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Household Expenditure Patterns
For Carbohydrate Sources in Russia

The volatile nature of the Russian political and economic system in recent years has brought about severe changes in the availability of food for consumers. Russia has experienced a staggering 35% year-to-year drop in forecast grain (primarily wheat) availability during the past 5 years, partially due to adverse weather conditions and in part due to the virtual elimination of grain exports. Imports of processed food have likewise been decimated since the devaluation of the ruble in August 1995. Reduced purchasing power has forced Russian consumers to rely more on basic food items such as bread, but the declining availability of grain has made even these "cheap" energy sources more expensive (USDA-FAS, 1998).

From September 1998 to August 1999, the price of wheat (in rubles) in Russia nearly tripled, going from 1,020 R to 3,010 R. Similarly, the price of top-grade flour more than doubled during this time period, from 3,380 R to 7,005 R. Surprisingly, these prices continue to rise even though the production and import projections for 1999 are higher than in previous years (USDA-FAS, 1999a). Government subsidization of bread and related carbohydrate sources have managed to limit the price increase for these household staples. Coupled with these rising prices are continuous annual declines in wheat and rice production. For example, Russian wheat and rice production were 46.2 M metric tons and 0.75 M metric tons, respectively in 1992, but production levels had decreased to 30.1 M metric tons and 0.46 M metric tons by the end of 1995, just prior to the survey (FAO). The decline has continued through 1998 to only 27.0 M metric tons and 0.41 M metric tons. This represents decreases of 41.5 and 45.2 percent from 1992 through 1998 for wheat and rice, respectively. There is little expectation that the situation will change positively in the near- or medium-term, making Russia a definite deficit market for these grain and their associated products, such as flour.

Lower than average potato harvests in recent years have also spurred Russian imports of potatoes. Prior to 1997-98, annual potato imports had dropped to roughly 70,000 tons due to above-average production. Low production in 1997-98 resulted in imports swelling to 180,000 tons. However, 1998-99 imports are forecasted to be only 130,000 tons because of the 1998 ruble devaluation (USDA-FAS, 1999b). As with grains, potatoes represent a primary energy source for Russian households that has become more expensive due to reduced purchasing power.

The size of the market, along with a desire to continue favorable political relations with Russia, have made raw commodity and processed food exports to Russia an important issue for both U.S. agribusinesses and government agencies. Because U.S. agriculture depends on foreign markets to sustain profitability, U.S. exporters must assess means for rebuilding and expanding shipments of small grains and potatoes to Russia. This could be achieved through a combination of favorable economic adjustments in Russia and U.S. agricultural policies encouraging exports. Appropriate actions by either country could effectively result in increased Russian household (disposable) income and cheaper U.S. imports. To comprehend the magnitude of market potential requires an understanding of the desires and purchasing habits of Russian consumers. However, a paucity of detailed information on household expenditure patterns has been a hindrance to such market research in the past.

This study provides some insight into the demand for carbohydrate sources (i.e. grain-based products and potatoes) by households in eastern Russia. For decades, information on food demand at the household level was an unobservable phenomenon in Russia. The allotment system of communism did not allow for variations in food expenditures and consumption resulting from price and/or income responses. The move towards a free market system in Russia has made it possible to measure household expenditures on various items and examine the impacts of prices, household income and demographic differences on consumption patterns.

Data and Procedures

The data used for this analysis comes from a 1996 one-week study of household expenditures in eastern Russia metropolitan areas. This data was gathered as part of a larger market study examining opportunities for exporting more U.S. rice to Russia. The survey was carried out in late February and March 1996.

Following the accepted survey protocol of focus interviews and testing of the survey instrument, a research design was developed focusing on eight major markets representative of the total market area of Siberia and the Russian Far East (RFE). Cities chosen for the survey were: Vladivostok (750,000), Khabarovsk (700,000), Irkutsk (500,000), Ulan Ude (500,000), Krasnoyarsk (800,000), Novosibirsk (1,000,000), Omsk (1,000,000), and Tomsk (1,000,000); populations are shown in parentheses and are approximations. The American Business Center of Vladivostok contracted with Russians trained in interviewing to conduct the on-site interviews.

