PREDICTING EXPENDITURE SHARES FOR COMPUTING PPP EXCHANGE RATES

C.J O'Donnell and D.S.P. Rao
Centre for Efficiency and Productivity Analysis
University of Queensland, Brisbane QLD 4072, Australia

7 April 2007

1. Introduction

Purchasing power parity (PPP) exchange rates are index numbers that measure differences in aggregate price levels across countries. PPPs are widely used by public and private sector agencies and individuals when making international comparisons of various economic aggregates, including GDP and the cost of living.

PPPs can be computed using common price index number formulas. Unfortunately, the most theoretically-appealing formulas can usually only be implemented if both price and expenditure share data are available. This paper is concerned with the problem of computing PPPs when price data are available but expenditure shares data are sparse. Our solution is to use econometric methods to predict unobserved expenditure shares. We apply the method to data obtained through the International Comparison Program (ICP).

The structure of the paper is as follows. In Section 2 we provide some background on PPP exchange rates and explain why they are preferred to market exchange rates when making international comparisons of economic aggregates. In Section 3 we present the Lasypeyres, Paasche, Fisher and Tornquist PPP index number formulas, all of which can be viewed as cost-of-living indexes. Like most PPP indexes, computation of these indexes requires data on prices and expenditure shares.

In Section 4 we explore the relationship between three PPP indexes and three estimable systems of expenditure (share) equations that are popular in the applied demand analysis literature. We show that i) the Tornqvist PPP index is underpinned by expenditure share equations that collapse to the Almost Ideal Demand System (AIDS) share equations under a parametric constraint, ii) maximisation of a quadratic utility function gives rise to a PPP index that is identical to the Fisher index under a parametric constraint, and iii) the well-known linear expenditure system (LES) can be used to motivate what we refer to as the Klein-Rubin PPP index. The index is so-named because the LES is derived under the assumption that consumers maximise a Klein-Rubin utility function.

In Section 5 we discuss our econometric approach to estimating the systems of equations discussed in Section 4 (and associated PPP indexes). The maximum likelihood approach is straightforward. The Bayesian approach is useful if certain types of economic information (e.g., the fact that expenditure functions are non-decreasing in prices) need to be incorporated into the estimation process.

In Section 6 we describe an ICP panel data set and report maximum likelihood estimates of different PPP indexes. In Section 7 we apply the methodology to Ethiopian and Ugandan data sets. The paper is concluded in Section 8.

2. PPP Exchange Rates

The economic theory of purchasing power parity (PPP) states that a unit of currency should be able to purchase the same bundle of goods and services in different countries. The theory is based on the idea that, in the long run, exchange rates will adjust to eliminate opportunities for arbitrage (i.e., opportunities for making profits by buying bundles of goods and services in one country and selling them in another). To illustrate, suppose a product costs 150 yen in Japan and 100 dollars in Australia, and that the exchange rate is 2 yen = 1 dollar. After doing the currency conversion, Australian consumers would realize that the cost of the product in Japan is only 75 dollars and would want to exchange their dollars for yen so they could buy the product in Japan. If they do this on a large scale, the increased demand for yen would drive up the price of the yen until it reached 1.5 yen = 1 dollar. Mathematically, the theory states that

$$(1) \qquad E_{ij} = \frac{P_j}{P_i}$$

where E_{ij} is the currency exchange rate between countries *i* and *j*, and P_j is the price level in country *j*. Thus, the theory suggests that exchange rates can be used to measure inter-country differences in average price levels.

Unfortunately, there are several reasons why the theory of PPP might not hold: it assumes markets in both countries are competitive; it only applies to goods and services that are both tradable and transportable; no allowances are made for transportation or transactions costs; and it only says something about exchange rates and price levels in the long-run. Indeed, there is a body of empirical evidence suggesting that short-run violations of equation (1) are both large and persistent – see Taylor and Taylor (2004). For all these reasons, economists tend to deflate nominal values by price ratios (i.e., price indexes) instead of exchange rates when making international comparisons of economic aggregates.

The price index P_j / P_i in (1) is sometimes known as a PPP exchange rate, or simply PPP. Computing PPPs is clearly an index number problem. The next section describes how index numbers can be computed using data on prices and expenditure shares.

3. Common Index Number Formulas

Several formulas are available for computing PPPs. These formulas are usually assessed in terms of whether or not they satisfy the following properties:

P.1 Positivity
P.2 Continuity
P.3 Proportionality
P.4 Commensurability (Dimensional Invariance)

They are also assessed in terms of their ability to pass the following tests:

T.1 Time-reversal Test
T.2 Mean-value Test
T.3 Factor-reversal Test
T.4 Transitivity (Circularity) Test

Suppose there are *K* commodities consumed in *J* countries. The following well-known formulas can be used to compute the PPP index number for country *j* using country *i* as a base:

$$P_{ij}^{L} = \sum_{k=1}^{K}\left(\frac{p_{kj}}{p_{ki}} \times s_{ki}\right) \qquad \text{(Laspeyres)} \tag{2}$$

$$P_{ij}^{P} = \frac{1}{\sum_{k=1}^{K}\left(\frac{p_{ki}}{p_{kj}} \times s_{kj}\right)} \qquad \text{(Paasche)} \tag{3}$$

$$P_{ij}^{F} = \left[P_{ij}^{L} \times P_{ij}^{P}\right]^{1/2} \qquad \text{(Fisher)} \tag{4}$$

where p_{kj} and s_{kj} represent the price and expenditure share of commodity *k* in country *j*. Unfortunately, the Laspeyres and Paasche indexes fail the time-reversal, factor-reversal and transitivity tests. The Fisher index is "almost ideal" in the sense that it satisfies all standard properties and tests except the transitivity test.

The Laspeyres price index given by (2) is an example of a cost-of-living index. This terminology derives from the fact that the index can be written as the ratio of two costs:

$$P_{ij}^{L} = \frac{p_j' q_i}{p_i' q_i} \tag{5}$$

where $q_i = (q_{1i}, ..., q_{Ki})'$ is the vector of quantities purchased in country *i* and $p_i = (p_{1i}, ..., p_{Ki})'$ is the associated price vector. The denominator in this expression is the cost of purchasing the quantity vector q_i at the prices prevailing in country *i*, while the numerator is the cost of purchasing the same bundle of goods at the prices prevailing in country *j*. The Paasche and Fisher price indexes are also cost-of-living indexes – the Paasche index compares the cost of purchasing a different bundle of goods, namely q_j, at the prices prevailing in the two countries; the Fisher index is a cost-of-living index by virtue of the fact that it is the geometric average of the Paasche and Laspeyres indexes.

The fact that PPP price indexes can be viewed as ratios of costs suggests we should be able to compute PPPs as ratios of minimum expenditures. Suppose a consumer in country *i* solves the expenditure minimization problem:

$$e(p_i, u) = \min_{q_i}\left\{p_i' q_i : u(q_i) = u\right\} \tag{6}$$

where *u*(.) is a utility function representing a complete, reflexive, transitive and continuous preference ordering (e.g., Varian, 1992, p.95). The function $e(p_i, u)$ is formally known as an expenditure function and gives the minimum cost of achieving a fixed level of utility at given prices. It has the following properties:

E.1 Nondecreasing in prices;
E.2 Homogeneous of degree 1 in prices; and
E.3 Concave in prices.

When expressed in terms of the expenditure function, the PPP price index number for country *j* using country *i* as a base is:

$$P_{ij} = \frac{e(p_j, u)}{e(p_i, u)}. \tag{7}$$

Different functional forms for utility and expenditure functions give rise to different PPP indexes. For example, suppose the expenditure function is of the translog form:

$$\ln e(p_i,u) = \alpha_0 + \sum_{k=1}^{K} \alpha_k \ln p_{ki} + \beta \ln u + 0.5 \sum_{k=1}^{K} \sum_{l=1}^{K} \alpha_{kl} \ln p_{ki} \ln p_{li} + 0.5\delta (\ln u)^2 + \sum_{k=1}^{K} \gamma_k \ln p_{ki} \ln u \tag{8}$$

Then the PPP price index number is the well-known Tornqvist price index

$$P_{ij}^{T} = \prod_{k=1}^{K} \left[\frac{p_{kj}}{p_{ki}} \right]^{\frac{s_{ki}+s_{kj}}{2}} \qquad \text{(Tornqvist)} \tag{9}$$

where

$$s_{ki} \equiv \frac{\partial \ln e(p_i,u)}{\partial \ln p_{ki}} = \alpha_k + \sum_{l=1}^{K} \alpha_{kl} \ln p_{li} + \gamma_k \ln u \qquad k = 1, \ldots, K. \tag{10}$$

is the Hicksian expenditure share of commodity *k* in country *i*. Proofs are provided in Appendix A. At first glance, the practical usefulness of (10) appears to be limited by the fact that utility levels are unobserved. We resolve this issue in the following section.

4. Estimable Expenditure (Share) Systems and PPPs

In this section we explore the relationship between the Fisher and Tornqvist PPP indexes and estimable systems of expenditure (share) equations that are popular in the applied demand analysis literature.

We begin by noting that the quantities that solve the expenditure minimization problem (6) also solve the following utility maximization problem:

$$v(p_i,m) = \max_{q_i} \{ u(q_i) : p_i' q_i = m \} \tag{11}$$

where *m* denotes income. The function $v(p_i,m)$ is formally known as an indirect utility function. It gives the maximum utility that can be obtained from a fixed level of income at given prices. It is the mathematical inverse of the expenditure function and has the following properties:

V.1 Nondecreasing in prices;
V.2 Homogeneous of degree 0 in prices and income; and
V.3 Quasiconvex in prices.

The expenditure and indirect utility functions satisfy the following important identities:

I.1 $e(p_i, v(p_i,m)) \equiv m$
I.2 $v(p_i, e(p_i,u)) \equiv u$

Identity I.1 says that the minimum expenditure necessary to reach utility level $v(p_i,m)$ is *m*, while identity I.2 says that the maximum utility that can be achieved from income $e(p_i,u)$ is *u*. These identities allow us to

define the PPP exchange rate (7) in terms of the indirect utility function. Specifically, the PPP price index number for country *j* using country *i* as a base can be found as the solution to (see Appendix B)

$$(12) \qquad v(p_i, m) = v(p_j, P_{ij} m).$$

Again, different functional forms for utility and expenditure functions will give rise to different PPP indexes. Three functional forms are of special interest.

First, suppose the utility function is of the quadratic form:

$$(13) \qquad u(q_j) = a' q_j + 0.5 q_j' A q_j$$

where $a > 0$ and A is a symmetric negative definite matrix. Then the PPP price index number is

$$(14) \qquad P_{ij}^{Q} = \frac{p_j'\gamma}{m} + \left(1 - \frac{p_i'\gamma}{m}\right)\left(\frac{p_j' A^{-1} p_j}{p_i' A^{-1} p_i}\right)^{0.5} \qquad \text{(Quadratic)}$$

where $\gamma \equiv -A^{-1}a$. Importantly, if $\gamma = 0$ then the PPP index given by (14) collapses to the Fisher PPP index, with expenditure shares given by:

$$(15) \qquad s_j = \left(p_j \circ A^{-1} p_j\right)\left(p_j' A^{-1} p_j\right)^{-1}$$

where $\circ$ denotes the Hadamard (element-wise) product. Details are provided in Appendix C. Observe that the expenditure shares (15) are invariant with respect to income, with the undesirable implication that PPPs for the rich are identical to PPPs for the poor.

