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MODELING INTERNATIONAL CONSUMPTION PATTERNS

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This article addresses a number of key problems commonly confronted in the literature on international demand analysis. These include data issues and requirements, multistage budgeting, outliers, group heteroskedasticity, and model selection. A two-stage demand system is fit to International Comparison Programme data for 114 countries for nine aggregate categories and eight food sub-categories of goods. Outliers are identified and omitted from the sample. Parameter estimates for the two stages are obtained with a maximum-likelihood procedure that corrects for group heteroskedasticity. Country-specific income and own-price elasticities are calculated and indicate that poor countries are more responsive to changes in income and prices than rich countries. We also find evidence for the strong version of Engel's law; when income doubles, the budget share of food declines by approximately 0.10.

1. Introduction

This article addresses a number of key problems commonly confronted in the literature on international demand analysis. International demand analysis or cross-country demand analysis estimates the demand for goods or services for a group of countries. Using cross-country consumption data, when available, is attractive because they generally have more variability in consumption, income and prices than do time-series data for a single country or do household data (Selvanathan and Selvanathan, 1993). This is particularly true for a sample of high-, middle-, and low-income countries. However, utilizing cross-country data to estimate the demand for goods or services is not without costs or problems. For example, the data requirements for estimating international consumption patterns for a large number of countries and commodities are demanding and stringent. Firstly, national currency units must be converted to a base-country unit, but it is well known that conversion by official exchange rates has serious disadvantages.

Fortunately, the International Comparison Programme (ICP) provides consumption data based on purchasing power parity (PPP) conversions for a large

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number of countries and consumption items. However, the ICP data are not without problems. These include issues of aggregation and of data quality issues such as outliers and group heteroskedasticity. While many studies ignore these issues of outliers and group heteroskedasticity, we show that the outlier problem can be remedied by calculating information inaccuracy measures and that one can correct for group heteroskedasticity by incorporating parameters into the log-likelihood function that properly weight the covariance matrices of the groups and by estimating the parameters with maximum likelihood.

Notwithstanding data requirements, estimating a cross-country demand system beyond a small number of aggregate or broad categories of goods is also challenging, in particular, due to lack of degrees of freedom. To address this, we propose using multistage budgeting as a parsimonious way of estimating the demand for broad categories of goods and for sub-categories of goods within the broad aggregates. To operationalize a multistage demand system, a model with appropriate preference structures should be chosen. Several popular models are discussed in terms of their preference structures and suggestions for model choice are presented.

Other problems of model selection are often ignored by many studies. For example, models with constant elasticity estimates or constant marginal shares, although appropriate for some applications, are not suitable for fitting cross-country consumption data, particularly for a sample of rich and poor countries. These models result in income and price elasticities that do not correspond to economic theory or empirical evidence. In this paper, we show that careful model selection guided by economic theory and proper functional form results in expenditure and price elasticities for aggregate commodities and disaggregate sub-categories that correspond to predictions by economic theory and empirical evidence.

In the empirical section, we fit a two-stage-demand system with the Florida-PI and Florida-Slutsky models to 1996 ICP data of 114 countries for nine broad categories and eight food sub-categories. The statistical fit of the two models, in terms of parameter significance, is satisfactory, and country-specific income and own-price elasticities behave in accordance with predictions of economic theory; low-income countries are more income and price responsive than high-income countries. We also find evidence for the strong version of Engel's law; when income doubles, the budget share of food declines by approximately 0.10.

The paper is organized as follows. Firstly, data needs and data problems associated with international consumption studies are discussed. Multistage budgeting is introduced and followed by a discussion on models. The Florida-PI and Florida-Slutsky models are introduced and fit to 1996 ICP data for 114 countries in a two-stage, cross-country-demand system. Information inaccuracy measures are calculated, and 23 countries are identified as outliers and omitted from the final regression. The resulting data of 91 countries exhibit group heteroskedasticity, and a maximum-likelihood procedure is developed and utilized to correct for it. Parameter estimates and associated asymptotic standard errors are obtained and reported for the two stages of cross-country-consumer allocation, and country-specific income and own-price elasticities of demand are reported and discussed. Finally, conclusions are drawn.

2. Data Needs for Cross-Country Demand Analysis

International consumption data, when available, are generally reported in different national currencies. To conduct international consumption studies, it is necessary to convert all currencies into a single denomination. One solution is to use official exchange rates to convert different local currencies to (say) U.S. dollars. However, this solution has serious disadvantages. One is that this method tends to overstate the poverty of low-income countries (Kravis *et al.*, 1982a). Another is that, because official exchange rates fluctuate widely over time for reasons independent of personal expenditures, conversions of expenditure data by official exchange rates can lead to highly spurious results (Theil *et al.*, 1989).

A more attractive method of converting national currency-based expenditure data into a single currency-base is through the use of purchasing power parity (PPP).[1] PPP is the number of local currency units required to buy equivalent goods with a unit of base-country currency. The objective is to develop an exchange rate that converts different national currencies to a single-base currency dependent upon the number of units it takes to purchase the same bundle of goods in the base country. As such, it more precisely relates consumption expenditures across countries than conversion by official exchange rates. Further, this method is not susceptible to the vagaries of exchange rate fluctuations, and, unlike official exchange rates, it accounts for both traded and non-traded goods and services (Reimer and Hertel, 2004).

2.1. *Aggregation Issues*

The ICP provides international consumption data based on PPP conversions that are comparable across a large number of countries for a relatively large number of consumption items. The ICP data are collected at a highly disaggregate level and require aggregation to what is called basic headings. The country-product-dummy (CPD) method and the Elteto, Koves and Szulc (EKS) method have been used by ICP to aggregate items to basic headings. When the matrix of all item values in a basic heading is complete, the two methods are identical. When the matrix has missing values, the two methods diverge. Gerardi (1982) recommends EKS while Kravis *et al.* (1982b) recommend CPD.

To aggregate ICP data beyond basic headings, the ICP generally chooses between two multilateral methods, EKS and Geary-Khamis (GK), and both provide transitive and base-country invariance (Gerardi, 1982). The EKS method, however, produces aggregations that are additively inconsistent, that is, the different category components of a broad-category heading (or grouping) do not sum to the broad category heading nor do the broad-category headings sum to total expenditure. Lack of additivity makes EKS aggregation ill-suited for international demand studies. GK aggregated data are additively consistent and may be used for international demand studies.

[1]Much of the early work on this method was inspired by Gilbert and Kravis (1954) and later by Kravis and colleagues (Kravis *et al.*, 1975, 1978, 1982a) at the University of Pennsylvania with the support of the Organization for Economic Co-Operation and Development (OECD). More recent work has been supported by the United Nations (1986–87, 2000, 2002), the World Bank (2004a, 2004b), and the OECD (1987, 1993, 2000, 2002).