Statistical determination of sample size necessary in each city revealed that 200 useable surveys would ensure a response rate with 95% repeatability and a 4% margin of error in responses in each city. Interviews were conducted in retail shops in middle-class neighborhoods. The intercept method was used to select respondents. All interviews were enumerated in Russian by Russians to avoid misinterpretation and limit bias. Inexpensive pens were given to survey respondents as a token of appreciation for their cooperation.

Average respondent age across the region was 36.34 years, ranging from 31.09 years in Ulan Ude to 41.26 years in Novosibirsk. Number of persons per household ranged from 3.28 in Novosibirsk to 3.99 in Omsk and averaged 3.64 over the entire sample population. Average monthly income net of housing subsidies for the region was 1.74 million rubles per household. Households in Krasnoyarsk, Vladivostok, Khabarovsk and Irkutsk had monthly incomes of at least 2 million rubles; households in the remaining four cities had monthly incomes of less than 1.5 million rubles.

Respondents were asked about expenditures and quantities of 20 food items: beef, pork, chicken, fish, processed meats, eggs, cheese, milk, butter, fats and oils, sugar/candy, fresh fruits and vegetables, canned fruits and vegetables, potatoes, bread, flour, rice, pasta, other grains, and beverages (non-alcoholic). Weekly food expenditures averaged 283,711 R per household and ranged from 162,916 R in Tomsk to 398,055 R in Irkutsk. Variations in diet were apparent, as expenditures varied across food categories for each city, particularly in percentage of food expenditures by category across the food budget. Housing subsidies were taken into account by using an indicator variable for whether or not a household received a subsidized housing.

The purpose of this study was to examine the demand for carbohydrate sources by Russian households under the economic and political conditions faced by Russia since the demise of communism. Five commodity groups were used in this analysis: potatoes, bread, flour, rice, and pasta. Households providing appropriate responses to the survey indicated their expenditures on these commodities and the quantities purchased during the one-week survey period (Table 1).

To examine the expenditures on various carbohydrate sources by responding households, an almost ideal demand system (AIDS) model was used (Deaton & Muellbauer, 1980). This model is an extension of the Working-Leser model for estimating Engel curves:

(1) $$w_i = a_i + b_i \log(EXP)$$

where w_i = budget share; EXP = expenditures; and $\acute{a}_i$ and $\hat{a}_i$ are estimated parameters.

Deaton & Muellbauer (1980) argued that $\acute{a}_i$ and $\hat{a}_i$ in the Working-Leser model can be made functions of prices, thereby accounting for price effects if one wished to estimate Engel curves using time series data. The premise of the AIDS model stems from duality concepts that link expenditures (EXP) to a cost function. After derivation, the general AIDS model is denoted as a system of equations with the form:

(2) $$w_i = a_i + \sum_j g_{ij} \log p_j + b_i \log\left(\frac{EXP}{P}\right)$$

where P is a price index defined by the nonlinear equation:

(3) $$\log P = t_0 + \sum_k t_k \log p_k + \tfrac{1}{2} \sum_k \sum_j d_{kj} \log p_k \log p_j$$

The theoretical restriction of additivity is met by:

(4) $$\sum_k a_k = 1, \ \sum_k b_k = 0, \ \sum_k g_{kj} = 0$$

and homogeneity is satisfied if and only if:

(5) $$\sum_k g_{jk} = 0$$

Symmetry is satisfied if:

(6) $$g_{ij} = g_{ji}$$

To circumvent the non-linearity of P that makes this demand system *almost* ideal, a linear approximation of P can be utilized, which Deaton and Muellbauer call the Stone Price Index:

(7) $$\log P^* = \sum_k w_k \log p_k \qquad P \cong \in P^*$$

which makes the price index (P) proportionally the same as some other price index (P*). The resulting model is now a *linear approximation* of the almost ideal demand system (LA/AIDS).

Prices were not provided by responding households; only quantities and expenditures for commodities were reported. Prices were therefore derived for consuming households by dividing expenditures (rubles) by quantities (kilograms). Some households showed extremely high or low prices paid per kilogram for one or more carbohydrate source. This outlier problem was dealt with by dropping those samples with the highest and lowest 2.5% of imputed prices, excluding those households that reported zero expenditures. Doing so resulted in 1,374 useable observations.

As eluded to in the previous paragraph, not all of the 1,600 responding households purchased some of every carbohydrate source during the survey period. Average prices from consuming households were assigned as prices for households that did not purchase commodities during the survey week so that as many observations as possible could be used in the demand estimations. Elementary statistics for prices are reported in Table 2.