Second, suppose the utility function is of the Klein-Rubin form:

$$(16) \qquad u(q_j) = \sum_{k=1}^{K} \beta_k \ln(q_{kj} - \gamma_k)$$

where γ_k is the subsistence level of consumption for the *k*-th commodity. In order for the utility function to be well-behaved we require $q_{kj} \geq \gamma_k \geq 0$ and $\beta_k > 0$ for all *k*, and $\beta_1 + ... + \beta_K = 1$. In this case the PPP price index number is given by

$$(17) \qquad P_{ij}^{K} = \frac{p_j'\gamma}{m} + \left(1 - \frac{p_i'\gamma}{m}\right)\left(\prod_{k=1}^{K}\left(p_{kj}/p_{ki}\right)^{\beta_k}\right) \qquad \text{(Klein-Rubin)}$$

where $\gamma = (\gamma_1, ..., \gamma_K)'$. Details are provided in Appendix D. The *k*-th expenditure equation is

$$(18) \qquad p_{kj} q_{kj} = \gamma_k p_{kj} + \beta_k \left(m - p_j'\gamma\right) \qquad k = 1, \ldots, K.$$

This system of equations is the well-known linear expenditure system (LES).

Finally, we saw in Section 3 that a translog expenditure function gives rise to a Tornqvist PPP index, with expenditure shares given by equation (10). To obtain an empirically tractable version of (10), we note that there exists a value of *u* such that the consumer's income is $m = e(p_j, u)$. Inverting the translog expenditure function yields the indirect utility function

$$\ln v(p_j, m) = \frac{\ln m - \alpha_0 - \sum_{k=1}^{K} \alpha_k \ln p_{kj} - 0.5 \sum_{k=1}^{K} \sum_{l=1}^{K} \alpha_{kl} \ln p_{kj} \ln p_{lj}}{\beta + \sum_{k=1}^{K} \gamma_k \ln p_{kj}}. \tag{19}$$

Empirical share equations can then be obtained by evaluating (10) at the utility level $v(p_j, m)$:

$$s_{hj} = \alpha_h + \sum_{l=1}^{K} \alpha_{hl} \ln p_{lj} + \gamma_h \left(\frac{\ln m - \left[\alpha_0 + \sum_{k=1}^{K} \alpha_k \ln p_{kj} + 0.5 \sum_{k=1}^{K} \sum_{l=1}^{K} \alpha_{kl} \ln p_{kj} \ln p_{lj} \right]}{\beta + \sum_{k=1}^{K} \gamma_k \ln p_{kj}} \right) \tag{20}$$

If there exists a value λ such that

$$\sum_k \gamma_k \ln p_{kj} = \lambda \text{ for all } j \tag{21}$$

then (20) is observationally equivalent to the *h*-th share equation of the well-known Almost Ideal Demand system (AIDS). For estimation purposes, it is common to linearize the AIDS share equations by replacing the term in square brackets on the right-hand side of (20) with

$$\ln P_j \equiv \sum_{l=1}^{K} s_{hj} \ln p_{hj}. \tag{22}$$

The *h*-th share equation of the so-called Linearised Almost Ideal Demand system (LAIDS) takes the form

$$s_{hj} = \alpha_h + \sum_{l=1}^{K} \alpha_{hl} \ln p_{lj} + \theta_h \ln\left(\frac{m}{P_j} \right) \tag{23}$$

where $\theta_h \equiv \gamma_h / \beta$.

In the following section we discuss methodology for estimating the systems of expenditure (share) equations given by equations (15), (18) and (23).

5. Empirical Models

The econometric problem is to estimate the parameters of equations (15), (18) and/or (23) in such a way that the associated estimated expenditure and indirect utility functions are consistent with properties E.1 to E.3 and V.1 to V.3. This means, for example, that the estimated parameters in equation (15) should be consistent with *A* being a symmetric negative definite matrix, while the estimated parameters in (18) should be consistent with $q_{kj} \geq \gamma_k \geq 0$.

The parameters of consumer demand (or expenditure or share) equations are usually estimated in a systems framework (rather than as single equations) because they must satisfy cross-equation constraints. Importantly, if the demand system comprises *K* share equations (e.g., equations 15 and 23) or expenditure functions (e.g., equation 18) then the econometric model usually consists of only *K*-1 equations. The reason for this reduction in the number of equations is that when the dependent variables in a system of linear equations sum to the value of a variable that appears on the right-hand side (e.g., when share equations

include an intercept, or expenditure equations use total expenditure as a regressor), the covariance matrix of the disturbance vector is singular. Thus, unless one equation is deleted from the system, maximum likelihood estimation breaks down. Matters are only slightly more complicated in the case of nonlinear models. In this paper we estimate i) Fisher PPPs using *K*-1 of the equations given by (15) (there is no intercept, but the deterministic components on the right-hand sides of the share equations sum to 1); ii) Klein-Rubin PPPs using *K*-1 of the equations given by (18) (income appears on the right-hand side), and iii) Tornqvist PPPs using *K*-1 of the equations given by (23) (again, income appears on the right-hand side).

After introducing error terms to account for approximation and measurement errors, the estimating equations and parametric constraints for the Fisher Expenditure System (FES) are.

(15) $$s_{hj} = \frac{p_{hj}\sum_{l=1}^{K}\beta_{hl}\,p_{lj}}{\sum_{k=1}^{K}\sum_{l=1}^{K}\beta_{kl}\,p_{kj}\,p_{lj}} + \varepsilon_{kj} \qquad h = 1, \ldots, K\text{-}1.$$

(24) $$\left[\beta_{kl}\right]^{-1} = A \text{ is symmetric negative definite}$$

The estimating equations and parametric constraints for the Linear Expenditure System (LES) are.

(18) $$p_{kj}q_{kj} = \gamma_k\,p_{kj} + \beta_k\left(m - p_j'\gamma\right) + \varepsilon_{kj} \qquad k = 1, \ldots, K\text{-}1.$$

(25) $q_{kj} \geq \gamma_k$ for all k (observed consumption greater than the subsistence level)

(26) $\gamma_k \geq 0$ for all k. (subsistence level nonnegative)

(27) $\beta_k > 0$ for all k (positive marginal utility)

Finally, the estimating equations and parametric constraints for the Linearised Almost Ideal Demand System (LAIDS) are:

(23) $$s_{hj} = \alpha_h + \sum_{l=1}^{K}\alpha_{hl}\ln p_{lj} + \theta_h \ln\left(\frac{m}{P_j}\right) + \varepsilon_{hj} \qquad h = 1, \ldots, K\text{-}1.$$

(28) $$\begin{cases} \sum_{k=1}^{K}\alpha_k = 1 \\ \sum_{k=1}^{K}\alpha_{kl} = 0 \text{ for all } l & \text{(homogeneity)} \\ \sum_{k=1}^{K}\theta_k = 0 \end{cases}$$

(29) $\alpha_{kl} = \alpha_{lk}$ for all l, k. (symmetry)

(30) $A = \left[\alpha_{kl}\right]$ is negative semi-definite (negativity and curvature)

where $\ln P_j$ is defined by (22). In each systerm, the vector of error terms $\varepsilon_j = (\varepsilon_{1j},...,\varepsilon_{Kj})'$ is assumed to follow a multivariate normal distribution with mean vector zero and covariance matrix Σ. Maximum likelihood estimates can be obtained using iterative SUR.

6. Application – ICP Benchmark Data for 1985 and 1996

We estimated the FES, LES and LAIDS models using data for countries participating in the 1985 and 1996 rounds of the ICP. The data comprised observations by country on nominal annual expenditures and PPPs for the 8 broad commodity groups listed in Tables 1 and 2. For each year, the PPPs were interpreted as nominal prices under the unobjectionable assumption that all nominal prices in the reference country, the USA, were equal to one. This simply means that quantities are measured in units such that the price of each commodity in the USA is $1 per unit. The 1996 data set was chained to the 1995 data set using the US CPI index numbers reported in Table 1. Expenditures were converted to a per capita basis using population data available from the POPULSTAT site (http://www.populstat.info/) maintained by Jan Lehmeyer.

Table 2 provides descriptive statistics for expenditure shares in 1985 and 1996. The data set comprised 178 observations (63 countries in 1985; 115 countries in 1996) but only 172 were used for estimation purposes – data from three representative countries (the U.K., Pakistan and Nigeria) were kept back for model validation purposes.

Table 3 reports estimated parameters for the FES, along with the squared correlations between observed and predicted values of the dependent variables. No attempt was made to impose the curvature constraint given by equation (24). The parameters have no natural economic interpretation, so we simply observe that most of the coefficients are statistically significant at the 5% level. The R^2 statistics are low, possibly because the FES imposes the restriction that expenditure shares are not a function of income.

Table 3 reports results for the linear expenditure system (LES) (equation 18). Many of the coefficients are statistically significant at the 5% level, but they fail to satisfy the inequality restrictions given by equations (25) to (27). Recall that the γs can be interpreted as subsistence levels of consumption. Thus, only two estimated subsistence level parameters are correctly signed. As we shall see, this leads to predicted expenditure shares that lie outside the unit interval. The extremely high R^2 statistics may be partly due to the fact that the subsistence parameters are permitted to take theoretically implausible values. Note that these R^2 statistics cannot be compared with those reported in Table 2 (or Table 4) because the dependent variables differ.

Table 4 reports results for the linearized almost ideal demand system (LAIDS) (equation 23). The coefficient estimates were constrained to satisfy equations (28) and (29), but were not constrained to satisfy the inequality restrictions (30). Many of the estimated parameters are statistically significant at the 5% level. The R^2 statistics for the LAIDS are comparable to those for the FES. Note that the LAIDS model uses the index (21) as an explanatory variable, implying there is correlation between the explanatory variables and the error terms (endogeneity).

Table 5 reports observed and predicted shares for the three countries that were not included in the sample used for estimation purposes. The predicted shares from the FES and LAIDS models are theoretically plausible (lie within the unit interval) and of a similar order of magnitude to the observed shares.

The predicted expenditure shares obtained from the FES, LES and LAIDS models were used to compute Fisher, Klein-Rubin and Tornqvist PPPs respectively. Table 6 reports these predicted PPPs along with observed exchange rates (where available) and PPPs computed using observed shares. Exchange rates were sourced from Officer (2002).

7. Application – Household Expenditure Data from Ethiopia and Uganda

We also used Ethiopian and Ugandan data to estimate the parameters of the LES. Ethiopian data covering the period 1999-2000 was sourced from the Ethiopian Central Statistical Authority (ECSA) through the World Bank. The ECSA surveyed more than 14,000 households to collect data on the quantities and values of foodstuffs and drinks consumed at home (including own production and goods obtained for free). Limited

ECSA survey documentation was available so we could not confirm whether the data file recorded expenditures and quantities on an average weekly or a monthly basis. However, quantity comparisons with Ugandan data (see below) suggest that both variables were measured on a monthly basis. Expenditures were measured in Birr, while quantities were generally measured by the gram (e.g., grains and meats), cubic centimetre (e.g., beverages) or number of items (e.g., eggs, cigarettes). An item/product listing is provided in Table 7.

Ugandan data covering the period 1999-2000 was sourced from the Uganda Bureau of Statistics (UBS), again through the World Bank. The UBS surveyed more than 10,000 households to collect monthly expenditures and quantities consumed for 55 food and beverage items. Details concerning the survey design and data processing are available in UBS (2001). A listing of products and average prices is provided in Table 8.

For this paper we chose to aggregate expenditures and quantities into 37 commodity groups. The mapping is presented in Table 9. Aggregation was affected by converting all quantities units into kilograms, litres and numbers of items. Average expenditure (in local currency) and quantity consumed for each commodity group is reported by country in Table 10. Expenditures and quantities consumed were further aggregated into 12 commodity groups – average expenditures and quantities for these groups are reported in Table 11.