The GK method does have drawbacks. One is that the numerical aggregations are dependent on which countries are included. This has led Eurostat to impose "fixity" on the data for European Union countries when aggregated with other Organization for Economic Co-Operation and Development (OECD) countries in initial ICP reports. Fixity, as does EKS aggregation, makes the resulting data non-additive and thereby unsuitable for international consumption comparisons (Drechsler, 1979; Ward, 1985). Another related problem is that a single set of quantity-weighted, average international prices tends to be closer to the price structure of richer countries, which are the larger countries in terms of GDP and, contrary to the EKS method, may overvalue consumption of poorer countries. ICP attempts to overcome this problem by regionalizing the data development process and by minimizing economic disparity within groups of comparable countries. But as discussed below, regionalization can introduce new data problems.

2.2. *Data Quality Issues*

While the availability of consistent, comparable expenditure data for a large array of items and countries is the first step in cross-country demand analysis, problems may exist in the relative quality of consumption data among countries. Experiences with ICP data reveal that data quality disparities exist, particularly for low-income African countries. This is perhaps not too surprising given that some African countries have problems even estimating their population.[2] Also data quality suffers when tourist expenditures cannot be separated from domestic population expenditures. This is the case for Jamaican data in the ICP Phase II and possibly the case of Bahamas' 1996 ICP data.

Underreporting of consumption of home-produced food may lead to significant errors in national food expenditure estimates. This is particularly a problem for many low-income countries where many poor households consume some of their home-produced food. ICP attempts to correct for this fact, but the final-expenditure estimates generally underestimate consumption of home-produced food.

Regionalization of data collection may also present problems. For example, the 1996 ICP data were collected between 1993 and 1996 by six different agencies for countries in Asia, Africa, the Middle East, the Caribbean, Latin America, the OECD countries, and the Commonwealth of Independent States (CIS) region. Most regions express their countries' data relative to the U.S., but not all do. For example, in the 1996 ICP data set, Asian data are expressed relative to Hong Kong, and Latin American data are expressed relative to Mexico. As a result, it is necessary for the researcher to express all data relative to a single-base country, and in our case we expressed all data relative to U.S. data.

We were able to express the Latin American data relative to the rest of the data easily because Mexico and the U.S. are represented in the OECD data. Merging the Asian data is more challenging. To do so, we first transform the Asian data by making Japan, represented in the OECD data, the base country. However,

[2]*The Economist* revealed that the 1984 population estimates by the Ethiopian government based on past censuses differed from the actual census account in mid-1984 by nine million persons out of a total of 42 million (*The Economist*, July 20, 1985, p. 30).

after this transformation, the transformed Asian data still are not yet comparable to the rest of the data. For example, it is well known that Singapore's per capita income is much larger than per capita income data of most sub-Saharan African countries. Yet, in the transformed Asian data, Singapore per capita income is still lower than most sub-Saharan African data.

In the final step, we transform the Asian data based on PPPs from the World Bank's (2001) World Development Indicators (WDI). The PPPs from the WDI closely match the 1996 ICP PPPs for all countries except for Asian countries. According to WDI data, Hong Kong's 1996 total real per capita consumption expenditure is 79.8 percent of the U.S. level. The Asian real per capita expenditure data are normalized so that Hong Kong's real per capita expenditure is equal to one, and the Asian real per capita data are then multiplied by 0.798 to obtain expenditures relative to the U.S. level (normalized to equal one). We perform a similar final transformation of the Asian data to obtain the real per capita expenditure data of each of the food sub-groups that are comparable to the U.S. data and the rest of the data.

3. Multistage Budgeting in Economic Modeling

The presence of transitive, additive and consistent data allows for fitting a complete demand system to cross-country data. Fitting a cross-country demand system to a large number of goods is made possible via multistage budgeting (Barten, 1977). This strategy categorizes goods into a manageable number of groupings so that econometric estimation is feasible. In the first stage, all consumers in each country are postulated to allocate their total expenditures among broadly defined categories of goods such as food and transportation. In the second stage, consumers allocate each group's expenditure among categories of goods within each group. For example, consumers allocate their total food expenditure among food sub-categories such as meat and vegetables. In the third stage, consumers would, for example, allocate total meat expenditure among beef, pork, chicken, turkey and lamb.

To operationalize multistage budgeting, certain assumptions concerning consumer preferences must be made. In the first stage, it is usual to maintain that preferences are strongly separable or additive (Deaton and Muellbauer, 1984). This preference structure is also referred to as block independence (Theil, 1980). In essence, it maintains that the consumer's utility from consuming, say food, is unaffected by the consumption of some other broad category such as transportation.

Block independence is reasonable to maintain in the first stage, but it is not generally reasonable to do so in lower levels of multistage budgeting. In stage two (or three), it is more appropriate to maintain that preferences are weakly separable or blockwise dependent (Theil, 1980). This preference structure maintains that the consumer's utility from consuming a good (meat) within a broad category (food) is affected by the consumption of other goods (e.g. vegetables and cereals) within the group. A schematic of multistage budgeting is presented in Figure 1.

When utilizing multistage budgeting to fit a demand system to per capita cross-country data, the issue of whether or not tastes are the same across all

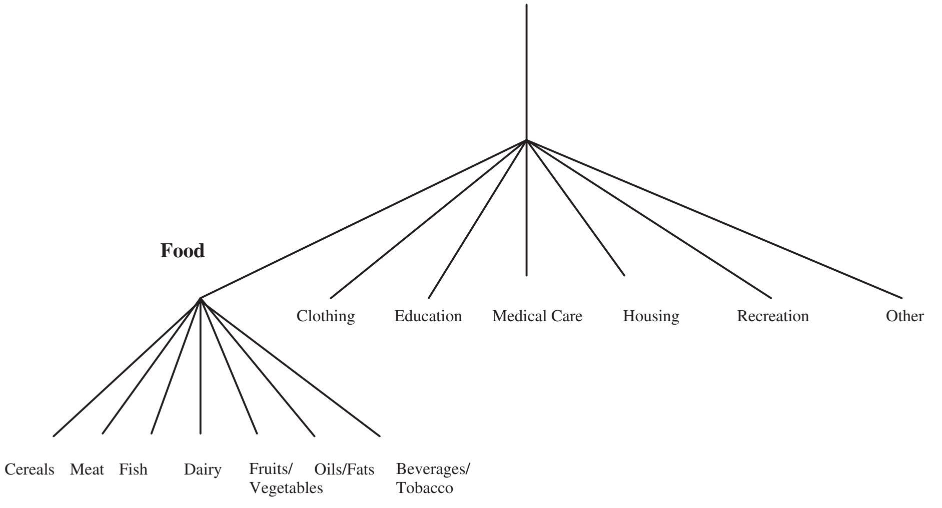

Figure 1. Two-Stage Budgeting Scheme

countries arises. It is standard practice in cross-country demand to maintain a common and consistent set of consumer preference for aggregate categories of goods. The assumption is more difficult to defend for highly disaggregate goods such as beef and pork. However, the evidence at the level of aggregation in this study is that preference structures across countries are surprisingly consistent and stable (Clements and Chen, 1996; Reimer and Hertel, 2004).