As previously mentioned, some households responding to the weekly food consumption/expenditure survey indicated no purchases of certain food items, possibly due to a high household inventory of that commodity or no preference for that commodity. To circumvent censored response bias in this study, the generalized Heckman procedure was used (Heien and Wessells; Heien and Durham; Saha et. al; Park et. al; Holcomb et. al). The first step of this procedure is a probit regression to determine the probability that a household would purchase a given protein source. According to Saha et. al, the probabilities are mathematically denoted as:

$$
\begin{aligned}
&pr[Z_{hi} = 1] = \Phi(W_h \delta_i), \\
&pr[Z_{hi} = 0] = 1 - \Phi(W_h \delta_i) \\
&i = 1, \ldots, n; h = 1, \ldots, H
\end{aligned}
\tag{8}
$$

where Ô is the cumulative distribution function (CDF), W_h is vector of regressors related to the purchase decision, and ä$_i$ is the coefficient vector associated with these regressors. A ratio of the probability distribution function (PDF) to the CDF can then be obtained in the form of the inverse Mills ratio (IMR). The IMR for each protein source for each household are estimated from the probit regressions is mathematically denoted as:

$$
\begin{aligned}
&I\hat{M}R_{hi} = \left\{ \frac{\phi\left(W_h \hat{\delta}_i\right)}{\Phi\left(W_h \hat{\delta}\right)_i} \; for Z_{hi} = 1 \right\}, \\
&I\hat{M}R_{hi} = \left\{ \frac{\phi\left(W_h \hat{\delta}_i\right)}{1 - \Phi\left(W_h \hat{\delta}_i\right)} \; for Z_{hi} = 0 \right\}
\end{aligned}
\tag{9}
$$

where ö represents the PDF. The IMR is then used to incorporate the censoring latent variable in the estimation of a linear expenditure system (LES). By doing so, the demand estimations could incorporate most of the useable observations.

Household size was added as an explanatory variable to account for differences in food budget shares associated with varying numbers of family members. An additional binary variable was included to indicate the presence of children under the age of 18 in the household size. Incorporating dummy variables for geographic location, the household head's occupation, and whether or not the household rents or owns their living quarters generates systems equations in the form of:

(10)

$$
\begin{aligned}
w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(EXP / P^*) + \delta_{i1} HSIZE + \delta_{i2} CHILD \\
+ \delta_{i3} KHABAR + \delta_{i4} ULAN + \delta_{i5} VLADI + \delta_{i6} KRASN \\
+ \delta_{i7} NOVOS + \delta_{i9} OMSK + \delta_{i10} TOMSK + \delta_{i11} INAPART \\
+ \delta_{i12} GOV + \delta_{i13} ED + \delta_{i14} MANU + \delta_{i15} COMMUN \\
+ \delta_{i16} TRADE + \delta_{i17} RETIRED + \delta_{i18} OTHR + \delta_{i19} IMR + \varepsilon_i
\end{aligned}
$$

where:

w_i	=	budget share of carbohydrate source i for i=1,...,5.
p_j	=	price of carbohydrate source j for j=1,...,5.
EXP	=	expenditures on all carbohydrates.
*P**	=	Stone's approximation of the carbohydrates price index.
HSIZE	=	household size.
CHILD	=	number of children under age 18 in the household.
KHABAR	=	binary variable representing households located in Khabarovsk.
ULAN	=	binary variable representing households located in Ulan Ude.
VLADI	=	binary variable representing households located in Vladivostok.
KRASN	=	binary variable representing households located in Krasnoyarsk.
NOVOS	=	binary variable representing households located in Novosibirsk.
OMSK	=	binary variable representing households located in Omsk.
TOMSK	=	binary variable representing households located in Tomsk.

INAPART = binary variable representing households living in rented apartments.

GOV = binary variable equal to “1" if the household working for the government.

ED = number of people in the household working in education.

MANU = number of people in the household working in a manufacturing industry.

COMMUN = number of people in the household working in communications.

TRADE = number of people in the household working at a skilled trade.

RETIRED = number of retired people in the household.

OTHPR = number of people in the household head works at some profession other than that falling under the survey’s category of “profession” (e.g. doctor, lawyer, engineer, etc.).