The commodity expenditure and quantity data reported in Tables 10 and 11 were used to construct PPP exchange rates using the Laspeyres, Paasche, Fisher and Tornqvist formula. The results are reported in the first two rows of Table 12. These index numbers are much lower than the average 1999/2000 exchange rate of 1 Birr = 190.53 schillings.

Data at the 12-item level was also used to estimate the parameters of the Fisher expenditure system (FES) and the Linear expenditure system (LES). Corresponding price indexes are reported in rows 3-5 in Table 12. The parameters of the FES have no economic interpretation and are not reported here. The estimated parameters of the LES are reported in Table 13. All parameters are statistically significant at usual levels of significance. Partly because of our experience with the ICP data, the γ coefficients were constrained to be non-negative (only the constraint on the fruits coefficient was binding).

8. Conclusion

The main objective of the paper is to devise a methodology for predicting expenditure shares for countries where such data are not available. The methodology developed here makes use of standard demand theory and derives estimable expenditure share equations for the Klein-Rubin and quadratic utility functions, as well as the translog expenditure function. The paper also provides a link between the estimated expenditure share equations and formulas for PPP exchange rate index numbers by deriving the index number formulas associated with the FES, LES and LAIDS demand systems. Once the expenditure share equations are estimated, it is possible to use the estimated parameters to predict expenditure shares for countries with price and income data. The methodology developed here is implemented on two data sets. The first data set comprised ICP data for the 1985 and 1996 benchmark years. Only aggregated data with eight broadly defined categories from private consumption were used in estimating various demand systems. Predictions were obtained for the United Kingdom, Pakistan and Nigeria – observations on these countries had been dropped from the sample prior to the estimation of the demand systems. The results obtained are very encouraging both in terms of the predicted shares and the resulting estimates of PPPs derived. The second data set consisted of household expenditure data from Ethiopia and Uganda, and the paper reports estimated PPPs associated with the standard Laspeyres, Paasche, Fisher and Tornqvist indexes.

Further work on this project will include the imposition of inequality constraints on the parameters of the various demand systems in a Bayesian framework. The Bayesian approach will also generate measures of reliability that are valid in finite samples.

References

Balk, B.M. (1981) “Second Thoughts on Wald’s Cost-of-Living Index and Frisch’s Double Expenditure method“ *Econometrica* 49(6):1553-1558.

Diewert, W.E. (1976) “Exact and Superlative Index Numbers“, *Journal of Econometrics* 4(2):115-145.

Konüs, A.A. and S.S. Byushgens (1926) “K Probleme pokupatelnoi cili deneg” (English translation of Russian title is “On the Problem of the Purchasing Power of Money”) *Voprosi Konyunkturi* II(1) (supplement to the Economic Bulletin of the Conjecture Institute):151-172.

Officer, L.H. (2002), "Exchange rate between the United States dollar and forty other countries, 1913 -1999." Economic History Services, EH.Net, 2002. URL: http://eh.net/hmit/exchangerates/

Taylor, A.M. and M.P. Taylor (2004) “The Purchasing Power Parity Debate” NBER Working Paper 10607. http://www.nber.org/papers/w10607.

Wegge, L.L. (1968) “The Demand Curves from a Quadratic Utility Indicator” *The Review of Economic Studies* 35(2):209-224.

Appendix A

The quadratic approximation lemma (Diewert, 1976, p.118,138) states that if and only if

(A1) $$f(z_1,...,z_K) = a_0 + \sum_{k=1}^{K} a_k z_k + \sum_{k=1}^{K}\sum_{l=1}^{K} a_{kl} z_k z_l$$

then

(A2) $$f(z_1^1,...,z_K^1) - f(z_1^0,...,z_K^0) = 0.5\sum_{k=1}^{K}\left[f_k(z_1^1,...,z_K^1) + f_k(z_1^1,...,z_K^1)\right]\left[z_k^1 - z_k^0\right]$$

where

(A3) $$f_k(z_1,...,z_K) \equiv \frac{\partial f(z_1,...,z_K)}{\partial z_k} = a_k + \sum_{l=1}^{K} a_{kl} z_l \ .$$

In the context of a translog functional form, the quadratic approximation lemma states that if and only if

(A4) $$f(\ln z_1,...,\ln z_K) = a_0 + \sum_{k=1}^{K} a_k \ln z_k + \sum_{k=1}^{K}\sum_{l=1}^{K} a_{kl} \ln z_k \ln z_l$$

then

(A5) $$f(\ln z_1^1,...,\ln z_K^1) - f(\ln z_1^0,...,\ln z_K^0) = 0.5\sum_{k=1}^{K}\left[f_k(\ln z_1^1,...,\ln z_K^1) + f_k(\ln z_1^1,...,\ln z_K^1)\right]\left[\ln z_k^1 - \ln z_k^0\right]$$

where

(A6) $$f_k(\ln z_1,...,\ln z_K) \equiv \frac{\partial f(\ln z_1,...,\ln z_K)}{\partial \ln z_k} = a_k + \sum_{l=1}^{K} a_{kl} \ln z_l \ .$$

Thus, if the expenditure function is translog:

(A7) $$\ln e(p_j,u) = \alpha_0 + \sum_{k=1}^{K} \alpha_k \ln p_{kj} + \beta \ln u + 0.5\sum_{k=1}^{K}\sum_{l=1}^{K} \alpha_{kl} \ln p_{kj} \ln p_{lj} + 0.5\delta(\ln u)^2 + \sum_{k=1}^{K} \gamma_k \ln p_{kj} \ln u$$

(A8) $$\ln e(p_i,u) = \alpha_0 + \sum_{k=1}^{K} \alpha_k \ln p_{ki} + \beta \ln u + 0.5\sum_{k=1}^{K}\sum_{l=1}^{K} \alpha_{kl} \ln p_{ki} \ln p_{li} + 0.5\delta(\ln u)^2 + \sum_{k=1}^{K} \gamma_k \ln p_{ki} \ln u$$

and

(A9) $$\ln e(p_j,u) - \ln e(p_i,u) = 0.5\sum_{k=1}^{K}\left[s_{kj} + s_{kj}\right]\left[\ln p_{kj} - \ln p_{ki}\right]$$

where

(A10) $$s_{kj} \equiv \frac{\partial \ln e(p_j,u)}{\partial \ln p_{kj}} = \alpha_k + \sum_{l=1}^{K} \alpha_{kl} \ln p_{lj} + \gamma_k \ln u \ .$$

Moroever, from (A9)

$$\text{(A11)} \quad \frac{e(p_j,u)}{e(p_i,u)} = \prod_{k=1}^{K}\left[\frac{p_{kj}}{p_{ki}}\right]^{\frac{s_{ki}+s_{kj}}{2}}$$

Thus, if the expenditure function is translog the PPP index is a Tornqvist index. Diewert (1976) proves the quadratic approximation lemma which, incidentally, does not involve any approximation. It is straightforward to show that (A11) holds for any expenditure function of the form:

$$\text{(A12)} \quad \ln e(p_j,u) = \alpha_0 + \sum_{k=1}^{K}\alpha_k \ln p_{kj} + 0.5\sum_{k=1}^{K}\sum_{l=1}^{K}\alpha_{kl}\ln p_{kj}\ln p_{lj} + h(u)\sum_{k=1}^{K}\gamma_k \ln p_{kj}$$

where $h(.)$ is any monotonic function.

Appendix B

Identity I.2 implies

$$\text{(B1)} \quad v\left(p_i, e(p_i,u)\right) = v\left(p_j, e(p_j,u)\right)$$
$$= v\left(p_j, P_{ij}e(p_i,u)\right) \qquad \text{using (7)}$$

It follows that

$$\text{(12)} \quad v\left(p_i, m\right) = v\left(p_j, P_{ij}m\right)$$

where m denotes the minimum expenditure required to achieve utility level u at prices p_i.

Appendix C

The quadratic utility function is

$$\text{(13)} \quad u(q_j) = a'q_j + 0.5q_j'Aq_j$$

The Lagrangean for the utility maximization problem (11) is

$$\text{(C1)} \quad L = a'q_j + 0.5q_j'Aq_j + \lambda\left(m - p_j'q_j\right)$$

The first-order conditions are

$$\text{(C2)} \quad \frac{\partial L}{\partial q_j} = a + Aq_j - \lambda p_j = 0$$

and

$$\text{(C3)} \quad \frac{\partial L}{\partial \lambda} = m - p_j'q_j = 0$$

Rearranging (C2):

(C4) $q_j = \lambda A^{-1} p_j - A^{-1} a$

Substituting (C4) into (C3) and re-arranging:

(C5) $\lambda = \left(p_j' A^{-1} p_j \right)^{-1} \left(m + p_j' A^{-1} a \right)$

Finally, substituting (C5) back into (C4) yields the Marshallian demands (e.g., Wegge, 1968, p.209):

(C6) $q_j = \left(p_j' A^{-1} p_j \right)^{-1} \left(m + p_j' A^{-1} a \right) A^{-1} p_j - A^{-1} a$

The associated indirect utility function is

(C7) $v(p_{1j}, ..., p_{Kj}, m) = 0.5 \left(p_j' A^{-1} p_j \right)^{-1} \left(m + p_j' A^{-1} a \right)^2 - 0.5 a' A^{-1} a$

Equation (12) in the main text implies the PPP price index solves

(C8) $0.5 \left(p_i' A^{-1} p_i \right)^{-1} \left(m + p_i' A^{-1} a \right)^2 - 0.5 a' A^{-1} a = 0.5 \left(p_j' A^{-1} p_j \right)^{-1} \left(P_{ij} m + p_j' A^{-1} a \right)^2 - 0.5 a' A^{-1} a$

The solution is:

(C9) $P_{ij}^Q = \left(1 + \frac{p_i' A^{-1} a}{m} \right) \left(\frac{p_j' A^{-1} p_j}{p_i' A^{-1} p_i} \right)^{0.5} - \frac{p_j' A^{-1} a}{m}$

or, using the notation of Balk (1981, p.1554),

(C10) $P_{ij}^Q = \frac{p_j' \gamma}{m} + \left(1 - \frac{p_i' \gamma}{m} \right) \left(\frac{p_j' A^{-1} p_j}{p_i' A^{-1} p_i} \right)^{0.5}$

where $\gamma \equiv -A^{-1} a$. Finally, if $\gamma = 0$ then the Marshallian demands are:

(C12) $q_j = A^{-1} p_j \left(p_j' A^{-1} p_j \right)^{-1} m$

and the associated PPP index is

(C13) $P_{ij} = \left(\frac{p_j' A^{-1} p_j}{p_i' A^{-1} p_i} \right)^{0.5}$

or, using (C12):

(C14) $P_{ij} = \left[\frac{p_j' q_j}{p_i' q_j} \frac{p_j' q_i}{p_i' q_i} \right]^{0.5} = P_{ij}^F$

Thus, if the utility function is the quadratic function (13) with the property $A^{-1}a = 0$ then the PPP index number is equal to the Fisher index (Konüs and Byushgens, 1926). In this case, the Marshallian expenditure shares are

$$(15) \qquad s_j = \left(p_j \circ A^{-1} p_j \right) \left(p_j' A^{-1} p_j \right)^{-1}$$

where $\circ$ is the Hadamard (element-wise) product.