4. Model Selection for Cross-Country Demand Analysis

When choosing a model for analyzing cross-country demand, it is important to use economic theory as a guide for choice of model. For example, economic theory suggests that consumer responses to price and income signals should be smaller for an affluent consumer than for a less affluent one. Engel's law states that the budget share of food decreases with increasing income. Accordingly, the budget share of food should be larger in Vietnam than in the U.S., and the income elasticity of demand for food is expected to be greater in Vietnam than in the U.S.

Two simple but poor choices for fitting cross-country data are the double-log model and linear-expenditure system (LES) (Stone, 1954). Elasticities obtained from the double-log model are constant for a good over all countries, rich and poor. The LES, characterized by constant marginal shares, estimates expenditure elasticities that converge towards one for both necessities and luxuries as income increases. Accordingly, the expenditure elasticities of necessities rise, not fall, as countries become more affluent. LES maintains additive preferences making it appropriate for estimating cross-country demand for broad categories of goods but inappropriate for estimating multistage, cross-country-demand systems.

Fortunately, other models exist with elasticities that do not, in the words of Timmer (1981), "fly in the face of all economic logic."[3] Two such demand systems are the Deaton-Muellbauer (1980) model (i.e. the Almost Ideal Demand System (AIDS)) and the Florida model (Seale *et al.*, 1991; Theil, 1996). The two models have the same real income term, that of Working's (1943) model, but they have different price terms.

The AIDS, derived from a pig-log expenditure function, and the Florida model, derived from the differential approach to consumer theory, have different preference structures. The Florida-PI model maintains either preference independence or block independence while the Florida-Slutsky model maintains either weak separability or blockwise dependence. The AIDS model, however, is neither weakly nor additively separable (Barten, 1993).

The AIDS and the Florida model may be used to estimate the demand for aggregate goods. However, the AIDS preference structure does not allow (conceptually) for estimating conditional demand systems, that is, demand systems that make use of multistage budgeting. Although both versions of the Florida model may be used in any stage, the Florida-PI model is more appropriate for broad categories of goods, and the Florida-Slutsky model is more appropriate for estimating the demand for goods within an aggregate grouping.

The marginal shares of AIDS and the Florida model are the same, and they vary from the average (budget) share by a constant (i.e. the income parameter). If the constant is negative (positive), the good is a necessity (luxury); if it is zero, the good is unitary income elastic. Accordingly, country-specific-income elasticities of demand decrease for both necessities and luxuries as income levels increase.

A weakness of these models is that they may predict negative budget shares in some cases for the lowest-income countries. By generalizing the LES, Rimmer and Powell (1996) develop the Implicitly Additive Demand System (AIDADS) that constrains predicted budget shares within the (0, 1) range, and several authors have fit the model to cross-country data (e.g. Cranfield *et al.*, 1998, 2003, 2004; Rimmer and Powell, 2001; Yu *et al.*, 2003; Reimer and Hertel, 2004). Unlike LES, AIDADS has marginal shares and expenditure elasticities that vary appropriately as countries become more affluent. As its name implies, AIDADS is implicitly directly additive in preference structure making it suitable for estimating demand for aggregate goods when preferences are additive. However, AIDADS is unsuitable for estimating disaggregate consumption categories under multistage budgeting (Reimer and Hertel, 2004). As the purpose of this study is to estimate a two-stage, cross-country-demand system (i.e. aggregate goods and disaggregate food group), we choose the Florida-PI model for aggregate stage one and the Florida-Slutsky model for disaggregate stage two (food group). The two versions are discussed below.

[3]Timmer is referring to Pollak and Wales (1978) who fit the LES and the quadratic expenditure system (QES) to U.K. household data and report own-price elasticities of demand for food increasing in absolute value with increasing total consumption expenditure.

4.1. *Florida-PI (Preference Independence) Model*

Using the differential approach to consumer demand, Theil *et al.* (1989) incorporate prices into Working's (1943) model. When consumer preferences are preference independent or block independent, the resulting model describes the budget share as a function of a linear-real-income term, a quadratic-pure-price term, a cubic-substitution term, and an error term. In the first stage of multistage budgeting, the model is fit to group-level data. Letting S_g ($g = 1, \ldots, G$) represent G groups of goods, the model is expressed as:

$$W_{gc} = \alpha_g + \beta_g q_c + (\alpha_g + \beta_g q_c)\left[\log\frac{p_{gc}}{\bar{P}_g} - \sum_{g=1}^{G}(\alpha_g + \beta_g q_c)\log\frac{p_{gc}}{\bar{P}_g}\right] \tag{1}$$

$$+\phi\left(\alpha_g + \beta_g q_c^*\right)\left[\log\frac{p_{gc}}{\bar{P}_g} - \sum_{g=1}^{G}\left(\alpha_g + \beta_g q_c^*\right)\log\frac{p_{gc}}{\bar{P}_g}\right] + \varepsilon_{gc}$$

where $W_{gc}(= p_{gc}q_{gc}/E_c)$ is the budget share of group S_g in country c, p_{gc} is the price of S_g in c, q_{gc} is the per capita quantity of S_g in c, E_c is total nominal per capita income in c, q_c is the natural logarithm of Q_c (total real per capita income in c), $q_c^* = (1 + q_c)$, $\bar{P}_g$ is the geometric mean price of S_g over all countries, ϕ, assumed constant, represents the income flexibility (the inverse of the income elasticity of the marginal utility of income), and ε_{gc} is the error term of the g-th equation in country c. The αs and βs are subject to the constraints

$$\sum_{g=1}^{G}\alpha_g = 1 \quad \text{and} \quad \sum_{g=1}^{G}\beta_g = 0. \tag{2}$$

The expenditure elasticity for the Florida-PI model under block independence is:

$$\eta_g = \frac{\Theta_{gc}}{\bar{W}_{gc}} = 1 + \frac{\beta_g}{\bar{W}_{gc}} \tag{3}$$

where $\bar{W}_{gc}$ is equal to the linear-real-income term or the budget share of group S_g in country c calculated at geometric mean prices across all countries, Θ_{gc} is the marginal share of group S_g in c, and β_g is the estimated coefficient on q_c in the g-th group equation.