IMR = inverse Mills ratio.

Because binary variables were used, one category from each of the demographic characteristics was excluded to avoid singularity. Therefore, the base households were those located in Irkutsk. Parameters for this system of equations were estimated using SHAZAM. Theoretical restrictions were imposed, and the equation for pasta was dropped from the system of equations to avoid singularity of the variance-covariance matrix of disturbance terms.

Results

Parameter estimates and their associated t-statistics are reported in Table 3. As expected, own-price coefficients for potatoes, bread, and flour are positive and significant, indicating that an increase (decrease) in product price increases (decreases) that source’s share of total carbohydrate expenditures. Surprisingly, budget shares for rice and pasta were not significantly impacted by changes in their respective prices, suggesting that households would increase or decrease the quantities purchased so that expenditures on these items remain the same.

Cross-price parameter estimates indicate that an increase (decrease) in the price of potatoes and/or flour will result in a smaller (larger) share of carbohydrate expenditures for bread. While this indicates that bread is a complement for either of these items, bread expenditures share does not significantly change with the price of rice or pasta. This finding is plausible, as bread is a staple of virtually every meal and/or snack in Russia. Surprisingly, the parameter estimates indicate that rice, a staple food item for most of the world, is not a significant substitute or complement for any of the other carbohydrate sources. The share of carbohydrate expenditures for pasta, however, were significantly (negatively) impacted by a change in the price of flour, suggesting that they are also complements.

The â parameters indicated some interesting findings for Russian households. As the households divert more rubles to carbohydrate expenditures, the share of budgeted carbohydrate expenditures for potatoes and pasta will rise. Conversely, the shares for bread, flour, and rice decline. These parameter estimates suggest that Russian households may welcome the opportunity to consume more potatoes and prepared pasta items if more rubles are available (and budgeted) for carbohydrate expenditures. Additionally, because incomes are restricted, the households may view bread, flour, and rice as more nutritious than potatoes and pasta due to their higher protein levels. In essence, the rubles spent on bread, flour, and rice may be redistributed among potatoes and pasta, with some of any additional income also being allocated to higher protein food items such as meat and poultry.

Parameter estimates for household size also presented some interesting insights. As expected, larger households spend more of their budgeted carbohydrates rubles on the least expensive items -- bread and flour. The share of carbohydrate expenditures assigned to potatoes decreases as household size increases. Conversely, the share for rice does not significantly change as more rubles are budgeted for carbohydrate expenditures.

The presence of children in the home did not significantly alter expenditure shares for any of the carbohydrate sources. Similarly, whether the household lived in a rented or owned home had no significant impact on the budget shares. Several differences were noted among geographic locations and household head occupations for the various carbohydrate sources.

Compensated own-price and cross-price elasticities, expenditure elasticities, and income elasticities have been computed and are presented in Table 4. As suggested by the statistically significant parameter estimates in Table 3, the compensated cross-price elasticities indicate that bread is a net complement for potatoes and flour when both substitution and income effects are considered. This is no real surprise, as bread is generally consumed at every meal regardless of the other carbohydrate sources offered as part of the meal. Pasta and flour, however, are net substitutes.

Expenditure elasticities ranged from 0.5 (rice) to 1.1 (pasta). These elasticities indicate that a 1% increase in budgeted carbohydrate expenditures would result in increased pasta consumption of greater than 1%. Russian pasta is generally made from the “hard” wheats of the region, not the durum wheats traditionally considered best for pasta production. It may be that as households budget more rubles for carbohydrates they purchase the higher-quality imported pasta, hence the expenditure elasticity greater than one.

Income elasticities have been made available through the use of an auxiliary regression of carbohydrate expenditures on household income. Multiplying the expenditure elasticities by the income elasticity of carbohydrate expenditures gives the income elasticities for each carbohydrate source (Hymans and Shapiro; Manser; Capps, Tedford, and Havlicek; Park et. al). These income elasticities indicate that the carbohydrate items are all normal goods. Furthermore, the fact that the income elasticities are near zero provide evidence for the premise that these food sources are viewed as staple items by the households.

Implications

Basic food items such as potatoes, bread, flour, rice, and pasta products have been, and continue to be, the most often consumed food items in Russian households. The findings presented in this study indicate that bread and flour remain the basic carbohydrate sources for these households, although an increase in purchasing power may see these households dedicate a larger share of their expenditures to potatoes and pasta products.

