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The Wealth and Poverty of Nations: True PPPs for 141 Countries

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Abstract

I set out a new method for estimating true (Konüs) PPPs. Household consumption per head deflated by these PPPs answers the question: by how much must the average expenditure per head of poor country A be increased to enable the typical inhabitant of A to enjoy the same utility level as the typical inhabitant of rich country B?

Conventional multilateral PPPs for household consumption, such as the ones published by the World Bank, are not based explicitly on economic theory. So it is not clear that they can answer the question above, particularly if consumer demand is not homothetic. And there is overwhelming empirical evidence against homotheticity.

The estimates of the standard of living in this paper are based on the economic theory of consumer demand. The main tool is the expenditure function. It turns out that it is not necessary to estimate all the parameters of the expenditure function but only the relatively small number which measure the consumer's response to income changes. This makes the method feasible even when there are large numbers of products.

The method is applied to 141 countries included in the World Bank's 2005 International Comparison Program, at the level of 100 products. The results give strong support for nonhomotheticity and also for the importance of background factors such as climate, demography, culture and religion. The gap between the richest and the poorest countries is wider than when household consumption is deflated by a conventional multilateral index such as the World Bank's PPP for consumption.

Keywords: Purchasing power parity (PPP), standard of living, international comparisons, Konüs, index number, welfare, homothetic
JEL Classifications: C43, D12, E01, I31, O47

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1. Introduction

In 2008, the World Bank published the results of the 2005 International Comparison Program or ICP (World Bank, 2008). This was the most comprehensive round to date, covering 146 countries including both India and China. In all, the 146 countries accounted for about 95% of the world's population, some 6.1 billion people. The Purchasing Power Parities (PPPs) generated by the current and previous rounds of the ICP are widely used both in policy circles and by economists for research purposes. They are employed to measure and compare standards of living, output levels and productivity across the globe. They are an essential building block in the Penn World Tables on which innumerable studies of growth and convergence have been based. But what do these PPPs actually measure and are they fit for purpose?

The PPPs used to bring a country's GDP or consumption under a common measuring rod, the so-called "international dollar", are averages of lower level PPPs. This paper argues that the World Bank's method for averaging PPPs is only appropriate if consumer demand is homothetic, i.e. all income elasticities are equal to one. But numerous studies of household budgets suggest the opposite: demand is not homothetic. Building on earlier work (Oulton, 2008 and 2012 [2009]), I employ an econometric method to estimate what I call Konüs (or "true") PPPs. These are designed to answer questions like: by how many times must we multiply the consumption per head of the Democratic Republic of Congo (DRC), the poorest of these 146 countries, in order to give the average Congolese the same welfare at current DRC prices as the average American?

The two main methods used to make cross-country comparisons of living standards are the multilateral index number approach and the econometric (or economic) approach.[1] The strength of the index number approach (whether EKS, Geary-Khamis or the method of Caves et al., 1982) is that it allows all available data to be used, i.e. the PPPs at the basic heading level (see Hill (1997) for a survey, also Diewert (1981) and (1987) and Balk (2009)). But the

[1] Two other methods have also been employed. First, Dowrick and Quiggin (1997) use a revealed preference approach to approximate the utility function; see also Dowrick (2009). Second, Hill (1999), (2004) and (2009) applies a minimum-spanning-tree approach to find the "best" chain index linking countries together; roughly speaking, the best chain index is the one which minimises the sum of the spreads between the Laspeyres and Paasche indices. Behind both these approaches is the idea that, if the utility function is homothetic, then the true index is bounded by the Laspeyres and Paasche indices. However, if the utility function is not homothetic, the true index may lie outside these bounds.

problem with the approach is that even if the indices correct for substitution bias they will still suffer from what might be called path-dependence bias or chain index drift (Hulten, 1973; Samuelson and Swamy, 1974). The latter problem arises if income elasticities are not all equal to one, as they surely are not. After all, one of the oldest and most reliable empirical findings in economics is Engel's Law: the proportion of the budget spent on food declines as income rises.

The consequences for the interpretation of conventional index numbers of the standard of living are serious. For example, even in a bilateral comparison of a poor country with a rich one, the true difference in living standards is not necessarily bounded by the Laspeyres and Paasche indices. In fact, there is no longer a single true measure of the standard of living but two different ones depending on which country's utility level, that of the rich one or the poor one, is taken as the reference level. Implicitly, multilateral indices such as those calculated by the World Bank are based on a reference utility level which lies somewhere (though exactly where is unknown) between that of the richest and poorest countries included in the comparison.

The econometric approach derives ultimately from Konüs (1939) who argued that a true cost-of-living or price index could be measured in principle by the consumer's expenditure function (dual to the utility function). In practice, the approach has up to now involved estimating systems of demand that are consistent with economic theory, for example the Almost Ideal demand system of Deaton and Muellbauer (1980) or its generalisation, the Quadratic Almost Ideal Demand System (QAIDS) of Banks et al. (1997). The difficulty here is that the number of independent parameters to be estimated rises roughly in proportion to the square of the number of products. So the econometrician soon runs out of degrees of freedom. That is why up to now true cost-of-living (Konüs) price indices have only been estimated for relatively small numbers of products at a high level of aggregation. For example, Neary (2004) used the data from Phase IV (1980) of the ICP to estimate standards of living using a QAIDS for just 11 products.[2] It is not at all clear that trustworthy results can be achieved at such a high level of aggregation. For example, one of his products is "food" which is made up of both rice and caviar. In reality of course, these 11 "products" and their associated "prices" are themselves index numbers.

So up to now researchers have faced a dilemma. Either use the detailed data, with an unknown price to be paid in terms of substitution and path-dependence bias. Or use

[2] Feenstra et al. (2010) also estimate a QAIDS for 11 product groups and 48 countries using pooled data for 1980 and 1996.

econometric methods, in which case international comparisons have to be based on a small number of "products". This paper shows how this dilemma can be avoided, following earlier work in Oulton (2008) and (2012).

Plan of the paper

Section 2 sets the scene for what follows. I ask the question, what do the World Bank's PPPs actually measure? Section 3 sets out the theoretical framework and how it will be used to estimate true PPPs for consumption. The basic idea here is that given the actual budget shares, the Konüs index can be estimated from these plus an adjustment which depends on only a small number of parameters from the consumer demand system. In fact it is only necessary to know the comparatively few parameters governing the consumer's response to income changes and not the much more numerous parameters governing responses to price changes. Section 4 discusses a flexible demand system, the generalised PIGLOG (an example of which is the QAIDS), and shows how the parameters necessary for the Konüs price index (true PPPs) can be estimated using this system. In section 5 I discuss the World Bank's International Comparison Program (ICP). Section 6 describes the data I used to get my results. These were of two kinds. First, there were the data kindly supplied by the World Bank: PPPs and the corresponding expenditures for 100 products ("Basic Headings") comprising what I call "Household Consumption" for each of 146 countries. Second, from a variety of sources I gathered data on background variables which arguably influence household expenditure patterns, such as climate, demography, religion, culture and history. Section 7 discusses the econometric results and presents new estimates of the standard of living based on the estimated Konüs PPPs. In principle any country could be taken as the base for estimating Konüs indices: that is, any country's utility level could be taken as the reference level. These results employ either the poorest country as the base or the richest one. Finally, Section 8 concludes.

2. What Do PPPs Measure?

Table 1 gives summary statistics for a number of different measures of the standard of living (see Appendix Table A2 for the detailed results for each country). The poorest country in the sample on any measure, the Democratic Republic of Congo (DRC), is taken as the reference

country. In each case the nominal magnitude is what I call "Household Consumption" (measured in local currency units) per head. This does not correspond exactly to any World Bank concept, though it is close to what the World Bank calls "Actual Individual Consumption". As far as possible Household Consumption measures what households themselves spend on goods and services: see section 4 for a more precise definition. Household Consumption per head is deflated by various deflators (all measured as local currency units per U.S. dollar): 1. the official exchange rate; 2. the World Bank's own PPP for a closely related magnitude (Individual Consumption by Households); 3. a multilateral EKS Fisher index; 4. a bilateral own-weighted PPP (in this case the DRC); and 5. a bilateral U.S.-weighted PPP. The World Bank's PPP is a multilateral one, i.e. PPPs and spending patterns for many third countries influence the index relating any two countries. But it also embodies the assumption of "regional fixity": the requirement that the relative PPP for any two countries within a region should not be affected by any country outside their region. The last three deflators are my own calculations. The multilateral EKS Fisher is conceptually similar to the World Bank's index except that it does not embody regional fixity, so the spending patterns of all 146 countries influence the index for any two countries. As Chart 1 shows, the World Bank's PPP and my multilateral EKS Fisher are remarkably similar in practice.

Table 1 illustrates a number of well-known results. First, deflating by the exchange rate produces a wider spread of living standards than does deflating by the World Bank's PPPs: with exchange rates, the standard deviation is higher and so is the maximum. The exchange rate is not generally considered appropriate for comparisons of living standards. This is partly because it is subject to sudden, large changes which are not accompanied by changes of similar size in living standards and partly too because of the Balassa-Samuelson effect. Labour-intensive services are cheaper in poor countries but the exchange rate tends to equalise the prices of goods. So according to the usual argument the exchange rate overstates the general price level in poor countries and therefore understates their standard of living.

The second well-known result illustrated in Table 1 is that, in bilateral comparisons with the U.S., the use of U.S. weights in the deflator produces a higher standard deviation and a higher maximum than does the use of a country's own weights. This is because with U.S. weights the bilateral PPP is in effect a Laspeyres price index while with own country weights it is a Paasche price index. It is generally found that the Laspeyres produces a higher price level and so a lower standard of living than does the Paasche, since there is usually a negative correlation between prices and quantities. This is the case here. That is, using U.S. weights,

the DRC price level is higher than with DRC weights, so the DRC income level is lower and the U.S. one higher than it is with DRC weights (247.8 compared to 190.6). The two multilateral indices, the World Bank's and my own, produce quite similar results and both lie in the interval spanned by the two bilateral indices. The bilateral Fisher index between the DRC and the U.S. is 217.3 (the square root of 247.8 x 190.6), which is quite close to the two multilateral indices.

To what questions are these various indices the answers? In the case of the two bilateral indices, this is quite simple. The bilateral PPP with U.S. weights index says that someone on the average Congolese income attempting to buy the U.S. bundle of goods and services (at DRC prices) could only buy a fraction equal to 1/247.8 (0.40%) of each item in that bundle. The bilateral own weights index says that someone on the average U.S. income attempting to buy the DRC bundle of goods and services (at U.S. prices) would be able to buy that bundle 190.6 times over (i.e. a multiple of 190.6 of the quantity of each item in the bundle).

It is harder to say what questions the two multilateral indices answer. Rather they are defined by their properties (Balk (2009)). Both make use of all the information about spending patterns and prices in the data, whereas the bilateral indices use information only about the two countries in question.[3] And both are transitive. That is, if using these indices country A is richer than country B and country B is richer than country C, then we can be sure that country A will turn out to be richer that country C. In fact, the index for country A relative to country C is the index for A relative to B times the index for B relative to C.

An obvious question to which we would like an answer is, by how many times would the income of the average inhabitant of the DRC have to be multiplied in order to give him or her the same level of utility or welfare as the average American? None of the indices in Table 1 is guaranteed to give the right answer to this question. This is clearest in the case of the bilateral PPP with U.S. weights. This tells us that if the average Congolese were given sufficient income to purchase the U.S. bundle at DRC prices, then this would enable him or her to purchase the actual DRC bundle 247.8 times over. The people of the DRC spend a comparatively high proportion of their budgets on rice. If they had American income levels they would no doubt eat more but they certainly would not want to consume 247.8 times as much rice as they currently do. In other words their spending patterns would probably be

[3] This is not quite true because the DRC and the U.S. are in two different ICP regions, Africa and OECD-Eurostat. The PPPs at the Basic Heading level for the DRC (DRC prices relative to U.S. prices) are therefore influenced by prices in all the ring countries as well as by prices in the DRC and the U.S. See below, section 4.

much closer to those of Americans (who spend a negligible proportion of their budgets on rice). But at DRC prices they would not necessarily wish to purchase the U.S. bundle either, even if their income were higher, since the U.S. bundle was only voluntarily chosen at U.S. prices and incomes. So what is the welfare significance of the 247.8 DRC bundles if DRC people would not in fact buy them even if they could?