Appendix D

For a utility function of Klein-Rubin form,

$$(16) \qquad u(q_j) = \sum_{k=1}^{K} \beta_k \ln(q_{kj} - \gamma_k)$$

the Lagrangean for the utility maximization problem (11) is

$$(D1) \qquad L = \sum_{k=1}^{K} \beta_k \ln(q_{kj} - \gamma_k) + \lambda \left(m - \sum_{k=1}^{K} p_{kj} q_{kj} \right)$$

The first-order conditions are

$$(D2) \qquad \frac{\partial L}{\partial q_{kj}} = \frac{\beta_k}{q_{kj} - \gamma_k} - \lambda p_{kj} = 0$$

and

$$(D3) \qquad \frac{\partial L}{\partial \lambda} = m - \sum_{k=1}^{K} p_{kj} q_{kj} = 0$$

Rearranging (D2):

$$(D4) \qquad q_{kj} = \gamma_k + \frac{\beta_k}{\lambda p_{kj}}$$

Substituting (D4) into (D3) and re-arranging:

$$(D5) \qquad \lambda = \left(m - \sum_{k=1}^{K} p_{kj} \gamma_k \right)^{-1}$$

where we have used the constraint $\sum_k \beta_k = 1$. Finally, substituting (D5) back into (D4) yields the Marshallian demands:

$$(D6) \qquad q_{kj} = \gamma_k + \frac{\beta_k}{p_{kj}} \left(m - \sum_{h=1}^{K} p_{hj} \gamma_h \right)$$

The associated indirect utility function is

(D7) $$v(p_{1j},...,p_{Kj},m)=\sum_{k=1}^{K}\beta_k\ln\beta_k-\sum_{k=1}^{K}\beta_k\ln p_{kj}+\sum_{k=1}^{K}\beta_k\ln\left(m-\sum_{h=1}^{K}p_{hj}\gamma_h\right)$$

Equation (12) in the main text implies the PPP price index solves

(D8) $$\sum_{k=1}^{K}\beta_k\ln p_{ki}+\sum_{k=1}^{K}\beta_k\ln\left(m-\sum_{h=1}^{K}p_{hi}\gamma_h\right)=\sum_{k=1}^{K}\beta_k\ln p_{kj}+\sum_{k=1}^{K}\beta_k\ln\left(P_{ij}m-\sum_{h=1}^{K}p_{hj}\gamma_h\right)$$

$$\sum_{k=1}^{K}\beta_k\ln\frac{p_{ki}}{p_{kj}}=\sum_{k=1}^{K}\beta_k\ln\left(P_{ij}m-\sum_{h=1}^{K}p_{hj}\gamma_h\right)-\sum_{k=1}^{K}\beta_k\ln\left(m-\sum_{h=1}^{K}p_{hj}\gamma_h\right)$$

$$\sum_{k=1}^{K}\beta_k\ln\frac{p_{ki}}{p_{kj}}=\ln m\left(P_{ij}-\frac{p_j'\gamma}{m}\right)-\ln m\left(1-\frac{p_i'\gamma}{m}\right)$$

$$\sum_{k=1}^{K}\beta_k\ln\frac{p_{ki}}{p_{kj}}=\ln\left[\left(P_{ij}-\frac{p_j'\gamma}{m}\right)\Big/\left(1-\frac{p_i'\gamma}{m}\right)\right]$$

The solution is:

(17) $$P_{ij}^{K}=\frac{p_j'\gamma}{m}+\left(1-\frac{p_i'\gamma}{m}\right)\left(\prod_{k=1}^{K}\left(p_{kj}/p_{ki}\right)^{\beta_k}\right)$$

Finally, from (D6), the *k*-th expenditure equation is:

(18) $$p_{kj}q_{kj}=p_{kj}\gamma_k+\beta_k\left(m-\sum_{h=1}^{K}p_{hj}\gamma_h\right)$$

Table 1. US CPI By Category (1984 = 100)

	Commodity	1985	1996
1	Food, Beverages and Tobacco	105.6	153.7
2	Clothing and footwear	105.0	131.7
3	Gross Rents, Fuel and Power	107.7	152.8
4	Household Equip. & Operation	103.8	124.7
5	Medical care	113.5	228.2
6	Transport and Communication	106.4	143.0
7	Recreation and Education	107.6	156.9
8	Misc. Goods & Services	114.5	215.4

Table 2. Descriptive Statistics for Expenditure Shares

	Commodity	1985 (N = 63)				1996 (N = 115)			
		Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
1	Food, Beverages and Tobacco	0.3592	0.1521	0.1279	0.6757	0.3566	0.1682	0.0973	0.7351
2	Clothing and footwear	0.0765	0.0267	0.0383	0.1517	0.0685	0.0274	0.0030	0.1490
3	Gross Rents, Fuel and Power	0.1353	0.0479	0.0452	0.2557	0.1372	0.0591	0.0145	0.3052
4	Household Equip. & Operation	0.0657	0.0252	0.0213	0.1521	0.0609	0.0269	0.0148	0.1521
5	Medical care	0.0636	0.0319	0.0096	0.1388	0.0696	0.0358	0.0067	0.1755
6	Transport and Communication	0.1015	0.0384	0.0202	0.1878	0.1031	0.0409	0.0104	0.1998
7	Recreation and Education	0.1131	0.0477	0.0209	0.2615	0.1083	0.0498	0.0101	0.2125
8	Misc. Goods & Services	0.0851	0.0525	0.0101	0.2330	0.0958	0.0532	0.0091	0.2386

Table 2. Estimated Fisher Expenditure System (FES)

Coefficient	Estimate	Asy. St. Error	Asy. t-ratio
B11	19.893*	4.392	4.529
B12	4.829	6.935	0.696
B13	7.380*	1.944	3.796
B14	-0.639	2.399	-0.266
B15	0.714	3.786	0.188
B16	3.548*	1.392	2.549
B17	5.043*	2.040	2.471
B18	2.837	2.983	0.951
B22	-6.464	3.425	-1.888
B23	2.146	1.680	1.277
B24	1.786	1.588	1.124
B25	2.603	2.915	0.893
B26	0.517	1.109	0.466
B27	2.369	1.476	1.604
B28	3.399	1.978	1.718
B33	-7.719*	2.482	-3.110
B34	4.495*	1.158	3.881
B35	3.921*	1.543	2.542
B36	5.081*	1.741	2.918
B37	5.906	4.356	1.356
B38	3.473*	1.347	2.578
B44	-2.812*	1.056	-2.662
B45	2.406*	1.143	2.106
B46	1.009	0.626	1.613
B47	3.158*	0.967	3.267
B48	1.920*	0.722	2.658
B55	-6.087*	2.408	-2.528
B56	2.426*	1.001	2.424
B57	2.874	1.492	1.927
B58	2.928*	1.187	2.466
B66	-3.970*	0.751	-5.289
B67	4.711*	1.100	4.281
B68	2.217*	0.784	2.830
B77	-11.865*	4.732	-2.508
B78	5.331*	1.147	4.648
B88	-7.571	4.085	-1.854
R-SQ-S1	0.270		
R-SQ-S2	0.018		
R-SQ-S3	0.086		
R-SQ-S4	0.242		
R-SQ-S5	0.042		
R-SQ-S6	0.049		
R-SQ-S7	0.090		
LOG-L	2282.934		

* Statistically significant at the 5% level.

Table 3. Estimated Linear Expenditure System (LES)

Coefficient	Estimate	Asy. St. Error	Asy. t-ratio
B1	0.171*	0.016	10.685
B2	0.067	0.044	1.529
B3	0.251*	0.047	5.310
B4	0.128*	0.029	4.406
B5	0.053	0.035	1.524
B6	0.118*	0.036	3.325
B7	0.094*	0.048	1.987
G1	413.740*	1.182	350.170
G2	40.583*	0.484	83.873
G3	-47.900*	1.223	-39.156
G4	-6.447*	0.714	-9.026
G5	-30.029*	0.788	-38.105
G6	-0.328	1.138	-0.288
G7	-64.861*	2.033	-31.900
G8	-61.777*	1.927	-32.059
R-SQ-E1	0.9991		
R-SQ-E2	0.9991		
R-SQ-E3	0.9955		
R-SQ-E4	0.9954		
R-SQ-E5	0.9502		
R-SQ-E6	0.9994		
R-SQ-E7	0.9816		
LOG_L	-14505.84		

* Statistically significant at the 5% level.

Table 4. Estimated Linearised Almost Ideal Demand System (LAIDS)

Coefficient	Estimate	Asy. St. Error	Asy. t-ratio
A1	1.176*	0.055	21.583
A11	0.108*	0.029	3.746
A12	-0.014	0.011	-1.334
A13	-0.025*	0.009	-2.774
A14	-0.041*	0.011	-3.661
A15	-0.001	0.008	-0.122
A16	-0.004	0.012	-0.327
A17	-0.013	0.011	-1.218
A2	0.136*	0.020	6.922
A22	0.003	0.007	0.431
A23	0.000	0.004	-0.081
A24	0.001	0.005	0.184
A25	0.002	0.004	0.585
A26	-0.005	0.005	-0.924
A27	0.000	0.005	-0.042
A3	-0.041	0.028	-1.453
A33	0.017*	0.006	3.059
A34	0.007	0.004	1.734
A35	0.005	0.003	1.615
A36	0.005	0.005	1.053
A37	-0.007	0.006	-1.229
A4	0.067*	0.017	3.858
A44	0.024*	0.008	2.936
A45	0.005	0.004	1.266
A46	0.001	0.005	0.220
A47	0.002	0.006	0.405
A5	-0.111*	0.016	-6.728
A55	-0.007	0.004	-1.612
A56	-0.001	0.004	-0.174
A57	-0.008	0.004	-1.804
A6	-0.018	0.023	-0.780
A66	0.003	0.007	0.368
A67	0.002	0.006	0.277
A7	-0.085*	0.026	-3.300
A77	0.022*	0.009	2.548
G1	-0.110*	0.007	-16.707
G2	-0.008*	0.002	-3.550
G3	0.024*	0.003	7.068
G4	0.001	0.002	0.427
G5	0.023*	0.002	11.639
G6	0.016*	0.003	5.791
G7	0.026*	0.003	8.271
R-SQ-S1	0.734		
R-SQ-S2	0.071		
R-SQ-S3	0.380		
R-SQ-S4	0.231		
R-SQ-S5	0.489		
R-SQ-S6	0.231		
R-SQ-S7	0.377		
LOG-L	2475.847		

* Statistically significant at the 5% level.