Three types of own-price elasticities of demand can be calculated. The Frisch-deflated own-price elasticity of group S_g results when own-price changes and income is compensated to keep the marginal utility of income constant. It is:

$$F_{ggc} = \frac{\phi(\bar{W}_{gc} + \beta_g)}{\bar{W}_{gc}} = \phi\eta_g. \tag{4}$$

The Slutsky (compensated) own-price elasticity measures the change in demand for group g when the price of g changes while real income remains unchanged; it is:

$$(5)\qquad S_{ggc} = \frac{\phi\left(\bar{W}_{gc} + \beta_g\right)\left(1 - \bar{W}_{gc} - \beta_g\right)}{\bar{W}_{ic}} = F_{ggc}\left(1 - \bar{W}_{gc} - \beta_g\right).$$

The Cournot (uncompensated) own-price elasticity refers to the situation when own-price changes while nominal income remains constant; it is:

$$(6)\qquad C_{ggc} = \frac{\phi\left(\bar{W}_{gc} + \beta_g\right)\left(1 - \bar{W}_{gc} - \beta_g\right)}{\bar{W}_{gc}} - \left(\bar{W}_{gc} + \beta_g\right) = S_{ggc} - \left(\bar{W}_{gc} + \beta_g\right).$$

4.2. *The Conditional Florida-Slutsky Model*

The Florida-Slutsky model may be written as a conditional cross-country-demand system, that is, the demand for good i contained in group S_g conditional on total group expenditure. The conditional Florida-Slutsky model, like Florida-PI, has three components. Its real-income and pure-price terms are similar to those of the Florida-PI, but its substitution term is linear instead of cubic:

$$(7)\qquad w_{ic}^* = \alpha_i^* + \beta_i^* q_{gc} + \left(\alpha_i^* + \beta_i^* q_{gc}\right)\left[\log\frac{p_{ic}}{\bar{P}_{i\in S_g}} - \sum_{j\in S_g}\left(\alpha_j^* + \beta_j^* q_{gc}\right)\log\frac{p_{jc}}{\bar{P}_{j\in S_g}}\right] + \sum_{j\in S_g}\pi_{ij}^*\log\frac{p_{jc}}{\bar{P}_{j\in S_g}}$$

where $w_{ic}^* = w_{ic}/W_{gc}$, w_{ic} is the (unconditional) budget share of good $i \in S_g$, W_{gc} is the budget share of group S_g in country c, $\bar{P}_{i\in S_g}$ is the geometric mean price of good $i \in S_g$ over all countries, q_{gc} is the log of real (total) expenditure on group S_g, and the α_i^*, β_i^* and π_{ij}^* are conditional parameters to be estimated. In particular, the π_{ij}^*s are the conditional Slutsky (compensated) price parameters.

The unconditional expenditure elasticity (η_{ic}^U) of the Florida-Slutsky is:

$$(8)\qquad \eta_{ic}^U = \eta_{gc}\eta_{ic}^* \quad i \in S_g$$

where η_{gc} is the unconditional expenditure elasticity of group S_g in c (calculated from equation (3)), $\eta_{ic}^* = 1 + \beta_i^*/\bar{w}_{ic}^*$ is the conditional expenditure elasticity of good $i \in S_g$ in country c, and $\bar{w}_{ic}^* = \alpha^* + \beta_i^* q_{gc}$ is the conditional budget share calculated at geometric mean prices.

The π_{ij}^* are constant in the Florida-Slutsky model, and conditional Slutsky own-price elasticities, $\pi_{ij}^*/\bar{w}_{ij}^*$, do not vary appropriately across countries with different levels of affluence. Unconditional Slutsky own-price elasticities are functions of the conditional ones and share the same undesirable property.

Fortunately, Frisch own-price elasticities exist when preferences are preference independent or block independent, and they vary appropriately when countries have different affluence levels. The unconditional Frisch own-price elasticity of demand for good $i \in S_g$ in country c is:

$$F_{iic}^{u} = \frac{\phi \Theta_{gc}}{\bar{W}_{gc}} \frac{\theta_{ic}^{*}}{\bar{w}_{ic}^{*}} = \phi \eta_{gc}^{U} \eta_{ic}^{*}. \tag{9}$$

Note $\theta_{ic}^{*} = \sum_{j \in S_g} \theta_{ijc}^{*}$ so that θ_{ic}^{*} should reasonably approximate θ_{iic}^{*}, and the unconditional Frisch own-price elasticities of demand should reasonably approximate their counterparts when preferences are blockwise dependent. Further, the Frisch own-price elasticity of demand is generally between, in magnitude, those of the corresponding Slutsky and Cournot own-price elasticities.

5. Estimation Issues and Solutions

Although ICP data may represent the "state of the art" in terms of cross-country-consumption data (Reimer and Hertel, 2004), fitting cross-country-demand systems to ICP data or any other cross-country data is not without problems. This section discusses two major issues when fitting a cross-country demand system to ICP data, and it suggests ways to deal appropriately with these problems. Certainly, the topics discussed are not exhaustive.

5.1. *Outliers*

As discussed earlier, poor quality data for some countries, particularly low-income African countries, are continuing problems with ICP data. Additionally, a large number of transitional countries from Central Asia and the Balkans is included for the first time in the 1996 ICP data, and these countries do not have past experiences with this type of survey. One strategy is to ignore the possibility of outliers and to fit a cross-country-demand system to the data of all sampled countries. However, if outliers are due to poor data quality, then the estimates may be unreliable.

The 1996 ICP data includes 115 countries: 24 from the Americas; 35 from Europe; 22 from Africa; and 33 from Asia (Table 1). One (Herzegovina) has no reported population figure for 1996 and is therefore deleted from the sample. To take into account the possibility of outliers, we calculate information inaccuracy measures for each of the remaining 114 countries (Seale *et al.*, 1991). These measures are based on statistical information theory and are calculated as $I_c = \sum_{i=1}^{n} w_{ic} \log \frac{w_{ic}}{\hat{w}_{ic}}$ where w_{ic} is the observed budget share of good i in country c, and $\hat{w}_{ic}$ is the fitted budget share of good i in country c. When the model fits perfectly, $\hat{w}_{ic} = w_{ic} \forall i, c$, and the value of I_c is zero. The value is positive when, for some i or c, $\hat{w}_{ic} - w_{ic}$ is non-zero. If the inaccuracy measure is greater than 0.10 (at two decimal places), we identify the associated country as an outlier and omit its data from the final analysis.

Twenty-three countries are outliers by this criterion, and these countries are indicated as such in Table 1. Of the 23, 17 are low-income countries, four are middle-income countries, and only two (Bahamas and Hong Kong) are high-income countries. Seven of the identified outliers are from Africa (Cole d'Ivoire, Egypt, Madagascar, Malawi, Nigeria, Tanzania and Zimbabwe), three (Bahamas,