A common response is to say that the answer to the question about welfare must lie somewhere between the two bilateral indices (Paasche and Laspeyres) so this justifies the use of some sort of average of them such as the bilateral Fisher. But this response is only correct theoretically if consumer demand is homothetic. If consumer demand is not homothetic, then the correct answer may lie outside the Laspeyres-Paasche spread (see e.g. Deaton and Muellbauer, 1980b, chapter 7).

I am arguing that conventional, multilateral PPPs have no strong theoretical basis.[4] Nevertheless these numbers are not completely arbitrary. They are in fact closely correlated with other measures of human welfare and happiness. Infant mortality for example could be considered a proxy measure of human happiness, insofar as parents feel grief for the loss of a child. There is a strongly negative correlation between infant mortality and real household consumption per head: see Chart 2. Here the deflator is the conventional EKS Fisher price index. Human happiness arguably depends on the time span available to enjoy consumption. Life expectancy is strongly positively correlated with real household consumption per head, though some middle income countries have surprisingly low life expectancy and there is some evidence of "diminishing returns" to additional consumption at the top end of the global income distribution (Chart 3). Finally, inequality (as measured by the Gini coefficient) is negatively correlated with prosperity (Chart 4). The correlations between these welfare indicators are as follows:

	Real HC per head	*Life expect-ancy*	*Infant mortality*	*Gini coeff-icient*
Real HC per head	1.00			
Life expectancy	0.71	1.00		
Infant mortality	-0.65	-0.92	1.00	
Gini coefficient	-0.55	-0.54	0.43	1.00

[4] Others, e.g. Deaton and Heston (2008) and Deaton (2010), have raised questions about some aspects of the ICP methodology, particularly the process by which prices gathered in different regions are compared (see section 4).

3. Estimating True (Konüs) PPPs

3.1 Konüs and Divisia price indices

In this section I consider how in theory we should answer the welfare question just posed. For the moment we consider a world of many countries each inhabited by a representative consumer. All consumers have identical tastes. Later these assumptions will be relaxed. Let the representative consumer's expenditure function be

$$x = E(\mathbf{p}, u), \quad \partial x / \partial u > 0$$

This shows the minimum expenditure x needed to reach utility level u when $\mathbf{p} = (p_1\ p_2 \ldots p_N)$ is the Nx1 price vector faced by the consumer**;** $x = \sum_i p_i q_i$ where the q_i are the quantities purchased. Expenditure in country t is therefore a function of prices in country t and the utility level. Suppose that, hypothetically, utility were held at its level in country b while the consumer faced the prices of country t. Let $x(t,b)$ denote the minimum expenditure required at the prices of country t to achieve the utility level of country b. Then

$$x(t,b) = E(\mathbf{p}(t), u(b)) \tag{1}$$

For brevity write the right hand side as

$$E(t,b) = E(\mathbf{p}(t), u(b))$$

where the first argument of $E(t,b)$ is the country for prices and the second is the country for utility. The Konüs price index for country t relative to country r, with country b as the base for utility, is defined as the ratio of the minimum expenditure required with the prices of country t to attain the utility level of country b, to the minimum expenditure required to attain this same utility level, when the consumer faces the prices of country r:[5]

$$P^K(t,r,b) = \frac{E(t,b)}{E(b,b)} \tag{2}$$

In other words, country r is the *reference* country and country t is the *base* country. (Clearly, $P^K(r,r,b) = 1$). The base country b might be the same as the reference country $(b = r)$, or the same as the country being compared $(b = t)$, or it might be some other country. In general,

[5] It is convenient if the reference country for the Konüs price index (the country when the index equals 1) is the same as the base country. But nothing important would be changed if we chose r as the reference country and defined the Konüs price index with base country b and reference one r as $P^K(t,b,r) = E(t,b)/E(r,b) = [E(t,b)/E(b,b)]/[E(r,b)/E(b,b)] = P^K(t,b)/P^K(r,b)$.

the Konüs price index depends on both the prices and the specified utility level. However as is well known, the index is independent of the utility level and depends only on the prices if and only if demand is homothetic, i.e. if all income elasticities are equal to one (Konüs, 1939; Samuelson and Swamy, 1974; Deaton and Muellbauer, chapter 7, 1980b).

Let the share of product *i* in total expenditure in country *t*, if utility were fixed at the level of the base country *b*, be $s_i(t,b)$; i.e. the share is a function of the prices prevailing in country *t* and the utility level in country *b*. Applying Shephard's Lemma to the expenditure function, equation (1),

$$s_i(t,b) = \frac{\partial \ln E(t,b)}{\partial \ln p_i(t)}, \quad i = 1,...,N \tag{3}$$

These can be called the hypothetical or *compensated* shares, the shares that would be observed if utility were held constant at some reference level (here, the level prevailing in country *b*), while prices followed their observed pattern across countries. The actual, observed shares in country *t* are

$$s_i(t,t) = \frac{\partial \ln E(t,t)}{\partial \ln p_i(t)}, \quad i = 1,...,N$$

(Note that the compensated shares in the base country *b*, $s_i(b,b)$, are the same as the actual shares in that country).

Now assume that there is a continuum of countries, so we can treat the index *t* as a continuous variable.[6] By totally differentiating the Konüs price index of equation (2) with respect to *t*, we obtain

$$\frac{d \ln P^K(t,r,b)}{dt} = \sum_{i=1}^{i=N} \frac{\partial \ln E(t,b)}{\partial \ln p_i(t)} \frac{d \ln p_i(t)}{dt} = \sum_{i=1}^{i=N} s_i(t,b) \frac{d \ln p_i(t)}{dt} \tag{4}$$

So the level of the Konüs price index in some country *T*, relative to its level in the base country *b*, is found by integration:

$$\ln P^K(T,r,b) = \int_r^T \left[\sum_{i=1}^{i=N} s_i(t,b) \left(\frac{d \ln p_i(t)}{dt} \right) \right] dt \tag{5}$$

The Konüs price index resembles a Divisia index (P^D) which can be written as:

$$\ln P^D(T,r) = \int_r^T \left[\sum_{i=1}^{i=N} s_i(t,t) \left(\frac{d \ln p_i(t)}{dt} \right) \right] dt \tag{6}$$

[6] Assuming a continuum of countries might seem a bit of a stretch given that there are only 146 countries in the 2005 ICP. But it is common elsewhere in economics to assume a continuum of consumers, firms or products.

The only difference between them is that the Konüs index employs the compensated, not the actual, shares as weights (Balk, 2005; Oulton, 2008).[7] However, in the homothetic case the compensated and the actual shares are always the same: $s_i(t,b) = s_i(t,t), \forall i,b$, since shares depend only on prices, not on utility (or real income); that is, the Konüs and Divisia indices are identical. So in this case the task of index number theory is to find the best discrete approximation to the continuous Divisia index of equation (6).

In fact in the homothetic case the problem of estimating true cost-of-living indices and indices of the standard of living, together with their counterparts on the production side, has been solved, at least within the limit of what is empirically possible. The solution was provided by Diewert's superlative index numbers, index numbers which are exact for some flexible functional form (Diewert, 1976). In the homothetic case, the true index is bounded by the Laspeyres and Paasche indices (Konüs, 1939). But superlative index numbers are only guaranteed to be good approximations locally, so they need to be chained together in order to approximate better the continuously changing weights in the Divisia index (6).[8]

Chained, superlative index numbers have usually been employed in time series, but cross-country, multilateral indices like the EKS Fisher indices (used by the OECD-Eurostat countries in the ICP) have similar properties.[9] From the standpoint of consumer theory and the economic approach to index numbers, we can therefore conclude that the multilateral index numbers of the ICP are justified if demand is homothetic.

Unfortunately, an overwhelming body of empirical evidence establishes that consumer demand is *not* homothetic. The most obvious manifestation of this is Engel's Law: the proportion of total household expenditure devoted to food falls as expenditure rises. Since its original publication in 1857, Engel's Law has been repeatedly confirmed. Houthakker (1957)

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[7] Since it is a line integral, the Divisia index is in general path-dependent unless demand is homothetic, as its inventor Divisia (1925-26) was well aware; see Hulten (1973) for detailed discussion and Apostol (1957), chapter 10, for the underlying mathematics. But the Konüs price index is not path-dependent since by definition utility is being held constant along the path (Oulton, 2008).

[8] Diewert (1976) was well aware of the need for chaining: see his footnote 16.

[9] One difference is that the EKS Fisher between (say) the DRC and the U.S. uses as one element a bilateral Fisher between these two countries as well as Fisher indices between all other countries in the comparison. In a time series comparison for say 1990 with 2011, a chain index links together the index for 1990 with 1991 with the index for 1991 with 1992, ... , with the index for 2010 with 2011, but does not use the direct comparison between 1990 and 2011.

showed that the Law held in some 40 household surveys from about 30 countries.[10] Engel's Law also holds in the much more econometrically sophisticated study of Banks *et al*. (1997) on UK household budgets. The prevalence of non-homotheticity is confirmed too by the more disaggregated studies of Blow *et al.* (2004), also on U.K. household budgets, which considered 18 product groups, and Oulton (2008) who considered 70 product groups.[11]

If demand is not homothetic, then superlative index numbers are not guaranteed to be good approximations to Konüs price indices, even locally. In fact the true price index may lie outside the Laspeyres-Paasche spread. And the true price index is no longer unique but depends on the reference level chosen for utility. The fact that the Konüs price index generally varies with the reference utility level is sometimes taken as puzzlingly paradoxical. But it can be given a simple intuitive justification. Consider a household with a very low standard of living spending 60% of its budget on food (as was the case with the working class households studied by Engel in 1857). Suppose the price of food rises by 20%, with other prices constant. Then money income will probably have to rise by close to (0.60 x 20% =) 12%, to leave utility unchanged, since there are limited possibilities for substituting clothing and shelter for food. Compare this household to a modern day British one, spending 15% of its budget on food prepared and served at home (Blow *et al*., 2004). Now the maximum rise in income required to hold utility constant is only (0.15 x 20 =) 3% and probably a good bit less as substitution opportunities are greater.

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[10] Engel's (1857) results for expenditure by households of various income levels in Saxony are described more accessibly in Marshall (1920), chapter IV; see also Chai and Moneta (2010) for a recent account of Engel's work. In each of the surveys that he collected Houthakker (1957) estimated the elasticity of expenditure on food and three other groups (clothing, housing and miscellaneous) with respect to total expenditure and to household size. For each product group, he regressed the log of expenditure on that group on the log of total expenditure and the log of family size. He used weighted least squares on grouped data; individual data was not available to him. The results for food were clear-cut: demand was inelastic with respect to expenditure in every survey. The results for clothing and miscellaneous were equally clear-cut: demand was expenditure-elastic. The result for housing was more mixed.

[11] An exception to this consensus is Dowrick and Quiggin (1997). They studied the 1980 and 1990 PPPs for 17 OECD countries, using 38 components of GDP, and argued that the data could be rationalised by a homothetic utility function. But their anomalous finding may be due partly to the fact that the per capita incomes of these countries were fairly similar, partly to the fact that some of the 38 components were not household spending, and partly to the low power of their nonparametric test (Neary, 2004). By contrast Crawford and Neary (2008) found using nonparametric methods that the cross-country data in Neary (2004) — 11 commodity groups in 60 countries from the World Bank's 1980 ICP — can be rationalised by a single non-homothetic utility function, but not by any homothetic utility function.