Pasta products have a more elastic demand than the other carbohydrate sources, yet the findings did not indicate that pasta was a significant substitute for bread or potatoes. It may be that Russian households have become generationally dependent on bread and potatoes, thereby making rice and pasta less suitable substitutes for these food items. The importance of these foods to Russian consumers is evident by the government subsidization of bread and the recently growing imports of potatoes when even grain imports are declining (USDA-FAS, 1999a and 1999b).

Depending upon the strength of the Russian ruble, market opportunities may exist for U.S. wheat, rice and potatoes. Availability of wheat and potatoes from the European Union and wheat from Australia, along with the rice supplied by Pacific Rim countries, will determine the ability of U.S. exporters to capture a larger share of Russian markets for carbohydrates. Likewise, commodity availability from Europe and Asia may impact the ability of the U.S. to politically bargain through the use of food aid programs. In the event that these markets become more viable, continued availability of USDA programs such as GSM 101 and 102 and other loan guarantee and export assistance programs could play a key role in realization of trade as an enabling mechanism for both importers and exporters.

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Table 1: Descriptive Statistics for Carbohydrate Expenditures and Quantities, Weekly Income, and Household Size for Responding Russian Households[a].

Variable	Mean	Standard Deviation	Minimum	Maximum
Potatoes				
Expenditure (rubles)	9,685.0	15,578.0	0	200,000
Quantity (kg)	4.43	6.09	0	50.00
Bread				
Expenditure (rubles)	18,000.0	17,962.0	0	150,000
Quantity (kg)	6.40	6.78	0	75.00
Flour				
Expenditure (rubles)	5,296.2	9,936.3	0	225,000
Quantity (kg)	1.39	2.41	0	50.00
Rice				
Expenditure (rubles)	3,764.3	4,754.0	0	60,000
Quantity (kg)	0.73	0.94	0	12.00
Pasta				
Expenditure (rubles)	5,715.2	6,671.4	0	70,000
Quantity (kg)	0.96	1.19	0	15.20
Weekly Income	427,810	781,130	16,154	23,077,000
Household Size	3.64	1.43	1	9

[a] Number of observations is 1,374 after dropping those households that did not indicate their income and/or their geographical location and after eliminating ±2.5% of “outlier” prices for each carbohydrate category.

Table 2: Descriptive Statistics for Imputed Carbohydrate Prices (rubles/kg) Paid by Responding Russian Households[a].

Variable	Mean	Standard Deviation	Minumum	Maximum
Potatoes	2,116.8	553.7	1,000.0	5,000.0
Bread	2,907.6	372.5	1,250.0	6,923.1
Flour	3,825.8	437.5	2,000.0	6,000.0
Rice	4,899.9	650.6	3,000.0	10,000.0
Pasta	6,089.9	1,110.7	3,000.0	12,000.0

[a] Number of observations is 1,374 after dropping those observations with no reported household income and/or household location and after eliminating the upper and lower 2.5% of "outlier" prices for each carbohydrate category.

Table 3: Parameter Estimates, LA/AIDS Carbohydrates Model.