TABLE 1

Classification of 115 Countries for Correction for Heteroskedasticity

Africa	America	Asia	Europe
Group 1. Countries included from the first three phases			
Malawi[2]	Brazil	Japan	Austria
Zambia	United States	Pakistan	Belgium
	Uruguay	Philippines[2]	Denmark
		South Korea	France
		Sri Lanka[2]	Germany
		Syria	Hungary
		Thailand	Ireland
			Italy
			Luxembourg
			Netherlands
			Poland
			Romania
			Spain
			United Kingdom
Group 2. Countries added in Phase IV			
Botswana	Argentina	Hong Kong[2]	Finland
Madagascar[2]	Bolivia	Indonesia	Greece
Morocco	Canada	Israel	Norway
Nigeria[2]	Chile		Portugal
Senegal	Ecuador[2]		
Tanzania[2]	Paraguay[2]		
Tunisia	Peru		
Zimbabwe[2]	Venezuela		
Africa	**America**	**Asia/Oceania**	**Europe**
Group 3. Additional countries in 1996			
Benin	Antigua & Barbuda	Armenia[2]	Albania[2]
Cameroon	Bahamas[2]	Australia	Belarus
Congo	Barbados	Azerbaijan[2]	Bulgaria
Cote d'Ivoire[2]	Belize	Bahrain[2]	Czech Republic
Egypt[2]	Bermuda	Bangladesh	Estonia
Gabon	Dominica	Fiji	Herzegovina[1]
Guinea	Grenada	Georgia[2]	Iceland
Kenya	Jamaica	Iran[2]	Latvia
Mali	Mexico	Jordan	Lithuania
Mauritius	Trinidad & Tobago	Kazakhstan	Macedonia
Sierra Leone	St. Kitts & Nevis	Kyrgyzstan	Moldova
Swaziland	St. Lucia	Lebanon	Russia
	St. Vincent & the Grenadines	Mongolia[2]	Slovakia
		Nepal	Slovenia
		New Zealand	Sweden
		Oman	Switzerland
		Qatar	Turkey
		Singapore	Ukraine
		Tajikistan[2]	
		Turkmenistan[2]	
		Uzbekistan	
		Vietnam	
		Yemen[2]	

Notes:

1. Herzegovina has no reported population figures for 1996 and is excluded from all analyses.
2. Twenty-three countries were identified as outliers using the information inaccuracy measures. Therefore, the remaining 91 countries are included in subsequent analyses.

Ecuador, and Paraguay) from America, one (Albania) from Europe, six (Armenia, Azerbaijan, Georgia, Mongolia, Tajikistan and Turkmenistan) from Central-Asian-Transition countries, and six others (Bahrain, Hong Kong, Iran, Philippines, Sri Lanka, and Yemen) from Asia.

It is interesting to note that whether or not a country is identified as an outlier is associated with when the country first appears in the ICP. For example, there are only three outliers among the countries that appear in the first three ICP phases.[4] Of the 33 countries introduced in Phase IV (1980), eight are outliers, and of the 60 countries introduced in 1996, 12 are outliers. This supports the rationale of grouping the data based on when a country first participates in the ICP and to correct for group heteroskedasticity based on this classification.

5.2. *Group Heteroskedasticity*

Group heteroskedasticity occurs when country groupings have differently sized covariance matrices. Previous cross-country-demand analyses indicate that ICP data exhibit group heteroskedasticity. Given prior evidence, estimation using the 1996 ICP data should account for the possibility of group heteroskedasticity.

Theil *et al.* (1989) divide the Phase IV data into group 1 (countries in either Phases II or III) and Group 2 (those that are in neither). Fitting the Florida-PI model to the group data individually, they find that the covariance matrix of the newly added group 2 is almost twice as large as that of group 1. To correct for group heteroskedasticity, they included two heteroskedastic parameters, k_g ($g = 1, 2$), in the log-likelihood function to appropriately weight the covariance matrices of the two groups. The k of group 1 is normalized to equal one, and the k of the other group is estimated with maximum likelihood using a grid search. Seale *et al.* (1991) use the same heteroskedastic scheme, but are able to directly estimate all parameters of the model (including the k) and their associated asymptotic standard errors with maximum likelihood.

In this paper, the heteroskedastic scheme is extended to accommodate three groupings. Group 1 consists of countries included in the first three phases of ICP, Group 2 consists of countries first included in Phase IV of the ICP, and Group 3 consists of countries first included in the 1996 ICP; Group 1 has 26 countries, Group 2 has 23 countries, and Group 3 has 65 countries. The countries in each group are presented in Table 1.

6. Estimation and Results

As previously stated, a two-stage-demand system is fit to 1996 ICP consumption data for 91 of 115 countries (Table 1). The first stage involves fitting the Florida-PI to nine aggregate consumption categories: food, beverages and tobacco; clothing and footwear; education; gross rent and fuel; house furnishings and operations; medical care; transport and communications; recreation; and

[4]The ICP data of Phase I refer to 10 countries in the year 1970 (Kravis *et al.*, 1975). The ICP data of Phase II refer to the original 10 countries in the year 1970 plus six more countries (16 total) in the year 1970 (Kravis *et al.*, 1978); consequently, the Phase II data supersede the Phase I data. The ICP data of Phase III refer to the 16 countries in Phase II plus 18 additional countries (34 total) in the year 1975 (Kravis *et al.*, 1982a).

TABLE 2

Maximum Likelihood Estimates of the Aggregate Model Using 91 Countries in 1996, with Outliers Excluded

	Parameter	Asymptotic Standard Error
Income flexibility	–0.839	0.022
	Beta (β*)	
Food, beverage & tobacco	–0.132	0.006
Clothing and footwear	–0.010	0.003
Education	0.001	0.003
Gross rent, fuel & power	0.027	0.005
House operations	0.009	0.003
Medical care	0.027	0.003
Other	0.038	0.004
Recreation	0.022	0.002
Transport	0.019	0.004
	Alpha (α*)	
Food, beverage & tobacco	0.145	0.009
Clothing and footwear	0.054	0.004
Education	0.071	0.004
Gross rent, fuel & power	0.181	0.008
House operations	0.073	0.004
Medical care	0.112	0.005
Other	0.154	0.006
Recreation	0.076	0.004
Transport	0.134	0.006
	K	
K1	1.310	0.159
K2	1.540	0.108

other consumption. Food includes food prepared and consumed at home but does not include food consumed away from home. The second stage involves fitting the conditional Florida-Slutsky model to eight food sub-categories: bread and cereals; meat; fish; dairy products; oils and fats; fruits and vegetables; beverages and tobacco; and other food products. All parameters of the Florida-PI and the Florida-Slutsky model are estimated by maximum likelihood (Barten, 1969) using the scoring method (Harvey, 1990, pp. 133–5) and the *GAUSS for Windows* (Aptech Systems, Inc., 2001) computer software.[5]

6.1. *Aggregate Results*

Table 2 presents the estimated parameters of the first stage, the aggregate model. The two K_g parameters exceed one, confirming the presence of group heteroskedasticity. The K parameters for the two groups of countries introduced in the Phase IV ICP data (1980) and in the 1996 ICP data are 1.31 and 1.54, respectively, and indicate that the covariance matrices are 1.31 and 1.54 times, respectively, as large as the covariance matrix of the countries introduced in either Phases I, II, or III of the ICP. These K parameters are estimated with maximum likelihood to properly weight the covariance matrices of the three-country groups in the log-likelihood function.

[5]For details of the estimation procedure, see Seale *et al.* (2003).

As indicated by negative βs, only two groupings (i.e. food, beverage and tobacco, and clothing and footwear) are necessities; the rest of the categories are luxuries except education that has unitary income elasticity. The β parameter for food, beverages and tobacco is by far the largest in absolute value. Its estimate of –0.132 (with an asymptotic standard error of 0.006) is comparable to the value of –0.134, obtained by Theil *et al.* (1989, table 5-4) for pooled ICP data.[6] This estimate retains the property of the strong version of Engel's law: when income doubles, the budget share of food declines by approximately 0.1 (Clements and Chen, 1996; Reimer and Hertel, 2004).