This leaves the welfare interpretation of conventional consumer price indices and their cross-country cousins, the Purchasing Power Parities (PPPs) constructed by the OECD and the World Bank, somewhat up in the air. If the true price index depends on the reference level of utility, how are we to interpret real world price indices? The answer in the time series context is that a chained, superlative index is likely to be approximately equal to a true price index with reference utility level at the midpoint of the sample period (Diewert, 1976 and 1981; Feenstra and Reinsdorf, 2000; Balk 2004).[12] For a cross-country comparison, the viewpoint will be that of a "middle" country. While there is nothing wrong with this viewpoint, there is no special reason why the midpoint should be so privileged. There is also the disadvantage that when the number of countries in the comparison is increased (or the sample period is extended), the viewpoint may change.

3.2 Estimating compensated shares: the Taylor series approach

Equation (4) shows that in order to calculate the Konüs price index in practice, we need to know the compensated shares, which differ in general from the actual ones in the non-homothetic case. We seek a way of at least approximating the compensated shares, which cannot of course be directly observed (except for the $s_i(b,b)$ which are both the actual and the compensated shares in country b). We can do this by expressing the actual shares $s_i(t,t)$ in terms of a Taylor series expansion of the compensated shares $s_i(t,b)$ in equation (4) around the point $\ln x = \ln E(t,b)$, i.e. holding prices constant at their levels in country t and

[12] Suppose a utility function exists which rationalises the data but may be non-homothetic. Diewert (1981) showed that there exists a utility level which is intermediate between the levels at the endpoints of the interval under study such that a Konüs price index over this interval, with utility fixed at the intermediate level, is bounded below by the Paasche and above by the Laspeyres. Balk (2004) showed that when the growth of prices is piecewise log linear a chained Fisher price index approximates a Konüs price index over an interval when the reference utility level is fixed at that of some intermediate point in the interval. More precise results are available for specific functional forms. Diewert (1976) showed that a Törnqvist price index is exact for a non-homothetic translog cost function when the reference utility level is the geometric mean of the utility levels at the endpoints; see also Diewert (2009) for extensions. For the AIDS, Feenstra and Reinsdorf (2000) showed that, if prices are growing at constant rates, the Divisia index between two time periods equals the Konüs price index when the reference utility level is a weighted average of utility levels along the path.

varying expenditure (utility):[13] The result after solving for the compensated shares is (see Oulton (2012) for more details):

$$s_i(t,b) = s_i(t,t) - \eta_{i1}\ln\left[\frac{x(t,t)/x(b,b)}{P^K(t,b,b)}\right] - \frac{\eta_{i2}}{2!}\left\{\ln\left[\frac{x(t,t)/x(b,b)}{P^K(t,b,b)}\right]\right\}^2 - \frac{\eta_{i3}}{3!}\left\{\ln\left[\frac{x(t,t)/x(b,b)}{P^K(t,b,b)}\right]\right\}^3 - \ldots, \quad i=1,\ldots,N;\ t\in[0,T] \tag{7}$$

where we have put

$$\eta_{ik} = \left(\frac{\partial^k s_i(\cdot,\cdot)}{\partial \ln E(\cdot,\cdot)^k}\right)_{\substack{\mathbf{p}=\mathbf{p}(t),\\ x=E(\mathbf{p}(t),u(b))}}, \quad k=1,2,\ldots;\ i=1,\ldots,N \tag{8}$$

The partial derivative η_{i1} is the semi-elasticity of the budget share of the *i*th product with respect to expenditure (real income), with prices held constant; it is evaluated at base country utility and at the prices of country *t*. Note that if the share equations are a *k*th order polynomial in expenditure (*x*), then a *k*th order Taylor series is exact for equation (7). If a *k*th order polynomial is a good approximation for the share equations, then a *k*th order Taylor series can be expected to be a good approximation for equation (7).

Equation (7) might not appear to take us very much further since the sought-for Konüs price index appears on the right hand side. But in fact it is the basis for a practical method of estimating the Konüs since it can be solved by iteration, provided that η_{i1} (and the higher order derivatives η_{i2}, η_{i3}, etc, that are required for a good approximation) were somehow known or could be estimated (see the next section on ways to do this). Then we could estimate the Konüs price index using equation (5) and (7). This is because these equations constitute a set of equations for $P^K(t,b,b)$ and hence for $P^K(t,r,b)$,[14] in which the compensated shares and the Konüs price index are the only unknowns; the actual shares $s_i(t,t)$, the money expenditures $x(t,t)$ and $x(b,b)$, and (by assumption) the semi-elasticities are all known.[15]

[13] From (1) and (3), the shares are functions of utility, but from (1) utility is a positive, monotonic function of expenditure when prices are held constant. So the Taylor series expansion can be done in terms of expenditure rather than utility.

[14] From the definition of the Konüs in equation (2), $P^K(t,r,b) = P^K(t,b,b)/P^K(r,b,b)$.

[15] If all the partial derivatives are zero except the first, i.e. all the Engel curves are linear, then the system of equations is linear and so can be solved explicitly.

The procedure to solve these equations is straightforward in principle. First, we need to take discrete approximations. Equations (7) must be understood to hold in discrete not continuous terms, i.e. for $t = 0,1,...,T$. We must also decide how many terms in the Taylor series are required. If the utility function is quadratic in expenditure, then only the first two terms of the Taylor series are needed: see the next section. Equation (5) must be replaced by a discrete approximation, e.g. a chained Törnqvist (P^T) or chained Fisher formula (P^F).

Let us define the following chained, *compensated* index numbers. Each index number is for period t relative to period *r*, with utility held constant at the level of period *b*.

Compensated Törnqvist:

$$\ln P^{CT}(t,r,b) = \sum_{i=1}^{i=N} \left(\frac{s_i(t,b) + s_i(r,b)}{2} \right) \ln \left(\frac{p_i(t)}{p_i(r)} \right) \tag{9}$$

Compensated Laspeyres:

$$P^{CL}(t,r,b) = \sum_{i=1}^{i=N} s_i(r,b) \frac{p_i(t)}{p_i(r)} \tag{10}$$

Compensated Paasche:[16]

$$P^{CP}(t,r,b) = \left[\sum_{i=1}^{i=N} s_i(t,b) \frac{p_i(r)}{p_i(t)} \right]^{-1} \tag{11}$$

Compensated Fisher:

$$P^{CF}(t,r,b) = [P^{CL}(t,r,b) \cdot P^{CP}(t,r,b)]^{1/2} \tag{12}$$

Each of these index numbers is defined in the same way as its empirical counterpart, except that compensated, not actual, shares are used. If $r = t-1$ these compensated indices are the links in the corresponding chained index. The natural choices for discrete approximations to the continuous Konüs price index are either the compensated Törnqvist, equation (9), or the compensated Fisher, equation (12). We now have

Proposition 2 The true index is bounded by the compensated Laspeyres and the compensated Paasche. This is the case when we are looking at links in a chain index, i.e. when we are comparing two adjacent years (or countries):

$$P^{CL}(t,t-1,b) \geq P^{CK}(t,t-1,b) \geq P^{CP}(t,t-1,b) \tag{13}$$

It is also true when we are looking at a bilateral (two-period or two-country) index, comparing year (country) *t* with reference year (country) *r*, with year (country) *b* as the base:

[16] The formula for the Paasche is not the usual one but is mathematically equivalent to the usual one.

$$P^{CL}(t,r,b) \geq P^{K}(t,r,b) \geq P^{CP}(t,r,b) \qquad (14)$$

Proof Since utility is being held constant at its level in period *b*, the proof of Proposition 2 follows similar lines to that of the well-known Konüs (1939) inequalities: see section A.2 of the Appendix to Oulton (2012) for the details.

We also need to take account of the Konüs (1939) inequalities relating *actual* Laspeyres and Paasche price indices to Konüs indices. Denote the *actual* Laspeyres and Paasche price indices for year (country) *t* relative to year (country) *r* by $P^{L}(t,r)$ and $P^{P}(t,r)$ respectively. (So the Laspeyres index uses the weights of year (country) *r* and the Paasche uses the weights of year (country) *t*). Then the Konüs (1939) inequalities state that

$$P^{L}(t,r) \geq P^{K}(t,r,r) \text{ and } P^{P}(t,r) \leq P^{K}(t,r,t) \qquad (15)$$

A Konüs index is only guaranteed to lie within the *actual* Laspeyres-Paasche spread if demand is homothetic so that $P^{K}(t,r,r) = P^{K}(t,r,t)$.

The Laspeyres-Paasche spreads, calculated using either compensated or actual shares, can be used as a check on the accuracy of whatever index number formula is adopted.[17]

Equations (7) now constitute a system of $(N-1)(T+1)$ independent equations since the *N* shares sum to one in each country.[18] Together with (4), this system can be solved iteratively, assuming that the η_{ik} are known:

1. Start with an initial guess at $P^{K}(t,b,b)$: this could be derived as a conventional multilateral index which uses actual not compensated shares.

2. Substitute this estimate of $P^{K}(t,b,b)$ into (7) to get estimates of the compensated shares for each of $N-1$ products and for each of $T+1$ countries; the share of the *N*th product can be derived as a residual.

3. Use these estimates of the compensated shares to obtain a new estimate of $P^{K}(t,b,b)$ from either of the two discrete approximations to (4), the Törnqvist (equation (9)) or the Fisher (equation (12)).[19]

[17] Of all superlative index numbers, only the Fisher is guaranteed to lie within the Laspeyres-Paasche spread (Hill, 2006), assuming all use indices compensated or all use actual shares, and all are chained or all are bilateral. But a *chained* Fisher is not guaranteed to lie within a *bilateral* Laspeyres-Paasche spread.

[18] The actual shares of course sum to one and since they derive from the expenditure function so do the compensated shares: see equation (3).

[19] In step 3 of the algorithm it is assumed that the observations are arranged in a natural order, for example ordered by real income per head. A refinement would be to use Hill's

4. Check whether the estimate of $P^K(t,b)$ has converged. If not, return to step 2.

The intuition behind this result is as follows. In the homothetic case it turns out that we do not need to know the individual parameters of the expenditure function: the observed shares encapsulate all the required information. In the non-homothetic case, we need to know the compensated shares. These can be thought of as like the actual shares, but contaminated by the effects of changes in real income. What is needed is to purge the actual shares of income effects.

So given knowledge of the η_{ik} up to the required order, we can estimate the Konüs price index. Estimating the η_{ik} themselves may still seem a difficult task but notice that only the response of demand to changes in real income needs to be known, not the response to price changes. This is a very significant reduction in the complexity of the task empirically. It is possible that estimates of the η_{ik} are available "off the shelf", from household budget studies. But in the context of the ICP this is not the case. However, as I show later, it is possible to use the data on prices and expenditures generated by the ICP itself to estimate the required income response parameters. To make further progress I turn now to consider systems of demand which are consistent with economic th(16)eory and also seem capable of fitting the data reasonably well.

3.3 Accounting for the differences between Konüs and conventional indices

We have already noted that the Konüs index may lie outside the Laspeyres-Paasche bound in a bilateral comparison using actual shares. But what determines the difference between a conventional chain index and a chained Konüs index? And how will the Konüs be affected by changes in the base? We have already seen that conventional multilateral indices may be thought of as Konüs indices with the middle country taken as base. So a natural comparison is to take either the richest or the poorest country as base. Suppose that the chained Konüs index with the poorest country as base generates a lower standard of living for the poorest country than the conventional index. Does this mean that the Konüs index with the *richest* country as base will generate a standard of living for the poorest country which is *higher* than under the conventional index? The answer is, not necessarily.

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minimum spanning tree approach to minimise the Laspeyres–Paasche spread (Hill, 1999 and 2004).