Table 5. Observed and Predicted Expenditure Shares

	I	T	S1	S2	S3	S4	S5	S6	S7	S8
Observed	Nigeria	1985	0.664	0.061	0.053	0.037	0.037	0.037	0.077	0.034
LES	Nigeria	1985	1.081	0.058	0.009	0.004	-0.027	0.015	-0.031	-0.109
FES	Nigeria	1985	0.553	0.074	0.069	0.041	0.051	0.074	0.071	0.066
LAIDS	Nigeria	1985	0.576	0.081	0.083	0.045	0.035	0.074	0.062	0.044
Observed	Pakistan	1985	0.426	0.063	0.163	0.043	0.010	0.131	0.101	0.064
LES	Pakistan	1985	0.639	0.076	0.106	0.069	0.028	0.073	-0.026	0.036
FES	Pakistan	1985	0.378	0.060	0.171	0.074	0.020	0.118	0.111	0.068
LAIDS	Pakistan	1985	0.446	0.065	0.112	0.065	0.052	0.093	0.104	0.063
Observed	U.K.	1985	0.164	0.061	0.173	0.057	0.078	0.140	0.141	0.185
LES	U.K.	1985	0.222	0.070	0.237	0.122	0.049	0.114	0.082	0.104
FES	U.K.	1985	0.311	0.071	0.140	0.073	0.058	0.122	0.127	0.098
LAIDS	U.K.	1985	0.203	0.061	0.168	0.072	0.094	0.124	0.151	0.126
Observed	Nigeria	1996	0.730	0.046	0.117	0.035	0.013	0.023	0.023	0.012
LES	Nigeria	1996	1.915	0.083	-0.189	-0.072	-0.083	-0.050	-0.325	-0.279
FES	Nigeria	1996	0.465	0.072	0.106	0.052	0.050	0.074	0.090	0.091
LAIDS	Nigeria	1996	0.630	0.087	0.066	0.047	0.011	0.066	0.065	0.027
Observed	Pakistan	1996	0.470	0.077	0.208	0.061	0.040	0.039	0.057	0.048
LES	Pakistan	1996	0.541	0.078	0.158	0.088	0.016	0.086	0.013	0.020
FES	Pakistan	1996	0.310	0.062	0.133	0.067	0.077	0.110	0.139	0.102
LAIDS	Pakistan	1996	0.423	0.074	0.123	0.068	0.047	0.095	0.099	0.070
Observed	U.K.	1996	0.164	0.049	0.162	0.053	0.087	0.140	0.152	0.194
LES	U.K.	1996	0.217	0.069	0.238	0.123	0.049	0.114	0.085	0.105
FES	U.K.	1996	0.351	0.078	0.141	0.057	0.069	0.101	0.113	0.090
LAIDS	U.K.	1996	0.205	0.064	0.171	0.061	0.097	0.125	0.146	0.132

Table 6. PPPs

Obs	Country	I	Year	Exch Rate	ICP PPP	Using Observed Shares				Using Predicted Shares					
						Laspeyres	Paasche	Fisher	Tornqvist	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin (USA income)	Klein-Rubin (Country Income)
1	Germany	1	1985	2.94	2.543	2.610	2.505	2.557	2.499	2.568	2.539	2.553	2.556	2.585	2.583
2	France	2	1985	8.98	7.394	7.681	7.188	7.431	7.267	7.637	7.446	7.541	7.429	7.625	7.615
3	Italy	3	1985	1908.90	1304.000	1342.995	1294.400	1318.473	1283.282	1359.918	1310.644	1335.053	1314.496	1290.375	1296.408
4	Netherlands	4	1985	3.32	2.504	2.559	2.434	2.496	2.460	2.557	2.510	2.533	2.493	2.542	2.541
5	Belgium	5	1985	59.34	45.580	47.279	44.263	45.746	44.925	47.833	46.232	47.026	45.694	46.813	46.884
6	Luxembourg	6	1985		43.540	45.280	44.155	44.714	43.214	45.544	44.176	44.855	44.594	44.706	44.645
7	U.K.	7	1985	0.77	0.568	0.592	0.559	0.575	0.560	0.597	0.570	0.583	0.573	0.578	0.575
8	Ireland	8	1985	0.94	0.748	0.769	0.729	0.749	0.729	0.789	0.740	0.764	0.743	0.740	0.719
9	Denmark	9	1985	10.60	10.221	10.503	10.119	10.309	10.183	10.618	10.378	10.498	10.287	10.244	10.287
10	Greece	10	1985	138.40	78.160	78.990	81.059	80.018	77.394	81.210	79.142	80.169	79.758	80.433	80.687
11	Spain	11	1985	169.98	92.460	99.534	90.822	95.078	94.078	102.252	95.659	98.900	95.156	90.685	91.559
12	Portugal	12	1985	172.07	70.380	73.384	68.749	71.029	70.772	80.115	69.835	74.799	70.709	62.285	64.028
13	Austria	13	1985	20.68	17.290	17.842	17.167	17.501	17.130	18.008	17.511	17.758	17.464	17.460	17.508
14	Finland	14	1985	6.20	6.384	6.548	6.261	6.403	6.333	6.884	6.649	6.765	6.394	6.380	6.437
15	Norway	15	1985	8.59	9.189	9.565	8.925	9.239	9.234	10.000	9.703	9.851	9.241	9.214	9.304
16	Sweden	16	1985	8.60	8.179	8.411	7.877	8.140	8.316	9.044	8.946	8.995	8.152	8.429	8.531
17	Australia	17	1985	1.43	1.231	1.270	1.226	1.248	1.244	1.237	1.228	1.233	1.247	1.251	1.252
18	New Zealand	18	1985	2.01	1.301	1.344	1.302	1.323	1.300	1.349	1.280	1.314	1.322	1.324	1.323
19	Japan	19	1985	238.47	212.900	218.883	205.290	211.977	217.825	235.595	231.220	233.398	212.491	218.604	221.603
20	Canada	20	1985	1.37	1.234	1.225	1.254	1.239	1.238	1.267	1.264	1.266	1.238	1.263	1.263
21	U.S.A.	21	1985	1.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
22	Turkey	22	1985		176.800	164.333	182.897	173.367	172.273	173.953	166.817	170.347	172.273	173.449	174.601
23	Poland	23	1985		73.260	74.741	70.138	72.403	79.548	83.026	72.842	77.767	71.089	61.872	63.809
24	Hungary	24	1985		17.020	17.395	14.668	15.974	17.849	18.592	16.059	17.279	15.747	15.024	15.244
25	Yugoslavia	25	1985		103.200	101.381	94.813	98.042	106.172	108.916	97.510	103.056	96.884	94.342	95.934
26	Hong Kong	26	1985	7.79	4.110	4.649	4.349	4.497	4.735	4.761	4.639	4.700	4.475	4.818	4.820
27	Iran	27	1985		61.550	60.959	64.163	62.540	65.372	69.334	66.775	68.043	62.298	62.777	63.839
28	Korea	28	1985	861.89	428.100	440.932	479.251	459.693	464.687	482.561	482.209	482.385	459.400	446.677	454.194
29	Thailand	29	1985	27.19	7.252	7.316	8.060	7.679	7.763	8.031	7.549	7.786	7.652	7.564	7.586
30	Sri Lanka	30	1985	27.19	6.350	6.082	7.336	6.680	6.594	6.963	6.806	6.884	6.566	6.577	6.487

Table 6. cont.

Obs	Country	I	Year	Exch Rate	ICP PPP	Using Observed Shares				Using Predicted Shares					
						Laspeyres	Paasche	Fisher	Tornqvist	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin (USA income)	Klein-Rubin (Country Income)
31	Philippines	31	1985	18.61	5.617	7.063	6.561	6.807	6.017	7.168	6.124	6.625	6.434	6.717	6.693
32	Pakistan	32	1985		3.731	3.892	4.254	4.069	3.825	4.287	4.035	4.159	3.857	4.094	4.004
33	Bangladesh	33	1985		5.933	5.054	6.889	5.901	5.627	6.029	5.900	5.964	5.863	5.801	5.510
34	India	34	1985	12.33	4.071	4.143	4.648	4.388	3.910	4.582	4.324	4.451	4.343	4.488	4.178
35	Benin	35	1985		87.500	100.268	85.719	92.708	81.853	105.183	89.732	97.151	92.235	83.711	85.417
36	Cameroon	36	1985		129.100	138.197	124.692	131.271	122.613	149.335	137.464	143.277	131.480	132.926	135.295
37	Congo	37	1985		160.800	168.133	163.420	165.760	149.445	188.696	171.168	179.718	167.239	161.947	162.849
38	Cote d'Ivoire	38	1985		152.800	162.003	152.421	157.139	124.720	163.366	143.510	153.116	152.569	146.758	147.918
39	Madagascar	39	1985		234.000	209.810	231.271	220.279	205.793	243.683	219.847	231.458	222.382	199.333	205.433
40	Mali	40	1985		169.600	152.642	172.396	162.219	146.173	172.526	158.926	165.586	160.844	149.492	152.729
41	Morocco	41	1985		2.097	2.194	2.137	2.165	1.991	2.368	2.162	2.263	2.172	2.125	2.049
42	Rwanda	42	1985		34.930	38.819	34.979	36.849	33.518	40.490	35.646	37.991	36.025	36.723	36.946
43	Senegal	43	1985		130.200	124.847	130.700	127.740	120.100	139.010	132.716	135.826	129.610	118.022	120.952
44	Tunisia	44	1985		0.243	0.258	0.241	0.249	0.226	0.267	0.250	0.258	0.248	0.295	0.247
45	Botswana	45	1985		0.480	0.586	0.479	0.530	0.495	0.601	0.539	0.570	0.522	0.623	0.515
46	Egypt	46	1985		0.236	0.227	0.232	0.229	0.219	0.258	0.246	0.252	0.233	0.357	0.200
47	Ethiopia	47	1985		0.738	0.693	0.742	0.717	0.652	0.777	0.713	0.744	0.726	1.686	0.679
48	Kenya	48	1985		4.178	4.601	4.166	4.378	3.988	4.909	4.426	4.661	4.402	4.384	4.167
49	Malawi	49	1985		0.405	0.475	0.413	0.443	0.367	0.467	0.409	0.437	0.435	0.482	0.444
50	Mauritius	50	1985		2.243	3.085	2.022	2.498	2.430	3.298	2.916	3.101	2.590	2.584	2.578
51	Nigeria	51	1985		0.861	0.687	0.817	0.749	0.620	0.803	0.757	0.780	0.756	1.193	0.631
52	Sierra Leone	52	1985		1.876	2.236	1.734	1.969	1.606	2.371	1.821	2.078	1.982	2.273	1.765
53	Swaziland	53	1985		0.524	0.549	0.557	0.553	0.439	0.603	0.562	0.582	0.552	0.663	0.517
54	Tanzania	54	1985		13.520	13.590	12.588	13.079	11.186	16.005	12.587	14.194	12.885	12.079	11.231
55	Zambia	55	1985		0.860	1.001	0.831	0.912	0.898	1.153	1.027	1.088	0.918	1.455	0.914
56	Zimbabwe	56	1985		0.460	0.540	0.448	0.492	0.437	0.548	0.497	0.522	0.493	0.580	0.461
57	Bahamas	57	1985		0.374	0.420	0.289	0.348	0.328	0.421	0.374	0.397	0.347	0.364	0.358
58	Barbados	58	1985		0.702	0.745	0.646	0.694	0.605	0.756	0.695	0.725	0.696	0.662	0.656
59	Grenada	59	1985		0.839	0.883	0.762	0.820	0.725	0.906	0.823	0.864	0.821	0.817	0.794
60	Jamaica	60	1985		1.162	1.363	1.254	1.307	1.067	1.321	1.193	1.256	1.297	1.167	1.159

Table 6. cont.

