	(13.05)	(99.08)	(74.87)	(34.31)	(70.79)	(66.45)	(109.48)	(92.99)	(6.35)	(13.80)	
g_{i1}	-0.061	-0.003	-0.003	-0.008	-0.011	-0.001	-0.001	-0.010	-0.005	-0.002	0.107
	(39.10)	(10.34)	(7.36)	(17.44)	(19.67)	(1.82)	(3.86)	(15.68)	(10.79)	(8.60)	
g_{i2}		0.015	-0.001	-0.002	-0.006	-0.004	-0.001	-0.007	-0.004	-0.001	0.014
		(82.56)	(5.22)	(9.67)	(27.10)	(22.27)	(22.70)	(28.26)	(18.02)	(11.82)	
g_{i3}			0.014	-0.004	-0.006	-0.002	-0.001	-0.006	-0.003	-0.001	0.014
			(48.45)	(17.21)	(21.42)	(8.72)	(10.72)	(19.29)	(14.98)	(4.99)	
g_{i4}				0.040	-0.004	-0.006	-0.002	-0.011	-0.005	-0.001	0.005
				(65.57)	(9.98)	(18.41)	(21.36)	(25.95)	(14.00)	(10.28)	
g_{i5}					0.053	-0.009	-0.003	-0.014	-0.003	-0.002	0.007
					(83.55)	(24.51)	(25.55)	(31.24)	(8.80)	(13.60)	
g_{i6}						0.041	-0.001	-0.005	-0.006	0.000	-0.007
						(75.40)	(7.41)	(13.80)	(21.81)	0.83	
g_{i7}							0.010	-0.002	-0.002	0.000	0.004
							(100.40)	(12.54)	(17.86)	(4.44)	
g_{i8}								0.027	-0.009	0.001	0.036
								(40.16)	(23.43)	(4.11)	
g_{i9}									0.028	0.000	0.010
									(57.64)	(3.36)	
g_{i10}										0.001	0.007
										(6.95)	
g_{i11}											
R^2	0.549	0.225	0.138	0.223	0.236	0.147	0.226	0.238	0.160	0.172	
$adj\ R^2$	0.549	0.225	0.138	0.223	0.236	0.147	0.226	0.238	0.160	0.172	

Notes: Parameter estimates of food away from home group are obtained by adding-up condition. Numbers in parentheses are t-values in absolute term. The row of g_{i11} and blank cells can be recovered by homogeneity and symmetry conditions, respectively. Demographic and seasonal dummy variables are omitted.

Appendix 2: Parameter Estimates of the AIDS with Inverse Mills Ratio (iterative SUR model)

Parameter		Non-glutinou Rice	Bread	Noodle	Fresh Fish	Fresh Meat	Milk	Eggs	Fresh Vegetables	Fresh Fruits	Fats and Oil	Food Away from Home
a_0	**5.482**											
	(3.63)											
a_i		**-0.137**	**0.059**	**0.051**	**-0.242**	**0.147**	**0.067**	**0.037**	**0.066**	**-0.126**	**0.010**	**1.068**
		(15.33)	**(1.43)**	**(1.79)**	**(8.39)**	**(2.88)**	**(2.18)**	**(2.25)**	**(1.01)**	**(17.56)**	**(3.83)**	
b_i		**0.005**	**-0.028**	**-0.019**	**-0.019**	**-0.034**	**-0.020**	**-0.011**	**-0.044**	**-0.004**	**-0.002**	**0.175**
		(10.95)	**(96.31)**	**(73.14)**	**(32.20)**	**(69.69)**	**(66.69)**	**(108.58)**	**(93.03)**	**(8.37)**	**(12.99)**	
g_{i1}		**-0.060**	**-0.004**	**-0.003**	**-0.008**	**-0.013**	**0.000**	**0.000**	**-0.011**	**-0.005**	**-0.002**	**0.106**
		(37.95)	**(9.98)**	**(7.23)**	**(15.76)**	**(19.66)**	**(0.65)**	**(1.58)**	**(14.91)**	**(10.24)**	**(8.21)**	
g_{i2}			**0.014**	**-0.001**	**0.003**	**-0.007**	**-0.004**	**-0.002**	**-0.006**	**0.000**	**-0.001**	**0.008**
			(11.30)	**(1.51)**	**(3.28)**	**(4.66)**	**(4.90)**	**(3.19)**	**(2.88)**	**(1.42)**	**(9.10)**	
g_{i3}				**0.014**	**0.001**	**-0.007**	**-0.003**	**-0.001**	**-0.005**	**0.000**	**-0.001**	**0.007**
				(21.62)	**(1.00)**	**(6.73)**	**(3.83)**	**(3.42)**	**(3.38)**	**(0.72)**	**(4.79)**	
g_{i4}					**0.043**	**0.002**	**0.000**	**0.001**	**-0.002**	**-0.005**	**-0.001**	**-0.034**
					(49.58)	**(2.05)**	**(0.29)**	**(2.69)**	**(1.25)**	**(12.47)**	**(5.96)**	
g_{i5}						**0.052**	**-0.010**	**-0.004**	**-0.013**	**0.001**	**-0.002**	**0.000**
						(27.18)	**(8.89)**	**(6.45)**	**(5.25)**	**(2.42)**	**(13.31)**	
g_{i6}							**0.042**	**-0.001**	**-0.004**	**-0.002**	**0.000**	**-0.017**
							(48.68)	**(2.34)**	**(2.52)**	**(7.31)**	**(0.56)**	
g_{i7}								**0.010**	**-0.001**	**0.000**	**0.000**	**-0.003**
								(47.51)	**(0.94)**	**(2.53)**	**(4.17)**	
g_{i8}									**0.032**	**-0.004**	**0.001**	**0.011**
									(10.07)	**(7.73)**	**(3.98)**	
g_{i9}										**0.026**	**0.000**	**-0.011**
										(53.34)	**(0.26)**	
g_{i10}											**0.001**	**0.006**
											(6.76)	
g_{i11}												
R^2		**0.549**	**0.223**	**0.138**	**0.222**	**0.236**	**0.147**	**0.226**	**0.237**	**0.160**	**0.172**	
$adj\ R^2$		**0.549**	**0.223**	**0.138**	**0.222**	**0.235**	**0.147**	**0.226**	**0.237**	**0.159**	**0.171**	

Notes: Parameter estimates of food away from home group are obtained by adding-up condition. Numbers in parentheses are t-values in absolute term. The row of g_{i11} and blank cells can be recovered by homogeneity and symmetry conditions, respectively. Demographic and seasonal dummy variables are omitted.