The only difference between the Konüs index and a conventional one is that the Konüs uses compensated shares and the conventional index actual ones. Let us suppose that both indices employ the Törnqvist form and that the countries are ordered by real consumption per head, in reverse order, i.e. with the *richest* country first. Then the growth rate of the chained Törnqvist approximation to a Konüs price index (P^{CT}) between two adjacent countries, *t*-1 and *t*, is given by (9), setting $r = t-1$, and that of a conventional Törnqvist price index (P^{T}) is:

$$\ln P^{T}(t,t-1) = \frac{1}{2}\sum_{i=1}^{i=N}\left[s_i(t-1,t-1) + s_i(t,t)\right]\ln\left(\frac{p_i(t)}{p_i(t-1)}\right) \qquad (17)$$

(Compensated and actual shares each sum to one in all countries) For both indices, cumulating these changes gives the price level in any country relative to that of the richest country, with a higher price index corresponding to a lower standard of living. By subtracting (17) from (9) we obtain

$$\ln P^{CT}(t,t-1,b) - \ln P^{T}(t,t-1) = \sum_{i=1}^{i=N} m_i(t,t-1,b)\ln\left(\frac{p_i(t)}{p_i(t-1)}\right) \qquad (18)$$

where

$$m_i(t,t-1,b) = \frac{1}{2}\left[s_i(t-1,b) + s_i(t,b)\right] - \frac{1}{2}\left[s_i(t-1,t-1) + s_i(t,t)\right],$$

$$\sum_{i-1}^{i=N} m_i(t,t-1,b) = 0$$

So for any link in the chain, the difference between the Konüs and the conventional index is a weighted sum of the price differences between the two adjacent countries; the weights, which sum to zero, are the excess of the mean compensated shares over the mean actual shares in the two countries.

Now suppose that the base country is the poorest one (i.e. $b = T$). Consider the products for which demand is *inelastic* so that compensated shares are higher than actual shares, i.e. $m_i(t,t-1,T) > 0$, and suppose that the relative prices of these products tend to be higher in low income countries. This means that, for these products, the price difference $\ln(p_i(t)/p_i(t-1))$ is relatively large (recall that the countries are in reverse order of their standards of living). In other words, the $m_i(t,t-1,b)$ are positively correlated with the $\ln(p_i(t)/p_i(t-1))$. So in this case we have $\ln P^{CT}(t,t-1,T) - \ln P^{T}(t,t-1) > 0$. Hence the true price level in the poorest country, measured by the Konüs index, is higher than the conventional measure; consequently the standard of living is lower.

This situation could arise as a result of the well-known Balassa-Samuelson effect: the prices of labour-intensive products, particularly personal services, tend to be higher in rich countries. And these are precisely the products for which income elasticity is greater than one. Putting it the other way round, the prices of products for which demand is income-*inelastic* tend to be higher in poorer countries.

But whether the correlation is positive or negative with the poorest country as base, clearly the sign will be reversed if instead the richest country is the base, since the signs of the $m_i(t,t-1,b) > 0$ will be reversed. This shows that for a single link in the chain, or for a bilateral index, the two Konüs indices must lie on opposite sides of the conventional index.

But what if there are many links in the chain? Then we could get a positive correlation between the $m_i(t,t-1,b)$ and the $\ln(p_i(t)/p_i(t-1))$ for some links and a negative correlation for one or more other links. Consequently it is possible for the two Konüs indices (one with the poorest and the other with the richest country as base) to both be greater or both be less than the conventional chained Törnqvist. This can be illustrated by means of a simple numerical example for the case of two goods and three countries. Consider two goods, 1 and 2, where good 1 is income-inelastic and three countries, A, B and C, where A is the poorest and C is the richest; C is the numeraire country for PPPs with all prices equal to 1. The data necessary to calculate conventional and Konüs chain indices of the Törnqvist form under four different assumptions about relative prices are assumed to be as follows.

Hypothetical two-good, three-country example

	Country		
Shares	*A*	*B*	*C*
Actual share of good 1 (ratio)	0.70	0.60	0.40
Compensated share of good 1			
with poorest country as base	0.70	0.64	0.50
with richest country as base	0.60	0.54	0.40
Relative price of good 1			
Case 1 — good 1 cheap in both A and B	1/5	1/10	1
Case 2 — good 1 expensive in both A and B	5	10	1
Case 3 — good 1 expensive in A, cheap in B	5	1/10	1
Case 4 — good 1 cheap in A, expensive in B	1/5	10	1

Note Compensated shares of good 1 are higher than actual ones for B and C when A (assumed the poorest country) is the base; they are lower than actual ones for A and B when C (assumed the richest country) is the base. These numbers are consistent with the assumption that good 1 is income-inelastic. The share (actual or compensated) of good 2 is one minus the share of good 1.

These data then yield the following results for the ratio of the Konüs to the conventional price index:

Ratio of Konüs to conventional price index

	Base country		*Does the conventional index lie between the two Konüs indices?*
	Poorest (A)	*Richest (C)*	
Case 1 — good 1 cheap in both A and B	0.86	1.01	Yes
Case 2 — good 1 expensive in both A and B	1.16	0.99	Yes
Case 3 — good 1 expensive in A, cheap in B	0.92	0.78	No
Case 4 — good 1 cheap in A, expensive in B	1.09	1.28	No

In Case 1 the income-inelastic good is cheap in both the poorer two countries, so the Konüs index exceeds the conventional one when the poorest country is the base; by the same token the conventional index exceeds the Konüs with the rich country as base. In Case 2 the

income-inelastic good is expensive in both the poorer countries so now the pattern of Case 1 is reversed. In Cases 3 and 4 we have a mixed pattern with good 1 being cheap in one of the poorer countries and expensive in the other. So we see that it is possible for the two Konüs price indices to lie either both below (Case 3) or both above (Case 4) the conventional index.

4 Demand Systems

4.1 The generalised PIGLOG demand system

In the previous section I set out a general method for deriving Konüs indices. To make further progress it is necessary to show how the method can be applied to a demand system which is both flexible and consistent with economic theory. The PIGLOG demand system, introduced by Muellbauer (1976) (see also Deaton and Muellbauer (1980a and 1980b, chapter 3)) has found wide application empirically; an example of the PIGLOG is the AIDS system. The PIGLOG has been extended by Banks *et al*. (1997) and in this form, known as the generalised PIGLOG, the expenditure function is:

$$\ln x = \ln A(\mathbf{p}) + \frac{B(\mathbf{p})}{1-\lambda(\mathbf{p})\ln u}\ln u \tag{19}$$

Here $A(\mathbf{p}) \geq 0$, $B(\mathbf{p}) > 0$ (non-satiation), and $\lambda(\mathbf{p}) \geq 0$. $A(\mathbf{p})$ is assumed homogeneous of degree 1 and $B(\mathbf{p})$ and $\lambda(\mathbf{p})$ homogeneous of degree 0 in prices $\mathbf{p}$; all three functions are assumed differentiable. I follow Banks *et al*. (1997) in specifying that

$$B(\mathbf{p}) = \prod_k p_k^{\beta_k},\ \sum_k \beta_k = 0 \tag{20}$$

and

$$\lambda(\mathbf{p}) = \sum_k \lambda_k \ln p_k,\ \sum_k \lambda_k = 0 \tag{21}$$

Applying Shephard's Lemma, the budget shares in this demand system are:

$$s_i = \frac{\partial \ln A(\mathbf{p})}{\partial \ln p_i} + \beta_i \ln\left[\frac{x}{A(\mathbf{p})}\right] + \frac{\lambda_i}{\prod_{k=1}^{k=N} p_k^{\beta_k}}\left\{\ln\left[\frac{x}{A(\mathbf{p})}\right]\right\}^2,\ i = 1,\ldots,N \tag{22}$$

The presence of the term in squared log expenditure has been found necessary empirically (Banks *et al*., 1997; Blow *et al*., 2004; Oulton, 2008).

In equation (7) above we found a Taylor series expansion for the compensated shares which involved the semi-elasticity of the shares with respect to real income, $\partial s_i / \partial \ln x$, and higher order derivatives, $\partial^2 s_i / \partial \ln x^2$, etc. Now from (22) we get that

$$\frac{\partial s_i}{\partial \ln x} = \frac{\partial \ln B(\mathbf{p})}{\partial \ln p_i} + \frac{2}{B(\mathbf{p})} \frac{\partial \lambda(\mathbf{p})}{\partial \ln p_i} \ln[x / A(\mathbf{p})]$$

$$\frac{\partial^2 s_i}{\partial [\ln x]^2} = \frac{2}{B(\mathbf{p})} \frac{\partial \lambda(\mathbf{p})}{\partial \ln p_i} \tag{23}$$

and higher order derivatives are zero.

These derivatives have to be evaluated when $x = E(\mathbf{p}(t), u(b))$. The simplest way to do this is to adopt the normalisation that $\ln[x(b,b) / A(\mathbf{p}(b)] = 0$. From (19)

$$\ln x(b,b) = \ln A(\mathbf{p}(b)) + \frac{B(\mathbf{p}(b)) \ln u(b)}{1 - \lambda(\mathbf{p}(b)) \ln u(b)} \tag{24}$$

Now choose monetary and quantity units so that $x(b,b) = A(\mathbf{p}(b)$. This is always possible since $A(\mathbf{p})$ depends only on prices while $x = \sum_i p_i q_i$ depends on both prices and quantities. For example, suppose that *x* is initially double $A(\mathbf{p})$ in country *b*. Then increase all quantity units by 100% (e.g. from 1kg to 2 kg) and increase all prices correspondingly by 100%. This doubles $A(\mathbf{p})$ while leaving *x* unchanged. Then under this normalisation (24) implies that

$$\ln u(b) = 0$$

It then follows also from (19) that

$$\ln x(t,b) = \ln A(\mathbf{p}(t)) + \frac{B(\mathbf{p}(t)) \ln u(b)}{1 - \lambda(\mathbf{p}(t)) \ln u(b)} = \ln A(\mathbf{p}(t)) \tag{25}$$

This last result shows that under this normalisation we can interpret $A(\mathbf{p})$ as the Konüs price index with base country *b*. More formally, using the definition of the Konüs price index, equation (2), for the generalised PIGLOG we find that:

$$P^K(t,b) = E(\mathbf{p}(t), u(b)) / E(\mathbf{p}(b), u(b)) = A(\mathbf{p}(t) / A(\mathbf{p}(b) \tag{26}$$

In other words, with this normalisation the Konüs price index is measured by the homothetic part of the expenditure function $A(\mathbf{p})$, so $[x(t,t) / x(b,b)] / [A(\mathbf{p}(t)) / A(\mathbf{p}(b))]$ measures real income relative to its level in country *b*.

We can now use these results to evaluate the derivatives in (23) at the point $x = E(\mathbf{p}(t), u(b))$, $\mathbf{p} = \mathbf{p}(t)$:

$$\eta_{i1}(t,b)=\left[\frac{\partial s_i}{\partial \ln x}\right]_{\substack{\mathbf{p}=\mathbf{p}(t)\\ x=E(t,b)}}=\frac{\partial \ln B(\mathbf{p}(t))}{\partial \ln p_i(t)}+\frac{2}{B(\mathbf{p}(t))}\frac{\partial \lambda(\mathbf{p}(t))}{\partial \ln p_i(t)}\ln\left[\frac{x(t,b)}{A(\mathbf{p}(t))}\right]$$

$$=\frac{\partial \ln B(\mathbf{p}(t))}{\partial \ln p_i(t)}=\beta_i$$

using (20) and (25), and

$$\eta_{i2}(t,b)=\left[\frac{\partial^2 s_i}{\partial[\ln x]^2}\right]_{\substack{\mathbf{p}=\mathbf{p}(t)\\ x=E(t,b)}}=\frac{2}{B(\mathbf{p}(t))}\frac{\partial \lambda(\mathbf{p}(t))}{\partial \ln p_i(t)}=\frac{2\lambda_i}{\prod_{k=1}^{N} p_k^{\beta_k}}$$

using (21). Substituting these results into (7) we obtain

$$s_i(t,b)=s_i(t,t)-\beta_i \ln\left[\frac{x(t,t)/x(b,b)}{P^K(t,b)}\right]-\frac{\lambda_i}{\prod_{k=1}^{N} p_k^{\beta_k}}\left\{\ln\left[\frac{x(t,t)/x(b,b)}{P^K(t,b)}\right]\right\}^2 \qquad (27)$$

and this Taylor series expansion is not an approximation but exact for the generalised PIGLOG.[20]

Therefore in order to implement the procedure outlined above for estimating the Konüs price index, we need to estimate only the N β_i parameters and the N λ_i parameters; in both cases only $N-1$ of these are independent because these coefficients each sum to zero across the products. That is, $2(N-1)$ parameters in total need to be estimated or just two per share equation. These parameters determine the consumer's response to changes in real income. We do *not* need to estimate the much more numerous parameters which determine the response to price changes. This is a huge reduction in the difficulty of the task.