Obs	Country	I	Year	Exch Rate	ICP PPP	Using Observed Shares				Using Predicted Shares					
						Laspeyres	Paasche	Fisher	Tornqvist	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin (USA income)	Klein-Rubin (Country Income)
61	St Lucia	61	1985		0.694	0.730	0.629	0.678	0.617	0.746	0.669	0.706	0.677	0.662	0.625
62	Suriname	62	1985		0.569	0.646	0.576	0.610	0.515	0.625	0.592	0.608	0.605	0.592	0.590
63	Trinidad &Tobago	63	1985		0.976	1.017	0.844	0.927	0.839	1.039	0.950	0.994	0.922	0.929	0.927
64	Germany	1	1996		2.010	3.201	3.137	3.169	2.873	3.145	3.108	3.127	3.168	3.144	3.140
65	France	2	1996		7.080	10.868	10.480	10.672	9.693	10.788	10.616	10.702	10.659	10.669	10.666
66	Italy	3	1996		1657.610	2498.404	2458.206	2478.223	2237.298	2580.607	2546.347	2563.420	2479.451	2409.755	2431.759
67	Netherlands	4	1996		2.070	3.244	3.166	3.205	2.886	3.193	3.133	3.163	3.206	3.195	3.192
68	Belgium	5	1996		38.530	59.241	58.084	58.659	53.107	59.667	59.111	59.388	58.648	58.426	58.571
69	Luxembourg	6	1996		38.440	61.664	60.287	60.971	55.022	61.654	60.859	61.255	60.973	59.489	59.543
70	United Kingdom	7	1996		0.680	1.040	1.031	1.035	0.937	1.058	1.040	1.049	1.036	1.014	1.013
71	Ireland	8	1996		0.730	1.095	1.073	1.084	0.981	1.117	1.091	1.104	1.084	1.062	1.055
72	Denmark	9	1996		9.090	13.688	13.297	13.491	12.385	13.776	13.543	13.659	13.496	13.012	13.082
73	Greece	10	1996		235.640	355.359	362.215	358.770	325.542	368.847	355.332	362.027	358.607	350.536	353.085
74	Spain	11	1996		129.130	199.707	203.259	201.475	177.649	199.932	197.528	198.726	201.482	191.970	192.564
75	Portugal	12	1996		129.870	206.613	205.723	206.168	183.942	211.892	204.481	208.153	205.807	195.447	197.458
76	Austria	13	1996		14.680	22.186	21.812	21.998	19.740	21.640	21.341	21.490	22.005	20.958	20.943
77	Finland	14	1996		6.640	9.967	9.706	9.836	8.839	10.050	9.917	9.983	9.837	9.554	9.599
78	Norway	15	1996		10.010	15.365	14.791	15.075	13.549	15.692	15.443	15.567	15.090	14.401	14.539
79	Sweden	16	1996		10.650	15.931	15.598	15.764	14.335	15.880	15.715	15.797	15.762	15.454	15.487
80	Australia	17	1996		1.360	2.050	2.005	2.027	1.859	2.076	2.053	2.064	2.027	2.070	2.071
81	New Zealand	18	1996		1.580	2.361	2.330	2.345	2.139	2.452	2.435	2.443	2.344	2.409	2.415
82	Japan	19	1996		176.580	275.753	255.878	265.630	246.638	297.806	292.039	294.908	265.844	285.789	288.982
83	Canada	20	1996		1.240	1.848	1.812	1.830	1.694	1.896	1.888	1.892	1.829	1.851	1.854
84	USA	21	1996		0.990	1.547	1.533	1.540	1.431	1.489	1.466	1.477	1.541	1.450	1.448
85	Turkey	22	1996		38095.700	64164.450	59820.750	61954.540	59433.980	68189.310	64440.120	66288.210	62304.230	60259.940	61262.150
86	Poland	23	1996		1.400	2.397	1.889	2.128	2.104	2.578	2.322	2.447	2.148	2.170	2.142
87	Hungary	24	1996		68.300	113.803	95.891	104.464	103.893	122.190	112.461	117.225	104.390	106.579	108.553
88	Hong Kong	26	1996		7.000	11.593	8.960	10.192	9.751	10.409	10.082	10.244	10.295	10.142	10.018
89	Iran	27	1996		640.300	825.086	670.615	743.851	756.341	904.706	861.323	882.748	761.464	768.349	786.320

Table 6. cont.

Obs	Country	I	Year	Exch Rate	ICP PPP	Using Observed Shares				Using Predicted Shares					
						Laspeyres	Paasche	Fisher	Tornqvist	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin (USA income)	Klein-Rubin (Country Income)
90	Korea	28	1996		666.490	977.588	926.383	951.641	862.144	940.650	926.122	933.358	949.181	917.224	914.702
91	Thailand	29	1996		13.560	19.068	17.211	18.116	16.218	17.911	17.264	17.585	18.036	17.453	17.382
92	Sri Lanka	30	1996		14.760	18.680	20.861	19.740	18.620	18.995	16.175	17.529	19.014	15.094	15.294
93	Philippines	31	1996		7.390	13.411	9.294	11.164	10.347	12.175	10.188	11.137	10.583	10.452	10.448
94	Pakistan	32	1996		9.560	14.152	11.017	12.486	12.280	13.568	11.895	12.704	12.055	12.139	12.143
95	Bangladesh	33	1996		10.040	14.244	12.258	13.213	13.633	14.284	11.644	12.897	12.592	11.917	11.906
96	Benin	35	1996		259.390	360.127	369.093	364.583	365.469	365.227	359.295	362.249	362.416	364.693	364.948
97	Cameroon	36	1996		266.620	347.541	360.811	354.114	366.508	358.852	356.624	357.736	353.500	349.669	351.195
98	Congo	37	1996		437.990	538.296	588.512	562.844	616.882	584.010	584.465	584.237	562.879	538.036	546.490
99	Cote d'Ivoire	38	1996		266.400	357.415	361.243	359.324	387.018	370.602	369.839	370.221	359.984	357.197	359.850
100	Madagascar	39	1996		1725.340	2453.225	2556.101	2504.135	2523.754	2550.266	2475.241	2512.474	2474.304	2530.581	2540.855
101	Mali	40	1996		246.980	353.717	356.830	355.270	345.981	359.216	345.371	352.226	349.515	364.088	364.250
102	Morocco	41	1996		4.070	5.210	5.596	5.399	5.622	5.661	5.561	5.610	5.429	5.489	5.460
103	Senegal	43	1996		246.070	325.718	344.990	335.215	333.824	338.825	334.412	336.611	334.302	327.122	329.289
104	Tunisia	44	1996		0.460	0.595	0.638	0.616	0.648	0.639	0.636	0.637	0.614	0.669	0.616
105	Botswana	45	1996		1.700	2.511	2.384	2.447	2.405	2.418	2.376	2.397	2.448	2.315	2.368
106	Egypt	46	1996		1.210	1.857	1.712	1.783	1.737	1.787	1.759	1.773	1.778	1.724	1.737
107	Kenya	48	1996		20.420	27.117	28.538	27.818	29.630	28.677	27.922	28.297	27.610	25.857	25.909
108	Malawi	49	1996		6.120	9.444	8.438	8.927	9.121	9.544	8.699	9.112	8.654	8.989	9.083
109	Mauritius	50	1996		10.510	14.073	13.737	13.904	14.444	14.447	13.720	14.079	13.825	14.449	14.444
110	Nigeria	51	1996		35.690	44.041	53.001	48.314	51.234	48.678	47.606	48.139	48.420	41.744	41.909
111	Sierra Leone	52	1996		345.730	452.179	474.818	463.360	488.362	491.977	464.028	477.798	454.053	427.108	432.036
112	Swaziland	53	1996		1.780	2.489	2.444	2.466	2.517	2.586	2.509	2.547	2.464	2.637	2.646
113	Tanzania	54	1996		257.810	370.822	372.931	371.875	369.125	379.844	363.542	371.603	358.461	355.231	356.812
114	Zambia	55	1996		709.130	896.963	1007.946	950.837	975.508	969.379	909.649	939.040	913.602	918.550	925.455
115	Zimbabwe	56	1996		3.460	4.538	4.580	4.559	4.752	4.718	4.614	4.666	4.528	4.713	4.691
116	Bahamas	57	1996		1.080	1.462	1.429	1.446	1.454	1.499	1.453	1.476	1.445	1.438	1.434
117	Barbados	58	1996		0.980	2.213	1.118	1.573	1.890	2.327	1.972	2.142	1.667	1.800	1.790
118	Grenada	59	1996		1.970	2.635	2.216	2.416	2.650	2.862	2.543	2.698	2.424	2.722	2.688
119	Jamaica	60	1996		27.100	37.074	37.064	37.069	37.606	41.681	38.873	40.252	36.900	40.234	40.678

Table 6. cont.

Obs	Country	I	Year	Exch Rate	ICP PPP	Using Observed Shares				Using Predicted Shares					
						Laspeyres	Paasche	Fisher	Tornqvist	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin (USA income)	Klein-Rubin (Country Income)
120	St. Lucia	61	1996		2.320	2.722	2.951	2.834	2.879	3.100	2.943	3.020	2.831	3.018	2.983
121	Trinidad &Tobago	63	1996		4.340	5.477	4.851	5.154	5.148	5.729	5.316	5.519	5.185	5.306	5.324
122	Gabon	64	1996		434.380	599.108	609.467	604.266	565.491	610.048	602.938	606.482	604.403	572.927	576.699
123	Guinea	65	1996		323.210	534.428	428.871	478.749	453.840	525.890	492.204	508.768	473.992	499.211	497.830
124	Fiji	66	1996		0.770	1.484	0.916	1.166	1.009	1.293	1.021	1.149	1.121	0.977	0.986
125	Indonesia	67	1996		711.680	1181.639	991.190	1082.233	918.146	1082.698	1021.359	1051.582	1076.521	1078.067	1068.449
126	Nepal	68	1996		10.360	18.010	13.137	15.382	14.538	16.901	14.091	15.432	14.532	15.766	15.769
127	Singapore	69	1996		1.710	2.598	2.224	2.404	2.009	2.338	2.276	2.307	2.417	2.343	2.330
128	Vietnam	70	1996		2.100	3.796	2.525	3.096	2.883	3.424	2.573	2.968	2.886	2.656	2.634
129	Antigua & Barbuda	71	1996		3.110	4.205	3.698	3.943	4.148	4.346	4.006	4.173	3.973	4.245	4.245
130	Belize	72	1996		1.430	1.905	1.814	1.859	1.955	1.988	1.885	1.936	1.868	2.012	1.986
131	Bermuda	73	1996		1.670	2.546	2.329	2.435	2.337	2.491	2.102	2.288	2.427	2.480	2.470
132	Dominica	74	1996		2.260	2.723	2.647	2.685	2.773	2.973	2.758	2.863	2.698	2.840	2.799
133	St. Kitts & Nevis	75	1996		2.150	2.752	2.511	2.629	2.735	2.956	2.735	2.844	2.635	2.880	2.874
134	St.Vincent & Grena-dines	76	1996		1.880	2.503	2.081	2.282	2.506	2.837	2.528	2.678	2.328	2.766	2.713
135	Albania	77	1996		31.590	52.109	52.891	52.498	50.575	59.606	52.686	56.039	52.185	43.083	44.536
136	Armenia	78	1996		95.760	186.631	165.088	175.530	175.129	216.132	172.402	193.033	172.286	134.726	141.257
137	Azerbaijan	79	1996		1005.920	1735.445	1573.817	1652.656	1775.862	2146.773	1801.486	1966.566	1619.349	973.438	1066.445
138	Belarus	80	1996		3615.860	6658.329	5198.777	5883.465	6858.562	7728.258	6695.685	7193.468	5996.236	5221.092	5464.278
139	Bulgaria	81	1996		41.560	68.517	64.224	66.336	78.783	76.295	71.256	73.733	66.302	67.733	69.209
140	Croatia	82	1996		3.730	6.226	5.287	5.738	6.570	6.885	6.460	6.669	5.855	5.502	5.561
141	Czech Republic	83	1996		11.340	18.644	15.794	17.160	19.988	20.666	19.063	19.849	17.182	18.181	18.526
142	Estonia	84	1996		5.130	8.509	7.295	7.878	9.050	9.500	8.915	9.203	7.952	7.937	8.078
143	Georgia	85	1996		0.340	0.589	0.554	0.571	0.583	0.720	0.618	0.667	0.562	0.791	0.451
144	Iceland	86	1996		81.620	126.261	119.392	122.779	135.400	134.926	132.262	133.587	122.563	121.739	123.557
145	Israel	87	1996		3.710	5.491	5.337	5.414	6.017	5.627	5.570	5.598	5.406	5.427	5.450
146	Kazakhstan	88	1996		18.640	35.209	25.976	30.242	33.034	40.465	34.946	37.604	31.433	26.937	27.985
147	Kyrgyz	89	1996		2.700	4.478	4.319	4.398	4.555	5.446	5.048	5.243	4.411	4.040	3.822
148	Latvia	90	1996		0.230	0.398	0.314	0.353	0.391	0.453	0.407	0.429	0.360	0.495	0.345
149	Lithuania	91	1996		1.480	2.429	2.136	2.278	2.461	2.753	2.502	2.625	2.289	2.358	2.317

Table 6. cont.