Table 3 presents expenditure elasticities, calculated at geometric mean prices, for selected countries from the 91 included countries. These country-specific, income-elasticity values represent the estimated percent change in quantity demanded for a particular good if total income increases by 1 percent. The income elasticity of demand for food, beverages and tobacco varies greatly among countries and is highest among low-income countries; it is 0.74 for Vietnam and 0.09 for the U.S. The income elasticity for clothing and footwear, another necessity, also decreases in value from low-income to high-income countries; it is 0.88 for Vietnam and 0.82 for the U.S.

Education has unitary elasticity for all countries, suggesting that education will increase or decrease in the same proportion as income changes. The other categories are luxuries with income elasticities greater than one. The elasticity values are higher for less affluent countries and span a wide range. Recreation is by far the most luxurious good with an income elasticity of demand in Vietnam of 2.20 and in the U.S. of 1.28. Other and medical care are the next most luxurious goods followed by gross rent, fuel and power, transportation and communication, and home furnishings and operations.

Table 4 presents, in ascending order of affluence, the estimated Slutsky, Frisch and Cournot own-price elasticities for the nine aggregate goods across the same selected countries. These measures perform in accordance with Timmer's proposition: own-price elasticities of demand are larger in absolute value for low-income countries than for high-income ones.

The values of the Cournot and Frisch own-price elasticities decline monotonically in absolute value when traveling from poor to rich countries, and they are larger (absolutely) than the corresponding Slutsky own-price elasticities. Frisch values are between the corresponding Cournot and Slutsky ones for food, beverage and tobacco, clothing and footwear, and education, and they are larger than both the corresponding Cournot and Slutsky elasticities for the other three goods. The Slutsky own-price elasticity of demand for food, beverages and tobacco is –0.39 for Vietnam, increases (absolutely) to –0.41 for Morocco, and declines thereafter (absolutely) to –0.07 for the U.S. For the eight other categories, the Slutsky own-price elasticity is largest for Vietnam (absolutely) and continues to fall in absolute value while traveling towards richer countries.

The Cournot own-price elasticity of demand for food is worthy of comment; it is –0.76 in Vietnam, decreases absolutely to –0.47 in Korea, and decreases

[6]The estimate of –0.134 for food, beverages and tobacco is obtained by simply adding the Theil, Chung and Seale's parameter estimate of food, –0.135, to that of beverages and tobacco, 0.001.

TABLE 3

INCOME ELASTICITIES FOR SELECTED COUNTRIES: AGGREGATE CATEGORIES USING 91 COUNTRIES IN 1996, WITH OUTLIERS EXCLUDED

	Normalized real income	Food	Clothing & footwear	Gross rent, fuel & power	House operations	Medical care	Education	Transport & communication	Recreation	Other
Vietnam	0.07	0.74	0.88	1.25	1.18	1.67	1.01	1.22	2.20	1.73
Jamaica	0.13	0.68	0.87	1.22	1.16	1.47	1.01	1.19	1.68	1.50
Ukraine	0.15	0.66	0.86	1.21	1.16	1.43	1.01	1.19	1.60	1.46
Peru	0.17	0.65	0.86	1.21	1.15	1.42	1.01	1.18	1.57	1.44
Thailand	0.17	0.65	0.86	1.21	1.15	1.41	1.01	1.18	1.56	1.43
Morocco	0.18	0.65	0.86	1.20	1.15	1.41	1.01	1.18	1.56	1.43
Brazil	0.22	0.62	0.86	1.20	1.15	1.37	1.01	1.17	1.50	1.39
Mexico	0.26	0.59	0.85	1.19	1.14	1.35	1.01	1.17	1.45	1.36
Poland	0.28	0.58	0.85	1.19	1.14	1.34	1.01	1.17	1.44	1.36
Argentina	0.39	0.51	0.85	1.18	1.14	1.31	1.01	1.16	1.39	1.32
Korea	0.49	0.47	0.84	1.17	1.13	1.29	1.01	1.15	1.36	1.31
France	0.68	0.32	0.83	1.16	1.13	1.26	1.01	1.15	1.32	1.27
Japan	0.74	0.28	0.83	1.16	1.12	1.26	1.01	1.14	1.31	1.26
United States	1.00	0.09	0.82	1.15	1.12	1.24	1.01	1.14	1.28	1.25

Note: Elasticity estimates are calculated using budget shares at geometric mean prices.

TABLE 4

Own-Price Elasticities for Selected Countries: Aggregate Consumption Categories Using 91 Countries in 1996, with Outliers Excluded