[20] Lewbel and Pendakur (2009) have recently proposed a new demand system, the Exact Affine Stone Index (EASI) system. This has all the advantages of the generalised PIGLOG (and of the QAIDS) while allowing Engel curves to be still more flexible, e.g. polynomials of cubic or higher order. In principle the method developed here could be applied to the EASI system as well. However, I have not been able to develop tractable expressions for the derivatives of the share equations with respect to log expenditure (the η_{ik}). From the point of view of the present paper, the EASI system suffers from the disadvantage that exact aggregation does not hold. This does not matter when the system is fitted to individual data but does when fitted to aggregate data: see below for discussion of aggregation over consumers who may differ in income and in other ways.

4.2 Aggregation over rich and poor consumers

Up to now I have assumed a single representative consumer in each country. But income obviously varies within a given country and not just across countries. So the pattern of spending will vary with the degree of income inequality within a given country, unless demand is homothetic, and we must allow for this.

Let the population be composed of *G* groups. The groups are assumed to be of equal size (e.g. percentiles, deciles or quintiles), with the first group being the poorest and the *G*th group the richest. The fraction of households in each group is then $1/G$. Let x_g be mean expenditure per household in the *g*th group. Within a group, each household's expenditure is assumed the same, namely the group mean. The share of product *i* in the expenditure of the *g*th group, s_{ig} ,is then

$$s_{ig} = \frac{p_i q_{ig}}{x_g}$$

where q_{ig} is the quantity per capita of the *i*th product purchased by each member of the *g*th group. The share of the *i*th product in aggregate expenditure is therefore

$$s_i = \frac{p_i q_i}{x} = \frac{\sum_{g=1}^{g=G} p_i q_{ig}}{Gx} = \sum_{g=1}^{g=G} \left[\frac{x_g}{Gx} \frac{p_i q_{ig}}{x_g} \right] = \sum_{g=1}^{g=G} w_g s_{ig} \tag{28}$$

where w_g is the share of the *g*th group in aggregate expenditure:

$$w_g = \frac{x_g}{Gx}, \quad \sum_{g=1}^{g=G} w_g = 1 \tag{29}$$

I assume that preferences have the Ernest Hemingway property: the rich are different from the poor but only because the rich have more money.[21] So the parameters of the expenditure function are the same for all households. All consumers in a given country are assumed to face the same prices. So from (22), the share of the *i*th product in expenditure by the *g*th group is:

$$s_{ig} = \frac{\partial \ln A(\mathbf{p})}{\partial \ln p_i} + \beta_i \ln \left[\frac{x_g}{A(\mathbf{p})} \right] + \frac{\lambda_i}{\prod_{k=1}^{k=N} p_k^{\beta_k}} \left\{ \ln \left[\frac{x_g}{A(\mathbf{p})} \right] \right\}^2$$

[21] The well-known (though apparently fictional (Clark, 2009)) dialogue runs as follows. Fitzgerald: "The rich are different from us, Ernest". Hemingway: "Yes, Scott, they have more money than we do".

Using (28), the aggregate share equations are weighted averages of the underlying equations for each group:

$$s_i = \sum_{g=1}^{g=G} w_g s_{ig} = \frac{\partial \ln A(\mathbf{p})}{\partial \ln p_i} + \beta_i \sum_{g=1}^{g=G} w_g \ln x_g - \beta_i \ln A(\mathbf{p}) \\ + \frac{\lambda_i}{\prod_{k=1}^{k=N} p_k^{\beta_k}} \left[\sum_{g=1}^{g=G} w_g (\ln x_g)^2 - 2 \ln A(\mathbf{p}) \sum_{g=1}^{g=G} w_g \ln x_g + [\ln A(\mathbf{p})]^2 \right] \tag{30}$$

This shows more precisely how spending patterns depend on income distribution. But it turns out that the budget shares depend on just two statistics of the income distribution which act as "correction factors" for mean expenditure. Define $I = -\sum_{g=1}^{g=G} w_g \ln w_g$, known as entropy (Theil, 1967), and define also the related statistic $J = \sum_{g=1}^{g=G} w_g (\ln w_g)^2$. It is shown in Oulton (2012) that equation (30) can be written in the following form:

$$s_i = \frac{\partial \ln A(\mathbf{p})}{\partial \ln p_i} + \beta_i \left\{ W_1 + \ln \left[\frac{x}{A(\mathbf{p})} \right] \right\} \\ + \frac{\lambda_i}{\prod_{k=1}^{k=N} p_k^{\beta_k}} \left\{ W_2 + 2 W_1 \ln \left[\frac{x}{A(\mathbf{p})} \right] + \left\{ \ln \left[\frac{x}{A(\mathbf{p})} \right] \right\}^2 \right\} \tag{31}$$

where we have set $W_1 = \ln G - I$ and $W_2 = J - 2I \ln G + (\ln G)^2$. In the case of a perfectly equal distribution (when $w_g = 1/G$), note that $I = \ln G$, $J = (\ln G)^2$, and $W_1 = W_2 = 0$, so that (31) then reduces back down to the original formulation, equation (22). Compared to (22), there are two additional variables in (31), W_1 and W_2, though no additional parameters.

The upshot is that the extended PIGLOG model can be further extended to capture the effect of income inequality. The additional empirical requirement is fairly modest: we need to know the shares of different groups in aggregate expenditure, at a reasonable level of detail.

4.3 Aggregation over different household types

Suppose there are a set of *H* characteristics that influence demand, in addition to income and prices. These could include household characteristics such as number of children, average age, and educational level, and also environmental characteristics such as climate. Now the share equations of the generalised PIGLOG for the *g*th income group could be written as:

$$s_{ig} = \frac{\partial \ln A(\mathbf{p})}{\partial \ln p_i} + \beta_i \ln\left[\frac{x_g}{A(\mathbf{p})}\right] + \frac{\lambda_i}{\prod_{k=1}^{k=N} p_k^{\beta_k}} \left\{\ln\left[\frac{x_g}{A(\mathbf{p})}\right]\right\}^2 + \sum_{h=1}^{h=H} \theta_{ih} K_{hg} \qquad (32)$$

where K_{hg} is the level of the *h*th characteristic in the *g*th group; I assume that each household in the *g*th group has the same level of each of the K_{hg} as all the other households in that group (this entails no loss of generality if there is only one household in each group). The θ_{ih} coefficients must satisfy the adding-up restrictions:

$$\sum_{i=1}^{i=N} \theta_{ih} = 0, \quad h = 1, 2, ..., H$$

(At some cost to parsimony, the model could be extended by interacting the characteristic variables with income). Again, underlying preferences are assumed to be the same but people's situations differ for various reasons, in the spirit of Stigler and Becker (1977):[22] at the same incomes and prices, people in cold climates buy more winter clothes. We can aggregate equation (32) over the income groups to obtain the same result as (31), but with an additional term:

$$+\sum_{h=1}^{h=H} \theta_{ih} K_h$$

where $K_h = \sum_{g=1}^{g=G} w_g K_{hg}$. Now K_h is a weighted average of the level of the *h*th characteristic in a particular country. The only difficulty from an empirical point of view is that it is an income-weighted, not a population-weighted, average. So for example if the rich have fewer children than the poor nowadays, then using the mean number of children per household as a measure would be a misspecification when estimating share equations from aggregate data. Since it is difficult to obtain income-weighted characteristics this difficulty is ignored in the empirical work and population averages are employed.

4.4 The equations to be estimated

We now need to write the model in a form closer to what is required for econometric estimation. Start by defining real expenditure as follows:

$$z(t,b) = \ln\left[\frac{x(t,t)}{A(\mathbf{p}(t))}\right] = \ln\left[\frac{x(t,t)/x(b,b)}{A(\mathbf{p}(t))/A(\mathbf{p}(b)}\right] = \ln\left[\frac{x(t,t)/x(b,b)}{P^K(t,b)}\right] \qquad (33)$$

Also let

[22] This approach seems likely to be more fruitful in the present context than assuming that tastes may differ; the latter approach is taken by van Veelen and van der Weide (2008).

$$y(t,b) = \frac{\left[\ln(x(t,t)/A(\mathbf{p}(t))\right]^2}{\prod_{k=1}^{N} p_k^{\beta_k}} = \frac{z(t,b)^2}{\prod_{k=1}^{N} p_k^{\beta_k}} \tag{34}$$

Then the share equations (22) can be written

$$s_i(t,t) = \frac{\partial \ln A(\mathbf{p}(t))}{\partial \ln p_i(t)} + \beta_i z(t,b) + \lambda_i y(t,b) + \sum_{h=1}^{h=H} \theta_{ih} K_h + \varepsilon_i(t) \tag{35}$$

Here we have allowed household and country characteristics to influence budget shares in accordance with (32) and also added an error term, $\varepsilon_i(t)$; the latter is to cover errors in measurement or specification, and also random variations in tastes. If we allow also for income inequality within countries the share equations are:

$$s_i(t,t) = \frac{\partial \ln A(\mathbf{p})}{\partial \ln p_i} + \beta_i w_1(t,b) + \lambda_i w_2(t,b) + \sum_{h=1}^{h=H} \theta_{ih} K_h + \varepsilon_i(t) \tag{36}$$

where we have put

$$w_1(t,b) = W_1(t) + z(t,b)$$

and

$$w_2(t,b) = \frac{W_2(t) + 2W_1(t)\ln\left[x(t,t)/A(\mathbf{p}(t))\right] + \left\{\ln\left[x(t,t)/A(\mathbf{p}(t))\right]\right\}^2}{\prod_{k=1}^{N} p_k^{\beta_k}(t)}$$

$$= \frac{W_2(t) + 2W_1(t)z(t,b)}{\prod_{k=1}^{N} p_k^{\beta_k}} + y(t,b)$$

As argued above, only the income response parameters in the share equations are required in order to estimate the compensated shares (and so the Konüs price indices), not the more numerous price response parameters. Given the number of price parameters, estimating them all will either be impossible given the number of observations available or will at the very least use up too many degrees of freedom. But how can we estimate the income response parameters while avoiding estimating all the other parameters of the system at the same time? After all, if we just estimate the share equations with the price variables omitted then our estimates of the income responses will undoubtedly be biased, since relative prices and real incomes are likely to be correlated across countries. The answer is to collapse the $N-1$ relative prices in the system into a smaller number of variables using principal components.[23] We can collapse the relative price data into (say) *M* principal components, where $M < N-1$ is to be chosen empirically. There is a price to be paid here: we can no longer impose all the

[23] See Johnson and Wichern (2002) for a textbook exposition of principal components.

restrictions required by the theory of demand. We can impose homogeneity by using relative rather than absolute prices, but not symmetry. But as emphasised earlier, we are not trying to test demand theory, but only to use it.