Obs	Country	I	Year	Exch Rate	ICP PPP	Using Observed Shares				Using Predicted Shares					
						Laspeyres	Paasche	Fisher	Tornqvist	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin (USA income)	Klein-Rubin (Country Income)
150	Macedonia	92	1996		21.090	34.470	30.943	32.659	35.112	37.473	35.139	36.287	32.805	32.292	32.833
151	Moldova	93	1996		0.950	1.735	1.393	1.554	1.691	2.083	1.833	1.954	1.562	1.734	1.417
152	Mongolia	94	1996		171.200	294.011	353.663	322.460	274.721	337.269	304.620	320.529	311.911	270.903	278.701
153	Romania	95	1996		761.410	1201.889	1203.761	1202.825	1156.806	1401.562	1278.919	1338.837	1196.949	1016.941	1058.969
154	Russia	96	1996		2147.560	3696.279	3013.013	3337.205	3384.287	4127.132	3639.381	3875.591	3365.385	2992.908	3101.390
155	Slovakia	97	1996		11.420	19.191	15.920	17.479	18.342	21.235	19.391	20.292	17.693	16.392	16.810
156	Slovenia	98	1996		101.890	152.949	147.441	150.170	155.290	163.808	160.187	161.987	150.095	148.017	150.335
157	Switzerland	99	1996		2.160	3.351	3.360	3.355	3.455	3.266	3.224	3.245	3.355	3.212	3.207
158	Tajikistan	100	1996		52.950	108.141	98.270	103.088	96.598	127.799	101.300	113.781	95.129	61.617	64.519
159	Turkimenistan	101	1996		432.220	896.794	697.782	791.054	944.601	1179.026	1018.524	1095.841	789.346	536.739	593.442
160	Ukraine	102	1996		0.440	0.811	0.601	0.698	0.855	0.935	0.832	0.882	0.713	0.954	0.703
161	Uzbekistan	103	1996		10.220	18.900	14.752	16.697	19.667	22.457	19.833	21.104	17.143	15.420	15.650
162	Argentina	104	1996		0.740	1.188	1.111	1.149	1.105	1.131	1.107	1.119	1.146	1.119	1.124
163	Bolivia	105	1996		1.970	2.984	2.985	2.985	2.971	2.992	2.889	2.940	2.970	2.935	2.927
164	Brazil	106	1996		0.720	1.160	1.067	1.113	1.065	1.105	1.071	1.088	1.110	1.089	1.106
165	Chile	107	1996		230.550	364.161	348.769	356.382	341.467	364.108	357.766	360.923	356.505	341.044	343.405
166	Ecuador	108	1996		1665.630	2575.530	2474.916	2524.722	2444.610	2546.649	2446.349	2495.995	2516.152	2491.135	2492.515
167	Mexico	109	1996		3.410	5.508	5.251	5.378	4.972	5.300	5.218	5.259	5.369	5.159	5.154
168	Panama	110	1996		0.490	0.722	0.740	0.731	0.715	0.747	0.739	0.743	0.730	0.763	0.733
169	Peru	111	1996		1.390	2.053	2.055	2.054	1.994	2.080	2.047	2.063	2.051	2.028	2.012
170	Uruguay	112	1996		5.700	8.824	8.632	8.727	8.239	8.572	8.379	8.475	8.712	8.539	8.530
171	Venezuela	113	1996		222.560	349.771	337.529	343.596	321.356	340.963	333.028	336.972	342.548	348.190	346.505
172	Bahrain	114	1996		0.550	1.217	0.603	0.857	0.748	1.017	0.670	0.825	0.840	0.606	0.829
173	Jordan	115	1996		0.790	1.200	0.908	1.044	0.978	1.072	0.980	1.025	1.028	0.796	1.012
174	Lebanon	116	1996		2485.340	5043.937	2836.034	3782.166	3414.155	4207.374	3672.747	3930.982	3747.276	3717.954	3622.374
175	Oman	117	1996		0.460	0.752	0.510	0.619	0.533	0.634	0.523	0.576	0.599	0.479	0.561
176	Qatar	118	1996		4.520	8.085	4.875	6.278	5.452	6.754	5.370	6.022	6.082	5.845	5.804
177	Syria	119	1996		27.080	40.696	32.213	36.207	38.800	40.727	35.897	38.236	36.229	33.653	33.914
178	Yemen	120	1996		137.220	197.388	178.147	187.521	182.806	190.129	163.807	176.478	183.196	162.831	163.695

Table 7. Ethiopian Food and Beverage Items

Item Code	Item	Quantity Units
1	Teff white	gram
2	Teff black	gram
3	Teff mixed	gram
4	Wheat white	gram
5	Wheat black	gram
6	Wheat mixed	gram
7	Barley black	gram
8	Barley white	gram
9	Barley mixed	gram
10	Barley for Beer	gram
11	Barley and wheat	gram
12	Maize	gram
13	Durrah	gram
14	Sorghum	gram
15	African millet	gram
16	Rice	gram
17	Oats	gram
18	Temge	gram
19	Sinar	gram
20	Maize Ripe	gram
21	Soya bean ripe	gram
22	Others	gram
23	Teff white	gram
24	Teff black	gram
25	Teff mixed	gram
26	Wheat white	gram
27	Wheat black	gram
28	Wheat mixed	gram
29	Barley white	gram
30	Barley mixed	gram
31	Barley for beer	gram
32	Barley and wheat	gram
33	Maize	gram
34	Durrah	gram
35	Sorghum	gram
36	African millet	gram
37	Teff white and sorghum	gram
38	Teff black and Durrah	gram
39	Wheat and Maize	gram
40	Teff and African millet	gram
41	Oats	gram
42	Barley black	gram
43	Beso	gram
44	Sinar	gram
45	Fafa	gram
46	Dube	gram
47	Others	gram
48	Horse beans	gram
49	Chick peas	gram
50	Peas	gram
51	Lentils	gram
52	Haricot beans	gram
53	Peas mixed	gram
54	Vetch	gram
55	Fenugreek	gram
56	Soya beans	gram

Table 7 continued.

Item Code	Item	Quantity Units
57	Gibto	gram
58	Others	gram
59	Horse beans milled	gram
60	Chick peas milled	gram
61	Peas milled	gram
62	Mixed pulses milled	gram
63	Vetch milled	gram
64	Peas split	gram
65	Lentils split	gram
66	Horse beans split	gram
67	Vetch split	gram
68	Haricot beans split	gram
69	Chick peas split	gram
70	Lentils milled	gram
71	Fenugreek milled	gram
72	Haricot beans milled	gram
73	Others	gram
74	Niger seed	gram
75	Linseed white	gram
76	Linseed black	gram
77	Sesame	gram
78	Sunflower	gram
79	Castor beans	gram
80	Rape seed	gram
81	Others	gram
82	Spaghetti	gram
83	Pastini	gram
84	Macaroni	gram
85	Telateli	gram
86	Bocatini	gram
87	Others	gram
88	Injera	gram
89	Wheat bread traditional	gram
90	Wheat bread bakery	gram
91	Cakes	gram
92	Biscuits	gram
93	Others	gram
94	Beef	gram
95	Mutton	gram
96	Chicken	gram
97	Pork	gram
98	Canned meat	gram
99	Goat meat	gram
100	Camel meat	gram
101	Gigra Kok meat	gram
102	Others	gram
103	Fish fresh	gram
104	Sardines	gram
105	Tuna	gram
106	Fish dried	gram
107	Others	gram
108	Milk	cubic cm
109	Milk powdered	gram
110	Cottage cheese	gram
111	Yoghurt clotted	cubic cm
112	Butter milk	cubic cm

Table 7 continued.

Item Code	Item	Quantity Units
113	Eggs	no.
114	Others	cubic cm
115	Butter unrefined	gram
116	Butter semi-refined	gram
117	Imported butter	gram
118	Edible oil local	cubic cm
119	Edible oil Imported	cubic cm
120	Others	cubic cm
121	Ethiopian kale	gram
122	Cabbage	gram
123	Lettuce	gram
124	Spinach	gram
125	Carrot	gram
126	Tomato	gram
127	Onions	gram
128	Garlic	gram
129	Pepper green	gram
130	Pumpkin	gram
131	Green beans	gram
132	Beet root	gram
133	Switzcharge	gram
134	Cauliflower	gram
135	Canned tomato	gram
136	Leaks	gram
137	Samma	gram
138	Shiferaw Aleko	gram
139	Alengele shinkurt	gram
140	Others	gram
141	Banana	gram
142	Orange local	gram
143	Lemon	gram
144	Mandarin	gram
145	Peach	gram
146	Avacado	gram
147	Pome apple	gram
148	Casimire	gram
149	Cactus	gram
150	Papaya	gram
151	Grapes	gram
152	Pineapple	gram
153	Guava	gram
154	Mango	gram
155	Water melon	gram
156	Strawberry	gram
157	Dates	gram
158	Ground nuts	gram
159	Juice	cubic cm
160	Citron	gram
161	Others	gram
162	Pepper whole	gram
163	Pepper milled	gram
164	Black pepper	gram
165	Long pepper	gram
166	White cumin	gram
167	Black cumin	gram
168	Ginger	gram

Table 7 continued.

Item Code	Item	Quantity Units
169	Cloves	gram
170	Cinnamon	gram
171	Cardamon	gram
172	Tumeric	gram
173	Mustard	gram
174	Rue	gram
175	Coriander	gram
176	Savory	gram
177	Fennel	gram
178	Chilies	gram
179	Basil	gram
180	False cardamon	gram
181	Others	gram
182	Potato	gram
183	Sweet potato	gram
184	Kocho	gram
185	Amicho	gram
186	Anchote	gram
187	Godere	gram
188	Boye	gram
189	Bula	gram
190	Others	gram
191	Tea leaves	gram
192	Coffee beans	gram
193	Coffee leaves	gram
194	Buck-thorn leaves	gram
195	Chat	gram
196	Mekmoko	gram
197	Coffee whole	gram
198	Others	gram
199	Salt	gram
200	Sugar	gram
201	Honey	gram
202	Marmalade	gram
203	Margarine	gram
204	Sugar cane	gram
205	Baking powder	gram
206	Candy and chewing gum	gram
207	Others	gram
208	Mineral water	cubic cm
209	Coca Cola, Fanta etc	cubic cm
210	Birz	cubic cm
211	Star O.pop etc	gram
212	Others	cubic cm
213	Spirit local	cubic cm
214	Cognac local	cubic cm
215	Brandy	cubic cm
216	Whisky	cubic cm
217	Gin local	cubic cm
218	Vermouth	cubic cm
219	Wine	cubic cm
220	Katikalla	cubic cm
221	Beer	cubic cm
222	Tela Borde Korefe	cubic cm
223	Mead	cubic cm
224	Others	cubic cm

Table 7 continued.