	Food, beverage & tobacco			Clothing & footwear			Gross rent, fuel & power		
	Slutsky	*Frisch*	*Cournot*	*Slutsky*	*Frisch*	*Cournot*	*Slutsky*	*Frisch*	*Cournot*
Vietnam	−0.39	−0.62	−0.76	−0.68	−0.74	−0.76	−0.91	−1.05	−1.04
Jamaica	−0.41	−0.57	−0.70	−0.68	−0.73	−0.75	−0.87	−1.02	−1.02
Ukraine	−0.41	−0.56	−0.67	−0.68	−0.73	−0.74	−0.86	−1.02	−1.01
Peru	−0.41	−0.55	−0.66	−0.68	−0.72	−0.74	−0.85	−1.01	−1.01
Thailand	−0.41	−0.55	−0.66	−0.68	−0.72	−0.74	−0.85	−1.01	−1.01
Morocco	−0.41	−0.54	−0.65	−0.68	−0.72	−0.74	−0.85	−1.01	−1.01
Brazil	−0.41	−0.52	−0.62	−0.68	−0.72	−0.74	−0.84	−1.00	−1.00
Mexico	−0.40	−0.49	−0.59	−0.68	−0.72	−0.73	−0.83	−1.00	−1.00
Poland	−0.40	−0.48	−0.58	−0.67	−0.71	−0.73	−0.82	−0.99	−1.00
Argentina	−0.37	−0.43	−0.51	−0.67	−0.71	−0.72	−0.81	−0.99	−0.99
Korea	−0.35	−0.40	−0.47	−0.67	−0.71	−0.72	−0.80	−0.98	−0.99
France	−0.25	−0.27	−0.32	−0.66	−0.70	−0.71	−0.78	−0.97	−0.98
Japan	−0.23	−0.24	−0.28	−0.66	−0.69	−0.71	−0.78	−0.97	−0.98
United States	−0.07	−0.07	−0.09	−0.66	−0.69	−0.70	−0.76	−0.97	−0.97
	House operations			Medical care			Education		
	Slutsky	*Frisch*	*Cournot*	*Slutsky*	*Frisch*	*Cournot*	*Slutsky*	*Frisch*	*Cournot*
Vietnam	−0.93	−0.99	−0.99	−1.31	−1.40	−1.37	−0.79	−0.85	−0.86
Jamaica	−0.91	−0.97	−0.97	−1.13	−1.23	−1.21	−0.79	−0.85	−0.86
Ukraine	−0.91	−0.97	−0.97	−1.10	−1.20	−1.18	−0.79	−0.85	−0.86
Peru	−0.90	−0.97	−0.97	−1.08	−1.19	−1.17	−0.79	−0.85	−0.86
Thailand	−0.90	−0.97	−0.97	−1.08	−1.18	−1.17	−0.79	−0.85	−0.86
Morocco	−0.90	−0.97	−0.97	−1.07	−1.18	−1.16	−0.79	−0.85	−0.86
Brazil	−0.90	−0.96	−0.96	−1.04	−1.15	−1.14	−0.79	−0.85	−0.86
Mexico	−0.89	−0.96	−0.96	−1.02	−1.13	−1.12	−0.79	−0.85	−0.86
Poland	−0.89	−0.96	−0.96	−1.01	−1.12	−1.11	−0.79	−0.85	−0.86
Argentina	−0.88	−0.95	−0.96	−0.97	−1.10	−1.09	−0.79	−0.85	−0.86
Korea	−0.88	−0.95	−0.95	−0.96	−1.09	−1.08	−0.79	−0.85	−0.86
France	−0.87	−0.94	−0.95	−0.92	−1.06	−1.05	−0.79	−0.85	−0.86
Japan	−0.87	−0.94	−0.95	−0.92	−1.05	−1.05	−0.79	−0.85	−0.86
United States	−0.86	−0.94	−0.94	−0.89	−1.04	−1.03	−0.79	−0.85	−0.86
	Transport & communication			Recreation			Other		
	Slutsky	*Frisch*	*Cournot*	*Slutsky*	*Frisch*	*Cournot*	*Slutsky*	*Frisch*	*Cournot*
Vietnam	−0.92	−1.02	−1.02	−1.77	−1.84	−1.81	−1.32	−1.45	−1.41
Jamaica	−0.89	−1.00	−1.00	−1.33	−1.41	−1.39	−1.11	−1.26	−1.23
Ukraine	−0.88	−1.00	−1.00	−1.27	−1.35	−1.33	−1.07	−1.22	−1.19
Peru	−0.87	−0.99	−0.99	−1.24	−1.32	−1.30	−1.06	−1.21	−1.18
Thailand	−0.87	−0.99	−0.99	−1.23	−1.31	−1.29	−1.05	−1.20	−1.18
Morocco	−0.87	−0.99	−0.99	−1.23	−1.30	−1.29	−1.05	−1.20	−1.17
Brazil	−0.86	−0.99	−0.99	−1.17	−1.26	−1.24	−1.01	−1.17	−1.15
Mexico	−0.86	−0.98	−0.98	−1.13	−1.22	−1.20	−0.98	−1.14	−1.12
Poland	−0.85	−0.98	−0.98	−1.12	−1.21	−1.19	−0.97	−1.14	−1.12
Argentina	−0.84	−0.97	−0.98	−1.07	−1.16	−1.15	−0.94	−1.11	−1.09
Korea	−0.84	−0.97	−0.97	−1.05	−1.14	−1.13	−0.92	−1.09	−1.08
France	−0.82	−0.96	−0.97	−1.01	−1.10	−1.10	−0.88	−1.07	−1.05
Japan	−0.82	−0.96	−0.97	−1.00	−1.10	−1.00	−0.87	−1.06	−1.05
United States	−0.81	−0.95	−0.96	−0.97	−1.08	−1.07	−0.84	−1.04	−1.04

Note: Elasticity estimates are calculated using budget shares at geometric mean prices.

TABLE 5

Maximum Likelihood Estimates of the Food Sub-categories Model using 91 Countries in 1996, with Outliers Excluded

	Parameter	Asymptotic Standard Error
	Beta (β*)	
Beverage and Tobacco	0.067	0.010
Breads and Cereals	–0.054	0.009
Meat	0.011	0.007
Fish	0.007	0.005
Dairy	0.010	0.006
Fats & Oils	–0.017	0.004
Fruits & Vegetables	–0.030	0.010
Other Foods	0.007	0.008
	Alpha (α*)	
Beverage and Tobacco	0.227	0.010
Breads and Cereals	0.134	0.009
Meat	0.177	0.007
Fish	0.052	0.005
Dairy	0.108	0.006
Fats & Oils	0.028	0.004
Fruits & Vegetables	0.153	0.010
Other Foods	0.120	0.007
	Diagonal of the Slutsky Matrix	
π_{11}^*	–0.069	0.015
π_{22}^*	–0.153	0.024
π_{33}^*	–0.178	0.026
π_{44}^*	–0.068	0.009
π_{55}^*	–0.086	0.013
π_{66}^*	–0.032	0.008
π_{77}^*	–0.152	0.031
π_{88}^*	–0.175	0.025
	K	
K1	1.359	0.176
K2	1.533	0.115

to –0.09 in the U.S. The Cournot own-price elasticities for the other eight categories exhibit significant price sensitivities. Except for food, the largest value (absolutely) is –0.76 for clothing and footwear in the U.S. Clothing and footwear and education are own-price inelastic for all countries while recreation, medical care, and other are own-price elastic for all countries. The Cournot own-price elasticities of demand for gross rent, fuel and power, house operations, and transport and communications are approximately unitary for all countries.

6.2. *Food Sub-Category Results*

Table 5 presents the estimated parameters for the second-stage model, the food sub-groups. As in the aggregate results, the two K_g parameters exceed one confirming the presence of group heteroskedasticity and are similar in sizes to the two K_g parameters of the aggregate first stage. The K parameters for the two groups of countries introduced in the Phase IV (1980) of the ICP and in the 1996 ICP data are 1.36 and 1.53, respectively, and indicate that the covariance matrices are 1.36 and 1.53 times, respectively, as large as the covariance matrix of the countries introduced in Phases I, II, or III of the ICP. As indicated by negative β^*s, three groupings (i.e. bread and cereals, fats and oils, and fruits and vegetables) are conditionally inelastic food categories while the remaining five are conditionally elastic.[7] The negative β^* for fruits and vegetables can be explained by the fact that the data for this sub-category include expenditures on roots and tubers, a staple among poor consumers. The diagonal elements of the Slutsky price matrix ($\pi^*_{ii}s$) are compensated conditional own-price parameters; they are reported along with associated asymptotic standard errors in Table 5. All are negative as expected and statistically different from zero ($\alpha = 0.05$).

Unconditional income elasticities for the eight food sub-categories of the selected countries are largest for Vietnam and decline in magnitude with affluence, with the smallest elasticities in the U.S. (Table 6). Across each country, breads and cereals, fats and oils, and vegetables and fruits have smaller elasticities than the more conditionally elastic food items: beverages and tobacco; meat; fish; dairy; and other. For example, the unconditional income elasticity for breads and cereals ranges from 0.59 in Vietnam to 0.05 in the U.S. In comparison, the elasticity for beverages and tobacco is higher than for breads and cereals across all countries and ranges from 1.43 in Vietnam to 0.12 in the U.S.