The final step then is to drop the price variables in the term $(\partial \ln A(\mathbf{p}(t)) / \partial \ln p_i(t))$ from (35) and (36), replacing them by M principal components of relative prices. The share equations (35) can now be written in a form suitable for econometric estimation as:

$$s_i(t,t) = \alpha_i^b + \sum_{k=1}^{M} \phi_{ik} PC_k(t) + \beta_i z(t,b) + \lambda_i y(t,b) + \sum_{h=1}^{h=H} \theta_{ih} K_h(t) + \varepsilon_i(t), \quad i = 1,...,N;\ t = 0,...,T \tag{37}$$

where α_i^b is the base-year-dependent constant term ($\sum_i \alpha_i^b = 1$); $PC_k(t)$ is the kth principal component of the $N-1$ relative prices; the ϕ_{ik} are coefficients subject to the cross-equation restrictions $\sum_i \phi_{ik} = 0,\ \forall k$; $\varepsilon_i(t)$ is the error term; and $z(t,b)$ and $y(t,b)$ are as defined by (33) and (34) respectively. When within-country income inequality is allowed for, equations (36) now become

$$s_i(t,t) = \alpha_i^b + \sum_{k=1}^{M} \phi_{ik} PC_k(t) + \beta_i w_1(t,b) + \lambda_i w_2(t,b) + \sum_{h=1}^{h=H} \theta_{ih} K_h + \varepsilon_i(t), \quad i = 1,...,N;\ t = 0,...,T \tag{38}$$

The presence of the principal components (and the household characteristics) in equations (37) and (38) means that the estimates of the coefficients on z and y (or on w_1 and w_2) need not be biased as they would be if prices and characteristics were simply omitted.[24]

Including household characteristics in the model requires that the compensated shares must now be adjusted for these too. One way is to take the viewpoint of the base country: that is, these variables must be set to their levels in the base country. So if the empirical model is that of equation (37), then, based on equation (27), the compensated shares can be estimated by:

$$\hat{s}_i(t,b) = \hat{s}_i(t,t) - \hat{\beta}_i \hat{z}(t,b) - \hat{\lambda}_i \hat{y}(t,b) - \sum_{h=1}^{h=H} \hat{\theta}_{ih} K_h(t) + \sum_{h=1}^{h=H} \hat{\theta}_{ih} K_h(b) \quad i = 1,...,N;\ t = 0,...,T \tag{39}$$

[24] The empirical flexibility of equation (37) could be increased by adding cubic and higher order terms in $z(t,b)$. (The coefficients on these additional terms must be constrained to sum to zero across products). The implied expenditure function could not now be written down in closed form but the share equations extended in this way could be regarded as polynomial approximations to the exact ones. However, in the presence of cubic and higher order terms the property of exact aggregation would no longer hold (Lewbel, 1991), making it hard to interpret the results in terms of individual welfare. See the next section for more on aggregation.

Here the hats (^) denote that an econometric estimate is required. (Hats appear over both z and y since the price index used to deflate nominal expenditure has itself to be estimated). An alternative is to take an "average" viewpoint and set the levels of the household characteristics equal to the world average in which case their contribution is zero. So under this second assumption the compensated shares are:

$$\hat{s}_i(t,b) = \hat{s}_i(t,t) - \hat{\beta}_i \hat{z}(t,b) - \hat{\lambda}_i \hat{y}(t,b) - \sum_{h=1}^{h=H} \hat{\theta}_{ih} K_h(t) + \sum_{h=1}^{h=H} \hat{\theta}_{ih} \overline{K}_h \qquad (40)$$
$$i = 1,...,N; \; t = 0,...,T$$

(Here $\overline{K}_h$ is the cross-country average level of characteristic h). If the empirical model is equation (38), the compensated shares equations must be adjusted in a similar fashion.

We have now reduced the problem to estimating a system of $N-1$ independent equations, each of which contains only $M+3$ coefficients — the θ_{ik} (M in number), α_i, β_i and λ_i.[25] The success of this strategy will depend on whether the variation in relative prices can be captured by a fairly small number of principal components — small that is in relation to the number of countries observed, $T+1$. This is obviously an empirical matter.

Equations (37) and (38) are nonlinear in the parameters of interest, since to measure both z and y correctly it is necessary to know the Konüs price index, the object of the whole exercise; in addition, to measure y we also need to know all the β_i and λ_i. The solution is an iterative process, similar to the one described in section 3.2, though a bit more complicated. Here the unknown parameters, the β_i and λ_i, are estimated jointly with the compensated shares and the Konüs price index. The system consists of equations (37) or (38) and the equation for the Konüs price index, either equation (9) if we use a compensated Törnqvist to approximate the Konüs or equation (12) if we use a compensated Fisher. The iterative process for a particular choice of the base country b is as follows:

1. Obtain initial estimates of the Konüs price index $P^K(t,b,b)$ and of the β_i and λ_i coefficients. An initial estimate of $P^K(t,b,b)$ can be obtained from a conventional multilateral index such as an EKS Fisher using actual instead of compensated shares. And for an initial estimate of the β_i, set $\beta_i = 0, \forall i$.

[25] This is not quite true since all the β_i appear in each equation via the denominator of y. We can handle this by an iterative procedure: see below.

2. Derive estimates of $z(t) = \ln[x(t) / P^K(t,b)]$ and of $y(t) = [z(t,b)]^2 / \prod_k p_k^{\beta_k}$, using the latest estimates of $P^K(t,b,b)$ and of the β_i. Using these new estimates of z and y, estimate equation (37) or (38) econometrically, to obtain new estimates of the β_i and λ_i.
3. Using the new estimates of the β_i and λ_i, estimate the compensated shares from equation (39). Then use the compensated shares to derive a new estimate of the Konüs price index $P^K(t,b,b)$ from equation (9) or equation (12).
4. If the estimate of the Konüs price index has not changed by less than a preset convergence condition, stop. If not, go back to step 2.

Finally, the estimates of the β_i and λ_i produced by the algorithm above can be plugged into the simpler algorithm of section 3.2 to generate Konüs price indices for any other base year.

5. The World Bank's 2005 International Comparisons Program (ICP) [26]

The 2005 ICP was the most comprehensive to date. It included 146 states or territories comprising 95% of the world's population (6.128 billion people).[27] The largest omitted country is Algeria; other absentees include Libya, North Korea and Caribbean nations such as Haiti and Cuba. China was included for the first time ever and India for the first time since 1985. The ICP gathered price data and corresponding expenditures for 129 "Basic Headings" (products) covering the whole of GDP. This project is concerned only with expenditures

[26] The definitive account of the 2005 International Comparison Program (ICP) is the World Bank's Final Report (World Bank, 2008), which supersedes the preliminary report (World Bank, 2007). But this must be supplemented by the "ICP 2003-2006 Handbook" (World Bank, 2005).

[27] The number of countries covered by the ICP has greatly expanded since the program began (World Bank, 2008, Appendix A). Phase I covered 10 countries (Kravis *et al*. 1975), Phase II covered 16 countries (Kravis *et al*. 1978), Phase III covered 30 (Kravis *et al*. 1982), Phase IV, which was benchmarked to 1980, covered 60, Phase V, benchmarked to 1985, covered 64 (United Nations, 1994), and Phase VI, which was benchmarked to 1993, covered 118. Phase VI was carried out on a regional basis. However it is ranked a failure because the cross-regional comparisons are not considered reliable. This failure led to substantial changes in the way that the next and most recent round in 2005 was carried out. Partly because of changes in methodology, the World Bank warns against comparing the 1993 with the 2005 results.

which fall within the category dubbed "Actual Individual Consumption" (AIC), which is split into two components "Individual Consumption Expenditure by Households" (ICHH, 106 Basic Headings) and "Individual Consumption Expenditure by Government" (ICG, 10 Basic Headings): see Table 2. Actual Individual Consumption comprises 116 Basic Headings in all and in total accounted for 69.0% of nominal GDP; Individual Consumption Expenditure by Households accounted for 59.6%. The remaining 13 Basic Headings fall within "Collective Consumption Expenditure by Government", "Gross Fixed Capital Formation" (split into three: "Machinery and Equipment, "Construction", and "Other Products"), "Changes in Inventories and Valuables", and "Balance of Exports and Imports". Together with Actual Individual Consumption, these broad groupings add up to GDP. The World Bank aggregates the Basic Headings within Actual Individual Consumption into 13 product groups: see Table 2. An example of a Basic Heading is "Rice"; another is "Bread", and a third is "Cultural services"; the full list of Basic Headings is shown in Table A1.

The Final Report (World Bank, 2008) contains estimates of PPPs for GDP as a whole, for the 18 product groups in Table 2, and for various major aggregates like Actual Individual Consumption. These high level PPPs were derived as index numbers over the lower level PPPs which were at the Basic Heading level. Basic Headings, which follow the COICOP classification system, are the lowest level for which expenditure data is available from the national accounts. Apart from willingness, this was also the condition for countries' participation in the ICP: the ability to provide expenditure data at the Basic Heading level, though as we shall see this condition was not completely fulfilled in practice by all participants.

The 2005 ICP was carried out in 6 different regional groups: see Table 3. These regional grouping are not primarily geographical though some are, for example "Africa". But "OECD-Eurostat" includes countries both from Europe, from the Middle East (Israel), from North America (the U.S., Canada, and Mexico), and from Asia (Australia, Japan, Korea and New Zealand).[28] The methodology for constructing PPPs at any level above that of the Basic Heading, including GDP, differs between regional groups. Within OECD-Eurostat the EKS-Fisher method was used, within Africa the Iklé method (Iklé, 1972), a variant of Geary-Khamis.

[28] In two cases the same country participated in two regional groupings. Egypt participated in both "Africa" and "West Asia" and Russia in "OECD-Eurostat" and "CIS". In the results presented here Egypt is included under West Asia and Russia under CIS.

There is no such thing as the price of a Basic Heading, even a relatively homogeneous one like "Rice". Rather there are prices for products which fall under the definition of the Basic Heading. There is usually no information on expenditure below the Basic Heading level, so the "price" of the Basic Heading is an unweighted average of the prices of the products classified to that Basic Heading. To identify products suitable for pricing, the World Bank made use of what they called "Specific product descriptions" (SPD): a description of a product which falls under a particular basic heading and for which a price could in principle be collected. A fictional example might be "Basmati rice, 1kg bag". Several or even many SPDs may fall under any Basic Heading.[29] A product suitable for pricing is then one which falls under the SPD for a Basic Heading. A fictional example might be "Waitrose own brand Basmati rice, 1kg bag, purchased in a Waitrose supermarket in London". The price of this product would be collected on a specific date, e.g. July 1st 2005. Prices for the 2005 ICP were in fact collected either monthly (Africa) or quarterly (other regions) during 2005 and then averaged over the year.

The procedure for gathering prices in the ICP was in principle similar to price collection procedures for constructing a Consumer Prices Index (CPI), except that the latter is a time series operation while the ICP is a cross section one. That is, within a Basic Heading the price collectors in each country are trying to gather prices for products which are identical in all relevant respects to the products being priced in every other country in their ICP region. In practice, this aim cannot be achieved completely since not every product is sold in every country. So much of the ICP's work was concerned with filling in the missing prices by various statistical procedures.

The PPPs of one region are linked with those of another through so-called "ring" countries. The ring countries, 18 in number, are a smaller group drawn from all the regions The ring countries participated in a second, more limited price collection programme which established transitive PPPs between these countries for each of the 18 product groups and for GDP. These PPPs could then be used to calculate a PPP for a country in one region with a country in any other region, without affecting the ranking of countries within any region.

[29] In fact, the Specific Product Description for Rice allows for five types (long grain, medium grain, …), five varieties (white, brown, …), two types of preparation (pre-cooked or uncooked) and whether or not the product is organically certified, yielding a potential total of 100 products, with the possibility of individual countries adding to the list if other characteristics are regionally important (World Bank, 2005, chapter 1). Of course, not all countries will have been able to provide prices for all these 100+ products.

PPPs, both the published, high level ones and the unpublished, Basic Heading level ones, are expressed as local currency units per U.S. dollar, which serves as the numeraire. PPPs can be thought of in two ways. First, they are like exchange rates, indeed they are exchange rates for specific products or groups of products. But second, they can be thought of as prices. The corresponding quantity unit for any Basic Heading is the quantity which could have been purchased in the U.S. in 2005 for one U.S. dollar. So, for each country, dividing the PPP for any Basic Heading by the PPP for (say) "Rice" (BH 1) gives a set of relative prices with "Rice" as the numeraire commodity. These relative prices can then be employed in estimating demand systems.