Explanatory Variables	Carbohydrate Sources: Potatoes	Bread	Flour	Rice	Pasta
$\log(P_{Potatoes})$	0.0739** (3.18)[a]	-0.0795** (-3.66)	-0.0136 (-0.96)	0.0167 (1.30)	0.0025 (0.13)
$\log(P_{Bread})$	-0.0795** (-3.66)	0.0992** (2.78)	-0.0352** (-1.97)	-0.0240 (-1.42)	0.0395 (1.51)
$\log(P_{Flour})$	-0.0136 (-0.96)	-0.0035** (-1.97)	0.0718** (3.35)	0.0079 (0.51)	-0.0308* (-1.83)
$\log(P_{Rice})$	0.0167 (1.30)	-0.0240 (-1.42)	0.0079 (0.51)	0.0106 (0.51)	-0.0112 (-0.68)
$\log(P_{Pasta})$	0.0025 (0.13)	0.0395 (1.51)	-0.0308* (-1.84)	-0.0112 (-0.68)	0.00003 (0.0009)
log(EXP/P*)	0.0878** (14.49)	-0.0409** (-5.45)	-0.0147** (-3.87)	-0.0474** (-13.67)	0.0152** (2.18)
HSIZE	-0.0165** (-3.66)	0.0205** (3.72)	0.0055* (1.95)	-0.0010 (-0.39)	----
CHILD	-0.0184 (-1.64)	-0.0057 (-0.41)	-0.0067 (-0.95)	-0.9915 (-1.53)	----
KHABAR	0.0118 (0.64)	-0.0147 (-0.65)	-0.0049 (-0.41)	-0.0183* (-1.69)	----
ULAN	-0.0148 (-0.83)	-0.0052 (-0.23)	0.0154 (1.35)	-0.0017 (-0.16)	----
VLADI	0.0327* (1.8)	0.0334 (1.50)	0.0079 (0.67)	0.0110 (1.04)	----
KRASN	0.0149 (0.84)	0.0829** (3.84)	-0.0281** (-2.50)	0.0030 (0.29)	----
NOVOS	-0.0288 (-1.64)	0.0734** (3.42)	0.0028 (0.25)	-0.0084 (-0.82)	----
OMSK	0.0348* (1.92)	-0.0006 (-0.03)	-0.0059 (-0.50)	0.0172 (1.60)	----

Table 3 (continued)

	Carbohydrate Sources				
Explanatory Variables	**Potatoes**	**Bread**	**Flour**	**Rice**	**Pasta**
TOMSK	-0.0146 (-0.81)	0.0883** (4.02)	0.0034 (0.30)	-0.0210** (-2.02)	----
INAPART	-0.0049 (-0.29)	0.0050 (0.24)	0.0023 (0.21)	0.0062 (0.64)	----
GOV	-0.0069 (-0.91)	0.0096 (1.03)	-0.0027 (-0.57)	0.0008 (0.19)	----
ED	-0.0016 (-0.12)	0.0078 (0.48)	-0.0182** (-2.24)	-0.0076 (-1.01)	----
MANU	-0.1514 (-1.64)	-0.0125 (-1.11)	-0.0021 (-0.37)	0.0045 (0.85)	----
COMMUN	-0.0053 (-0.35)	-0.0309* (-1.69)	-0.0253** (-2.69)	-0.0136 (-1.58)	----
TRADE	0.0120 (1.18)	-0.0097 (-0.79)	-0.0025 (-0.40)	0.0048 (0.82)	----
RETIRED	0.0117 (1.36)	-0.0155 (-1.48)	0.0063 (1.17)	-0.0050 (-1.02)	----
OTHPR	-0.0038 (-0.47)	0.0003 (0.03)	-0.0053 (-1.05)	0.0015 (0.32)	----
MILLS	-0.2456** (-11.64)	-0.2420** (-14.64)	-0.1674** (-16.66)	-1.1414** (-18.09)	----
CONSTANT	0.2688** (8.61)	0.4674** (14.32)	0.2460** (11.94)	0.3098** (16.60)	-0.2921
R^2	0.296	0.208	0.265	0.298	----

[a] Denotes t-statistic value.
* Statistically significant at the á=0.10 level.
** Statistically significant at the á=0.05 level.

Table 4: Own-Price[a], Cross-Price[b], Expenditure[c], and Income[d] Elasticities for Carbohydrate Sources.

Elasticity	Carbohydrate Source				
	Potatoes	Bread	Flour	Rice	Pasta
Potatoes	-0.6068	-0.1588	-0.0860	0.2848	-0.0088
Bread	-0.3587	-0.7255	-0.2410	-0.0025	0.2133
Flour	-0.0033	-0.0069	-0.2801	0.4521	0.1263
Rice	0.1091	-0.0266	0.1068	-0.7506	-0.1054
Pasta	0.0292	0.1095	0.2919	-0.0161	-1.0202
Expenditure	0.9171	0.9062	0.8734	0.5268	1.1013
Income	0.0171	0.0169	0.0163	0.0098	0.0206

[a] $å_{ii} = 1/w_i [ã_{ii} - â_i (á_i + Óã_{ri}\log(p_r))]-1$
[b] $å_{ij} = 1/w_i [ã_{ij} - â_i (á_j + Óã_{rj}\log(p_r))]$
[c] $ç_i = 1 + â_i/w_i$
[d] From multiplying $ç_i$ by the income elasticity of carbohydrate expenditures.