Frisch own-price elasticities are calculated according to equation (9); they are reported in Table 7. The values of the unconditional Frisch own-price elasticities are smaller (absolutely) for the conditionally inelastic food groups (i.e. breads and cereals, fats and oils, and fruits and vegetables). The values range for breads and cereals from –0.49 in Vietnam to –0.04 in the U.S. Similarly, the Frisch own-price elasticities for fats and oils, and for fruits and vegetables range from –0.46 and –0.54, respectively, in Vietnam, to –0.03 and –0.06, respectively, in the U.S.

For the poorest selected country, Vietnam, the unconditional Frisch own-price elasticities for the conditionally elastic food sub-categories are –1.19 for beverage and tobacco, –0.66 for meat, –0.74 for fish, –0.69 for dairy, and –0.66 for other. As one travels from Vietnam to the wealthier countries, the values of these elasticities decline absolutely with affluence. For the U.S., the wealthiest country, they are –0.09 for beverage and tobacco, –0.08 for fish and for dairy, and –0.07 for meat and for other.

7. Closing Comments

This paper addresses key issues and problems associated with estimating a multistage, cross-country-demand system across a large number of countries and a relatively large number of goods. These include issues of currency conversions, aggregations, preferences, multistage budgeting, data quality, outliers, group heteroskedasticity, and model selection. Fortunately, satisfactory solutions can be found for most problems by using data based on PPPs (instead of data based on currency conversions by official exchange rates) and by fitting models that give economically valid results concerning income and price sensitivity measures. Specifically, we fit a two-stage-demand system with the Florida-PI and Florida-Slutsky models to 1996 ICP data of 91 countries for nine broad categories

[7]Parameter estimates are conditional on total per capita food expenditures, not total per capita expenditures.

TABLE 6

Unconditional Income Elasticities for Selected Countries: Food Sub-categories Using 91 Countries, with Outliers Excluded

	Beverage & Tobacco	Cereal	Meat	Fish	Dairy	Oils & Fats	Fruits & Vegetables	Other Food
Vietnam	1.43	0.59	0.79	0.88	0.83	0.55	0.64	0.79
Jamaica	0.99	0.50	0.72	0.79	0.75	0.44	0.57	0.72
Ukraine	0.97	0.49	0.70	0.76	0.73	0.43	0.56	0.70
Peru	0.93	0.47	0.69	0.75	0.72	0.41	0.54	0.69
Thailand	0.91	0.46	0.69	0.75	0.72	0.39	0.54	0.69
Morocco	0.90	0.46	0.69	0.75	0.72	0.38	0.54	0.69
Brazil	0.87	0.44	0.66	0.71	0.68	0.37	0.52	0.66
Mexico	0.80	0.40	0.63	0.67	0.65	0.32	0.49	0.63
Poland	0.79	0.40	0.62	0.66	0.64	0.33	0.48	0.62
Argentina	0.66	0.30	0.54	0.58	0.56	0.19	0.41	0.54
Korea	0.63	0.31	0.50	0.54	0.52	0.24	0.38	0.50
France	0.41	0.19	0.34	0.36	0.35	0.12	0.26	0.34
Japan	0.37	0.18	0.30	0.32	0.31	0.13	0.23	0.30
United States	0.12	0.05	0.10	0.10	0.10	0.03	0.07	0.10

Note: Elasticity estimates are calculated using budget shares at geometric mean prices.

TABLE 7

Unconditional Frisch Own-Price Elasticities for Selected Countries: Food Sub-categories Using 91 Countries, with Outliers Excluded

	Beverage & Tobacco	Cereal	Meat	Fish	Dairy	Oils & Fats	Fruits & Vegetables	Other Food
Vietnam	–1.19	–0.49	–0.66	–0.74	–0.69	–0.46	–0.54	–0.66
Jamaica	–0.83	–0.42	–0.61	–0.66	–0.63	–0.37	–0.48	–0.61
Ukraine	–0.82	–0.41	–0.60	–0.65	–0.62	–0.37	–0.47	–0.60
Peru	–0.79	–0.40	–0.59	–0.63	–0.61	–0.35	–0.46	–0.58
Thailand	–0.77	–0.39	–0.59	–0.63	–0.61	–0.33	–0.46	–0.58
Morocco	–0.75	–0.38	–0.57	–0.62	–0.60	–0.32	–0.45	–0.57
Brazil	–0.73	–0.37	–0.55	–0.60	–0.57	–0.31	–0.43	–0.55
Mexico	–0.67	–0.33	–0.52	–0.56	–0.54	–0.27	–0.40	–0.52
Poland	–0.66	–0.33	–0.51	–0.55	–0.53	–0.27	–0.40	–0.51
Argentina	–0.56	–0.26	–0.46	–0.49	–0.47	–0.16	–0.34	–0.46
Korea	–0.53	–0.26	–0.43	–0.46	–0.44	–0.20	–0.33	–0.42
France	–0.35	–0.16	–0.29	–0.31	–0.30	–0.10	–0.22	–0.29
Japan	–0.32	–0.15	–0.25	–0.27	–0.26	–0.11	–0.19	–0.25
United States	–0.09	–0.04	–0.07	–0.08	–0.08	–0.03	–0.06	–0.07

Note: Elasticity estimates are calculated using budget shares at geometric mean prices.

and eight food sub-categories. The statistical fit of the two models, in terms of parameter significance, are satisfactory, and country-specific expenditure and own-price elasticities behave in accordance with predictions of economic theory; low-income countries are more income and price responsive than high-income countries. We also find evidence for the strong version of Engel's law; when income doubles, the budget share of food declines by approximately 0.10.

Although the Florida-Slutsky model performs well in estimating the conditional second stage for the eight food sub-categories, it does have weaknesses. In particular, its constant Slutsky price parameters make its estimated Slutsky and Cournot price elasticities inappropriate for cross-country comparisons of these elasticities. Price elasticities may be approximated based on the Frisch price elasticities, but future research into a more suitable functional form that still has appropriate preference structures would be worthy. Future research could also further disaggregate the broad categories to include estimation of the demand for energy. Also, future research involving estimating the demand for other sub-category goods beyond the food category would be welcomed.

In closing, the parameter estimates obtained by fitting the Florida-PI and Florida-Slutsky models to the nine aggregate consumer categories and the eight food sub-categories can easily be utilized to calculate income and price elasticities for countries outside the 1996 ICP sample. Essentially, all that is necessary to calculate the aggregate elasticities, in addition to the first-stage parameters, are total real per capita income data. To calculate conditional elasticities for the eight food sub-categories, one only needs second-stage parameters and total per capita real food expenditure; to calculate the unconditional elasticities, one would additionally need total real per capita income and the first-stage parameters.

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