6. The Data

6.1 Data provided by the World Bank

The data employed in this study were kindly supplied by the World Bank. This dataset consisted of expenditures and corresponding PPPs for each of the 129 Basic Headings which make up GDP; the Basic Headings are listed in Table A1 of the Data Appendix. The expenditures and PPPs were for each of the 146 countries that were eventually included in the ICP. That is, there were in all (146 x 129) = 18,834 PPPs and the same number of expenditures, with no missing values. The expenditures are expressed in local currency units and the PPPs as local currency units per U.S. dollar. At the country and Basic Heading level, these data are unfortunately confidential. In addition, the spreadsheet included population and official exchange rates; the latter variable played no role in the estimation results to be reported.

Definition of Household Consumption

In using these data to estimate the share equations, the first issue is, how should total expenditure (which I call Household Consumption) be defined? The World Bank classifies the first 106 Basic Headings to Actual Individual Consumption, but there are some problems. First, BH 106 (Net purchases abroad). This is the difference between expenditure abroad by residents and expenditure at home by non-residents. But it is not allocated by product. In addition, it is zero for 44 countries, i.e. these countries do not make the distinction between resident and non-resident expenditure. Ideally, we would like to exclude foreign purchases

from expenditure on each Basic Heading while including residents' purchases abroad, again broken down by Basic Heading. Then foreign as well as domestic prices would have to be included as explanatory variables in the demand system. This is not feasible, so the simplest solution is just to exclude BH 106 from Household Consumption.

Second, Financial Intermediation Services Indirectly Measured or FISIM (BH 103) is zero for 42 countries, in fact for most countries outside of the OECD-Eurostat region, and it is (puzzlingly) negative for three countries. So I decided to exclude it from Household Consumption, which is thus the total of expenditure on BH 1-102, 104 and 105.

Finally, even this total does not correspond exactly to actual spending by households. The reason is that the World Bank included part of Individual Consumption Expenditure by Government under expenditure classified to the corresponding Basic Headings in the data that they sent me. Consequently, some Basic Headings which occur in the classification (see Appendix C of World Bank (2008)) do not appear in the data. There are no PPPs and no expenditures for the following categories:

Code	*Name*
130111	Housing (1 BH)
130210	Health benefits and reimbursement (1 BH)
130211	Medical products, appliances and equipment (3 BH)
130212	Health services (4 BH)
130300	Recreation and culture (1 BH)
130411	Education benefits and reimbursements (1 BH)
130420	Production of education services (1 BH)

The reason is that expenditure under these headings is included under similar Basic Headings for individual consumption by households. The importance of this feature of the data can be gauged by comparing total expenditure over BH 1-106 (the data sent to me) with the published total for Actual Individual Consumption (World Bank, 2008). For the Africa, South America and West Asia regions the difference was essentially zero. For the other regions it was larger. For countries in the Asia/Pacific region the calculated total exceeded the published one by on average 3.1% (with a maximum of 13.0%), for those in the CIS by 4.6%, and for those in the OECD-Eurostat region by 9.3% (with a maximum of 21.8%).[30]

[30] These percentage differences also include the effect of distributing expenditure by NPISH amongst corresponding Basic Headings for households. But this latter effect is comparatively small: see the next paragraph.

NPISH

Actual Individual Consumption includes consumption by Non-Profit Institutions Serving Households (NPISH). According to footnote g to Table 3 of the Final Report (World Bank, 2008): "The difference between the actual individual consumption and the sum of individual consumption expenditure by households and individual consumption expenditure by government is NPISH for OECD-Eurostat and CIS regions." In other words, in all other regions expenditure by NPISH is included in household expenditure. For the OECD-Eurostat and CIS regions, we can calculate NPISH expenditure by subtracting the sum of household and individual government expenditure from Actual Individual Consumption. But we can only derive total NPISH expenditure: we do not know its distribution across the 13 product groups, still less across the 106 Basic Headings. NPISH expenditure is about 3% of Actual Individual Consumption for OECD-Eurostat countries and 1.2% for the CIS countries. The maximum share of NPISH expenditure in AIC is 3.5% (Ireland and Luxembourg). Note however that in the U.S. NPISH expenditure is recorded as zero, so clearly the US is an exception within the OECD-Eurostat region. The upshot is that for most countries, including the US, household consumption includes expenditure by NPISH, both in total and at the group (and BH) level. In comparing the standard of living of (say) the UK with the US, we should allow for the fact that household expenditure excludes NPISH in the UK but not in the US.

Zero expenditures

Though there are no missing values in the dataset, there are a considerable number of zero values for expenditure; that is, it has been possible to collect the prices of some products even though no-one is (apparently) spending any money on them. It may be that "zero" expenditure just means negligibly small, but in most cases it probably reflects deficiencies in the consumer surveys on which the national accounts rest. In all there were 480 zeros recorded amongst the 105 Basic Headings covering household consumption, i.e. Basic Headings 1-105, or 3% of the total of (146 x 105 =) 15,330 expenditures.

There are 22 Basic Headings where more than 5 countries record zero expenditure. these are listed in Table 4, in descending order of the number of countries. The Basic Heading with the largest number of zeros is Prostitution, where 81 countries report no expenditure. Even some countries where prostitution is legal report zero expenditure.

There are also some countries which report an anomalously large number of zeros. Table 5 lists the top 11 countries for zero expenditures. These 11 countries accounted for 40% of all

the zeros. In the end I decided to exclude the top 5 countries in Table 5 from the demand analysis (Comoros, Angola, Djibouti, Tanzania from the Africa region and the Maldives from Asia/Pacific), on the grounds that their expenditure data are unreliable. Though zero expenditures are commonest in the Africa region, they are not unknown elsewhere: one large and wealthy OECD country records zero expenditure for Lamb, mutton and goat (BH 9) and for Package holidays (BH 92).

A considerable further reduction in the number of zeros was achieved by aggregating a few Basic Headings. Expenditure on Prostitution (BH 98) was added to expenditure on Other Services n.e.c (BH 105). Expenditure on Combined transport (BH 76) was distributed across Rail, Air, Road and Water transportation (BH 72-75). Rail (BH 72) and Water (BH 75) were amalgamated. Package holidays (BH 92) was amalgamated with Air transport (BH 74).

The result is that the overall total expenditure in Household Consumption still covers BH 1-102, 104, and 105, but the total number of Basic Headings and PPPs is now 100, for each of 141 countries.

6.2 Background variables

The aim here was to gather all the variables which might conceivably influence spending patterns apart from prices and incomes. But a constraint was the need for the variables to be available for all the 141 countries eventually selected for analysis. The variables which I was able to find fell into 10 categories:

1. Climate (5 variables: rainfall, maximum temperature, minimum temperature, proportion of frost days, and distance from the equator)
2. Religion (4 variables: proportions of the population that are Christian, Muslim, Buddhist, and Hindu)
3. Hegemony and culture (7 dummy variables: U.S., U.K., French, Belgian, Russian, or Portuguese hegemony, and Arab culture)
4. Health (3 variables: life expectancy, infant mortality, and public expenditure on health as percent of GDP)
5. Education (3 variables: proportion of the population over 25 that has at most primary, secondary or higher education)
6. Urbanisation (1 variable: the proportion of the population living in cities))

7. Policy (1 variable: openness to international trade, [exports + imports]/GDP, adjusted for population size)
8. World Bank ICP region (5 dummy variables)
9. Demography (2 variables: the proportion of the population under 15 and the proportion over 64)
10. Inequality (2 variables: *I* and *J*, defined above in section 3)

The case for including the climate variables is obvious: people spend more on winter clothes in cold climates. The case for religion is equally clear, if only because of the well-known prohibitions on pork (BH 7) and alcohol (BH 30-32). The hegemony variables are intended to capture the idea that a hegemonic power may influence the spending patterns of the countries over which hegemony is or was exercised. "Hegemony" is a wider concept than colonialism. Thus Egypt was never a British colony and an Egyptian government always ran Egypt even during the heyday of the British Empire. It is just that the British government controlled the Egyptian one. The European empires (along with that of Japan) have all been dismantled but it is possible that their now vanished hegemony still influences spending patterns. For example, more than sixty years after independence Indians and Pakistanis are still devoted to cricket. Whether such persistence will show up in spending patterns at the level of the Basic Headings of the ICP is more open to question. In accordance with the Monroe Doctrine, the U.S. is assigned hegemony over the 11 South American countries (including Mexico) in the sample plus Liberia and the Philippines. In the approach here a country is only subject to at most one hegemon. But some countries have been subject to more than one. E.g. Iraq is counted as subject to British hegemony even though its territory once formed part of the Ottoman Empire. Being subject to the Ottoman Empire is counted as too remote in time to influence current spending patterns, as is being subject to the Spanish Empire in the case of South American countries. Other possible hegemons are the Netherlands and Japan, but these would only account for respectively one and two countries in our sample. "Culture" captures a different but related notion, the idea for example that Tunisian Muslims have something in common with Syrian Christians which may influence their spending patterns, namely Arabic language and culture. Another possible culture variable is Slav culture but this would largely overlap with the Russian hegemony group, as would Hispanic culture with the U.S. hegemony group (except for Brazil and Liberia).

Amongst the health variables, life expectancy may proxy for average age, and public expenditure on health may directly influence private expenditure. It is a commonplace that

education changes peoples' tastes. Openness to international trade, by making available a wider range of goods, may also change tastes, as may living in cities.

Household size or number of children per household has always been found significant in household budget studies. The two demographic variables are intended to proxy for these. The two inequality variables are the ones shown earlier to be appropriate to demand analysis. ICP region dummies are included since these will pick up any methodological differences between the regions.

Thus there are in all 33 background variables which I have been able to find. But this number falls to 30 if the three educational variables, which (even after some extrapolation) are available for only 105 countries, are excluded. A full description and sources are given in the Data Appendix.

7. Models and Results

7.1 The models

Based on equations (37) and (38), four models have been fitted to the data. The models were distinguished by the expenditure variables included on the right hand side:

Model I — z is the only real income variable (simple PIGLOG: equation (37) with $\lambda_i = 0, \forall i$)

Model II — w_1 is the only real income variable (simple PIGLOG with allowance for within-country inequality: equation (38) with $\lambda_i = 0, \forall i$)

Model III — z and y are the real income variables (generalised PIGLOG: equation (37))

Model IV — w_1 and w_2 are the real income variables (generalised PIGLOG with allowance for within-country inequality: equation (38))

Each of these models can be fitted with and without the background variables. And there are two ways in which the background variables can be included in the estimates of the standard of living. First, compensated shares can be measured with the background variables set to the levels of the base country. Second, the background variables can be set to world average levels. So there are three sets of results to report for each model and for each base country. Any one or all of the 141 countries could be chosen as the base country. In fact, two countries were chosen, the poorest and the richest. The poorest country as measured by real household consumption per head (whatever deflator is used for nominal consumption) is the Democratic

Republic of Congo (DRC) and the richest is the United States. So there are in all (4 x 3 x 2 =) 24 sets of results to report.

The background variables numbered 30 (the educational variables had to be excluded in order to cover the whole sample). The reason for showing results both with and without the background variables is that these variables are not necessarily independent of real income or real consumption. For example Masters and McMillan (2001) have argued that a tropical climate is a cause of low incomes. Certainly we can expect many of the background variables to be correlated with the level of development, either because they are causative or because both the background variables and real income are determined by common factors.

In addition to the background variables each model included 24 principal components of the 99 log relative prices; these principal components accounted for 91% of the variation in the log relative prices. (The first principal component accounted for 36% and the first ten accounted for 80% of the variation). A conventional measure of real expenditure is significantly correlated with only the first two of these principal components. Since we have 141 observations it would have been possible to include all the 99 relative prices, but this would have severely reduced the number of degrees of freedom, especially since as we shall see the inclusion of a large number of background variables is empirically justified. Recall that our main aim in including the price variables is to avoid biasing the estimates of the coefficients on the expenditure variables.