Item Code	Item	Quantity Units
225	Nyala	no.
226	Gureza	no.
227	Gissila	no.
228	Sportsman	no.
229	Rothmans	no.
230	Craven	no.
231	Pall Mall	no.
232	Marlboro	no.
233	Winston	no.
234	Kent	no.
235	More	no.
236	Peter	no.
237	Bond	no.
238	Grusse	no.
239	Royals	no.
240	Sofrudin	no.
241	Others	no.
242	Suret	gram
243	Gaye	gram
244	Addis club	gram
245	Others	gram
246	Coffee	na
247	Tea	na
248	Milk with Tea or Coffee	na
249	Meal	na
250	Alcoholic Drinks	cubic cm
251	Non Alcoholic Drinks	cubic cm
252	Others	na

Table 8. Ugandan Food and Beverage Items

Item Code	Item	Original Quantity Units
101	Matooke	bunch
102	Matooke	bunch
103	Matooke	bunch
104	Matooke	na
105	Sweet Potatoes (Fresh)	20 litre tin
106	Sweet Potatoes (Dry)	na
107	Cassava (Fresh)	20 litre tin
108	Cassava (Dry/Flour)	na
109	Irish Potatoes	20 litre tin
110	Rice	kilogram
111	Maize (grains)	na
112	Maize (cobs)	na
113	Maize (flour)	kilogram
114	Bread	kilogram
115	Millet	na
116	Sorghum	kilogram
117	Beef	kilogram
118	Pork	na
119	Goat Meat	na
120	Other Meat	na
121	Chicken	na
122	Fresh fish	na
123	Dry/Smoked fish	na
124	Eggs	na
125	Fresh milk	litre
126	Infant Formula Foods	na
127	Cooking oil/ghee	litre
128	Margarine, Butter, etc.	na
129	Passion Fruits	na
130	Sweet bananas	na
131	Mangoes	na
132	Oranges	na
133	Onions	na
134	Tomatoes	na
135	Cabbages	na
136	Dodo	na
137	Other Vegetables	na
138	Beans (fresh)	kilogram
139	Beans (dry)	na
140	Groundnuts (In shell)	kilogram
141	Groundnuts (Shelled)	kilogram
142	Groundnuts (Pounded)	kilogram
143	Peas	na
144	Sim sim	na
145	Sugar	kilogram
146	Coffee	na
147	Tea	na
148	Salt	kilogram
149	Soda/juice	na
150	Beer	na
151	Other Alcoholic drinks	na
152	Cigarettes	na
153	Other Tobacco	na
154	Expenditure in Restaurants etc.	na
159	Other food, drinks etc.	na

(a) Inferred from prices reported in UBS (2001) and at http://www.ubos.org/nsdcpix.html.
(b) Speijer, Kajumba and Ssango (1999) report that the average bunch weight of highland bananas ranges from 5.9kg to 19.2 kg (average = 13kg).

Table 9. Mappings

ICP Code	Item	Description	Ethiopian Item Code	Uganda Item Code
11 01 11 9	1	Bread	89, 90	114
	2	Sorghum	14, 35, 38	116
	3	Millet	15, 36	115
	4	Rice	16	110
	5	Other bread and cereals	1-13, 17-34, 37, 39-48, 74-88, 91-93	111-113
11 01 12 9	6	Beef	94	117
	7	Chicken	96	121
	8	Pork	97	118
	9	Goat meat	99	119
	10	Other meat	95, 98, 100-102	120
11 01 13 9	11	Fresh fish	103	122
	12	Other fish and seafood	104-107	123
11 01 14 9	13	Eggs	113	124
	14	Fresh Milk	108	125
	15	Other Milk, cheese, eggs	109-112, 114	126
11 01 15 9	16	Butter and Margarine	115-117, 203	128
	17	Other edible oils and fats	118-120	127
11 01 16 9	18	Banana	141	101-104
	19	Orange	142	132
	20	Mango	154	131
	21	Other fruits	143-153, 155-161	129-130, 140-142
11 01 17 9	22	Onion	127	133
	23	Tomato	126	134
	24	Cabbage	122	135
	25	Sweet Potato	183	105-106
	26	Irish Potato	182	109
	27	Other vegetables	49-73, 121, 123-125, 128-140, 184-190	107, 108, 136-139, 143-144
11 01 18 9	28	Sugar, jam, honey, confection-ery	200-202, 204-207	145
11 01 19 1	29	Salt	199	148
	30	Other food products n.e.c.	162-181, 249, 252	159, 154
11 01 20 9	31	Coffee	192-193, 197, 246	146
	32	Tea	191, 247	147
	33	Other non-alcoholic beverages	194-196, 198, 208-212, 248, 251	149
11 02 10 9	34	Beer	221	150
	35	Other alcoholic beverages	213-220, 222-224, 250	151
11 02 21 1	36	Cigarettes	225-241	152
	37	Other tobacco products	242-245	153

Table 10. Average Prices and Per Capita Expenditures for 37 Items: 1990/2000

Item	Description	Ethiopia		Uganda	
		Average Monthly Per Capita Expenditure (a)	Average Price (b)	Average Monthly Per Capita Expenditure (c)	Average Price (d)
1	Bread	27.93954	3.401304	40.94157	524.0556
2	Sorghum	47.36655	2.024482	28.93289	471.5900
3	Millet	5.259460	1.564116	70.46658	462.2640
4	Rice	3.772763	5.007539	79.34229	836.0215
5	Other bread and cereals	287.6849	2.469166	222.1096	426.9236
6	Beef	39.38618	11.17193	192.5003	1837.948
7	Chicken	3.403206	9.289485	43.17646	2889.163
8	Pork	0.4584957	22.62085	23.35375	1420.955
9	Goat meat	4.454751	9.536558	29.99145	1893.051
10	Other meat	10.87840	9.631294	13.15336	1587.624
11	Fresh fish	2.461663	3.631203	115.6745	746.9220
12	Other fish and seafood	0.2721556	9.672974	67.01625	580.2512
13	Eggs	4.312022	0.3502515	18.86819	223.6328
14	Fresh Milk	20.75615	2.418591	151.7851	293.1463
15	Other Milk, cheese, eggs	7.034791	3.937427	1.454698	4082.152
16	Butter and Margarine	8.108628	23.42614	5.235128	1012.618
17	Other edible oils and fats	47.14349	14.70061	85.65365	392.1214
18	Banana	0.9724652	1.788017	458.3604	129.8263
19	Orange	0.6911781	2.301580	4.658056	253.7488
20	Mango	0.7014441	1.814982	4.979964	253.1774
21	Other fruits	3.464358	2.744350	108.3258	571.0940
22	Onion	21.00858	4.036829	32.09951	166.2340
23	Tomato	5.687362	2.535632	71.81441	164.9625
24	Cabbage	0.9940330	1.070232	15.51844	236.5609
25	Sweet Potato	3.399920	1.063875	293.4708	52.65817
26	Irish Potato	14.22096	1.444011	69.46428	68.06266
27	Other vegetables	108.0485	3.198911	583.6378	337.6472
28	Sugar, jam, honey, confectionery	25.41726	5.335174	224.2974	1051.906
29	Salt	7.363608	1.887064	44.54103	289.4738
30	Other food products n.e.c.	64.13566	14.02593	0.0037965	100.0000
31	Coffee	34.31292	11.25669	1.756574	248.2686
32	Tea	6.344255	15.78789	28.74425	171.4492
33	Other non-alcoholic beverages	28.89451	8.548281	42.80269	590.7814
34	Beer	0.5334232	9.148598	81.75349	1064.229
35	Other alcoholic beverages	7.758637	8.431199	89.92254	365.1930
36	Cigarettes	14.50512	159.8711	46.46260	216.1217
37	Other tobacco products	2.029874	15.33279	8.659693	134.0667

(a) Birr
(b) Birr per kilogram, Birr per litre, or Birr each.
(c) Schillings
(d) Schillings per kilogram, Schillings per litre, or Schillings each.

Table 11. Average Prices and Per Capita Expenditures for 12 Items: 1990/2000

Item	Description	Ethiopia		Uganda	
		Average Monthly Expenditure (a)	Average Price (b)	Average Monthly Expenditure (c)	Average Price (d)
1	Bread and Cereals	372.0233	2.448817	441.7959	466.7053
2	Meat	58.58104	10.77049	302.1861	1885.103
3	Fish	2.733818	4.921582	182.7254	663.1399
4	Milk, cheese, eggs	32.10296	1.939903	172.1057	266.8283
5	Edible oils and fats	55.25211	15.78728	91.14333	396.1482
6	Fruits	5.829446	2.314591	576.0501	236.8655
7	Vegetables	153.3593	2.690410	1066.057	165.2852
8	Sugar, jam, honey, confectionery	25.41726	5.335174	224.3050	1051.906
9	Other food products n.e.c.	71.49927	6.949909	44.54303	289.4638
10	Non-alcoholic beverages	69.55168	10.25286	73.31334	195.0432
11	Alcoholic beverages	8.292060	8.431492	171.7086	480.9801
12	Tobacco products	16.53500	73.63470	55.12801	178.0169

(a) Birr
(b) Birr per kilogram or litre equivalent.
(c) Schillings
(d) Schillings per kilogram or litre equivalent..

Table 12. PPP Exchange Rates: Uganda Relative to Ethiopia

	Laspeyres	Paasche	Fisher	Tornqvist	Klein-Rubin
Observed Shares; 37 Items	133.981	45.162	77.787	92.371	-
Observed Shares; 12 Items	123.016	52.212	80.143	89.607	-
Predicted Shares; 12 Items; Ethiopian data; ML	-	-	117.803	na	87.256
Predicted Shares; 12 Items; Ugandan data; ML	-	-	55.382	na	88.484
Predicted Shares; 12 Items; all data; ML	-	-	93.836	na	82.757

Table 13. Estimated Linear Expenditure System

	Item	Ugandan Observations N = 10534		Ethiopian Observations N = 17332		All Observations N = 27866	
		Estimate	Asymptotic t-ratio	Estimate	Asymptotic t-ratio	Estimate	Asymptotic t-ratio
γ_1	Bread and Cereals	0.100	12.16	111.840	150.12	0.065	11.14
γ_2	Meat	0.014	3.55	0.607	7.39	0.027	11.51
γ_3	Fish	0.089	12.77	0.213	5.08	0.117	30.41
γ_4	Milk, cheese, eggs	0.066	4.30	3.707	8.29	0.087	7.85
γ_5	Edible oils and fats	0.051	20.66	0.851	19.21	0.043	24.19
γ_6	Fruits	0.000	0.00	2.417	11.02	0.000	0.00
γ_7	Vegetables	1.144	26.42	21.333	38.70	1.241	46.62
γ_8	Sugar, jam, etc.	0.089	27.50	1.567	24.81	0.100	54.14
γ_9	Other food n.e.c.	0.105	85.34	4.986	27.75	0.075	23.58
γ_{10}	Non-alcoholic beverages	0.141	15.41	1.490	14.78	0.122	19.27
γ_{11}	Alcoholic beverages	0.021	1.29	0.325	6.74	0.076	7.80
γ_{12}	Tobacco products	0.129	6.57	0.000	0.00	0.000	0.00
β_1	Bread and Cereals	0.124	82.34	0.161	72.38	0.151	143.60
β_2	Meat	0.115	63.55	0.086	69.28	0.107	103.35
β_3	Fish	0.047	36.64	0.003	9.40	0.039	55.27
β_4	Milk, cheese, eggs	0.067	55.71	0.071	46.53	0.065	84.85
β_5	Edible oils and fats	0.028	70.12	0.067	90.30	0.032	115.76
β_6	Fruits	0.187	100.80	0.005	7.90	0.168	117.47
β_7	Vegetables	0.237	100.60	0.110	67.32	0.223	159.91
β_8	Sugar, jam, etc.	0.052	59.63	0.027	60.39	0.047	95.50
β_9	Other food n.e.c.	0.005	36.78	0.097	59.83	0.017	46.75
β_{10}	Non-alcoholic beverages	0.027	33.45	0.092	76.46	0.034	63.97
β_{11}	Alcoholic beverages	0.092	39.93	0.016	31.15	0.078	59.53
β_{12}	Tobacco products	0.020	17.21	0.266	75.70	0.039	43.55
Log Likelihood		-827642.5		-1101234		-2116107	