The estimation method was OLS which automatically imposes the adding-up restrictions on the coefficients. Since the same variables are included in all equations, OLS is equivalent to SUR here. The algorithm set out in section 3.6 was applied with 60 iterations. But before getting to the results, I discuss some preliminary tests.

7.2 Preliminary tests

Though this paper does not seek to test the theory of demand, it is nonetheless encouraging that the data seem to be at least consistent with the theory and that the theory has explanatory power. Evidence for this comes from seeing how much explanatory power each group of variables has. I fitted models I-IV with first of all just prices (the 24 principal components of the 99 log relative prices) and the expenditure variables included and then added each of the nine groups of background variables in turn. (For the purposes of this test I did not iterate the system). At each stage I calculated the mean R^2 across the 100 regressions: see Table 6. With no background variables at all, the models explain on average 37-38% of the cross-country

variation in budget shares. With all nine groups of background variables included (30 variables in all), this percentage rises to 58-59%. (Note that there is quite a lot of variation in budget shares to explain: see Appendix Table A3). When the groups are entered sequentially, culture, climate and religion seem the most important, but it is interesting that the five ICP region dummies still add some explanatory power, even when all other background variables have already been included. This may reflect differences in the implementation of the ICP between different regions. Of course, the order in which different groups are entered may affect the apparent importance of different groups but entering the background groups sequentially in the reverse order produced similar results. Finally, if all background and expenditure variables are excluded, i.e. only prices and a constant are included, the mean R^2 falls to 0.0646. Including the background variables in addition to prices and a constant raises R^2 to 0.2420. But this is considerably less than the effect of including just log expenditure in the regressions in addition to prices and a constant (this is Model I with no background variables), which raises R^2 from 0.0646 to 0.3716 (see Table 6 again for the latter figure).

There are two important takeaways from Table 6. First, there is strong empirical support for the importance of non-homotheticity in demand. Second, there is strong empirical support for the inclusion of background variables in the model.

7.3 Econometric results for models I-IV

A summary of the results for models I-IV, fitted with and without the background variables, appears in Table 7.[31] These results take the poorest country, the DRC, as the base. The real income variables contribute a lot of explanatory power as we have just seen and in addition they are often individually significant. E.g. for model IV, w_1 is significant at the 5% level in 18 cases when background variables are included and w_2 is significant at the 5% level in 12 cases (in 31 and 16 cases respectively when background variables are excluded). Suppose that the expenditure variables should not be included in these regressions because demand is homothetic. Then if they were, wrongly, included one would expect them to be significant about 5 times in 100 regressions at the 5% level. In fact the number of cases where they are significant comfortably exceeds this threshold. I take this to be further confirmation that demand is not homothetic.

[31] The estimated values of the coefficients on the income variables in Models II and IV (w_1 and w_2), the β_i and λ_i, together with robust *t* statistics, appear in Appendix Table A5.

A worrying feature revealed by Table 7 is the large number of compensated shares which are initially estimated to be negative (the "negative raw compensated shares"). As well as the *number* of negative raw compensated shares, their average *size* is also relevant. Table 7 shows that the average size is quite small: between -0.64% and -0.69% when background variables are included. This lessens the concern somewhat. Nevertheless negative compensated shares are economically impossible so they must be adjusted in some way to be non-negative while ensuring that the total of all compensated shares still adds to one (100%). The procedure adopted was in several stages. First, if a compensated share for a particular country was initially negative, it was set equal to the actual share in the base country, after adjusting the latter to reflect differences in prices between the base country and the country in question (using the estimated contribution of the price variables in the two countries to do this). Second, if the result was still negative, then the compensated share was set equal to the actual share in the base country, without adjusting for prices. Then each compensated share was multiplied by a common factor so that the sum of the shares again equalled one. After that process was completed, there are no more negative compensated shares and the number of zero compensated shares is about the same as the number of zero actual shares.

Though this fixes the problem, we still want to know why it occurs. Looking at equations (39) for the compensated shares, at first it seems obvious that they can yield a negative answer when the poorest country is the base. With 100 products, each share on average is only 1% and there is a huge range of real income. So it would seem easy for the left hand side of these equations to be negative in the case of income-elastic products (i.e. when $\beta_i > 0$ in the linear case of model I). But this is not the whole story since the β_i and λ_i are themselves estimated from data on actual shares which are never negative. Indeed, if the only variable on the right hand side of the share equations were (log) real income (z), and the model fitted perfectly, then negative estimates of compensated shares would never arise. However, prices and background variables also play a role and the fit is imperfect. Chart 5 illustrates this point. Here the solid line shows the Engel curve for some product; its lower point is the estimated actual share observed in the DRC. In the "ideal" case its upper point would be the estimated actual share observed in the richest country, the U.S. But because of differences in prices or background variables the actual U.S. share can lie below the solid line (the "realistic" case). The dashed line shows the effect of projecting backwards from the estimated actual U.S. share to get the compensated share, which can clearly yield a negative result. Adding some curvature to the Engel curve (as with models III or IV) may help but cannot

eliminate the problem. The fact that negative estimated compensated shares are possible is a limitation of the PIGLOG model.[32]

7.4 New estimates of the standard of living using Konüs PPPs

Table 8 compares summary statistics of the standard of living for the four models (detailed results for each country are in Appendix Table A4). The upper panel reports Konüs indices of household consumption per head with the DRC as the base, the lower panels with the U.S. as the base. The models are estimated either with background variables included in the regressions and affecting the compensated shares or with background variables excluded altogether. When background variables are included in the regressions, the compensated shares can be calculated either with the effects of background variables set to those of the base country or to world average levels. So for each model and each base country there are three sets of results.

Excluding background variables reduces measured global inequality for each of models I-IV, whichever country is taken as the base. But that background variables should be included is strongly suggested by Table 6. Whether background variables are standardised to those of the base country or to world average levels makes little difference: the standard deviation and the spread between richest and poorest are very similar. The other interesting fact to emerge from Table 8 is that allowing for within-country inequality (i.e. comparing model II with model I or IV with III) significantly increases global inequality when the poorest country is the base but has the opposite effect when the richest country is the base.

Given the econometric results, from now on I concentrate on models I-IV with background variables included in the regressions and compensated shares standardised to those of the base country. And I focus particularly on Model IV since this is the most satisfactory from a theoretical and empirical viewpoint.

How different are the Konüs results from those generated by conventional index numbers? The answers are in Table 9. It will be seen that in every case the Konüs measures suggest greater inequality than the two conventional multilateral ones (when Household Consumption is deflated by either my own EKS Fisher PPP or by the World Bank's PPP for Individual Consumption by Households). The conventional measure which comes closest is

[32] I also tried a less theory-bound approach, estimating a model with a fifth order polynomial in log real income (z). But this did not reduce the number or mean size of the negative raw compensated shares.

the bilateral one which uses U.S. weights in the price index. Charts 6-9 plot each of the four Konüs measures of the standard of living (with the DRC as base) against the conventional EKS Fisher one. The Konüs measures and the conventional one are nearly identical at income levels below the median country (Tunisia) but above the median there is an increasing divergence. So the Konüs stretches out the global income distribution for countries above the median.

Three findings stand out from Table 9. First, according to Model IV (with background variables standardized to base country levels) the gap between richest and poorest is 11% wider than according to the conventional multilateral (EKS Fisher) measure when the DRC is the base and 23% wider when the U.S. is the base. Second, the gap is wider using Konüs measures than conventional ones, whichever country is the base. Third, for all models the gap is wider when the richest country is the base than when the poorest one is. Though this finding may seem paradoxical, we have already seen that it is quite possible in theory (see section 3.3). Finally, Table 10 shows that though estimates of the gap differ somewhat across models and bases, all the Konüs measures show very similar rankings in the sense that they are all highly correlated.

Do these new measures of the standard of living satisfy the criterion derived in section 3 that they should lie within the Laspeyres-Paasche spread? The Laspeyres-Paasche spread for the compensated *chain* indices turns out to be wide and there are no violations. The spread for the compensated *bilateral* indices is much narrower. Chart 10 plots the compensated *bilateral* Laspeyres (U.S. weights) and the *bilateral* Paasche (own weights) indices against the compensated *chained* Törnqvist with the DRC as the base (and reference country), distinguishing between countries below and above the median standard of living. Chart 11 does the same for the U.S. as the base country (with the DRC still the reference). The Konüs measures generally lie within the spread between a compensated Laspeyres and a compensated Paasche, as required by Proposition 2 above. For Model IV there are no violations of the bilateral bounds when the DRC is the base. When the U.S. is the base 10 countries violate the bilateral Laspeyres lower bound, by an average of 7%; 3 countries violate the Paasche upper bound by an average of only 1%.

But we must also take account of the restrictions implied by the well-known Konüs (1939) inequalities relating the Konüs to *actual* Laspeyres and Paasche indices: these are stated in equation (15) in Section 3. They imply that when household consumption is deflated by a bilateral Laspeyres price index, which weights individual PPPs by *actual* U.S. shares,

the result is a *lower* bound to the Konüs measure with the *poorest* country taken as the base. In the notation of Table 1:

$$Q^L \leq Q^K_{\cdot,DRC}$$

Also, when household consumption is deflated by a bilateral Paasche price index, which weights individual PPPs by each country's own *actual* shares, the result is an *upper* bound to the Konüs measure when the *richest* country is taken as the base:

$$Q^P \geq Q^K_{\cdot,US}$$

Using the theoretically preferred Model IV, seven countries (all within the OECD-Eurostat group) infringe the Paasche upper bound, though by an average of only 2% (Chart 13). But 49 countries infringe the Laspeyres lower bound, by an average of 8% (Chart 12). However, if we adjust for these infringements by setting the Konüs measure ($Q^K_{IV,DRC}$) equal to the Laspeyres bound in these cases, we find that the mean is now 56.5, the median is 27.0, the standard deviation is 61.9 and the maximum is 247.8, little changed from the unadjusted values. The conclusion then remains that global inequality in living standards is higher than suggested by conventional multilateral indices.

All the estimates of the standard of living reported here use the same ordering for the countries in the chain index, namely the one generated by the EKS Fisher index. But some experiments indicate that the estimates can be sensitive to the ordering of the countries. This suggests that the minimum-spanning-tree approach might be fruitfully used to refine the estimates, but this is beyond the scope of the present paper.

8. Conclusions

This paper has set out a new method for estimating true (Konüs) PPPs, based on the theory of consumer demand and of Konüs cost-of-living indices. The idea is to estimate the compensated shares of each commodity in the household budget and then to use these compensated shares in place of the actual ones in the index number which is the overall PPP. Compensated shares are related to actual shares but, unlike for the latter, utility is held constant at some given level while prices can vary. To derive compensated shares from actual ones we need to estimate the semi-elasticities of the budget shares with respect to income (expenditure). This has been done by fitting a model of consumer demand econometrically

using the same data as underlie the World Bank's overall PPPs, namely PPPs at the Basic Heading level together with the corresponding expenditures. The econometric analysis has also taken account of background variables which may influence spending patterns independently of prices and income.

The aim of the exercise has not been to *test* the theory of consumer demand, which is best done at the household level, but rather to *use* it to obtain better estimates of the standard of living across the world. Nonetheless, some interesting facts have emerged about the structure of demand at the level of the 100 Basic Headings within Household Consumption. On average we have been able to explain about 59% of the variation in budget shares across our 141 countries using prices, income (expenditure), and background variables such as religion, culture, and climate as explanatory factors. Strong support for non-homotheticity has also emerged.

Household Consumption deflated by these new, Konüs PPPs answers the question: by how much must the average expenditure per head of poor country A be increased to enable the typical inhabitant of A to enjoy the same utility level as the typical inhabitant of rich country B? These new estimates of the standard of living show a substantially greater dispersion across countries than when consumption is deflated by conventional multilateral PPPs: the standard of living in the poorest country, with the poorest country as the base, is now only 89% of the level estimated using conventional multilateral PPPs (using the preferred model IV). Surprisingly, when we take the viewpoint of the richest country, the poorest country does even worse, with only 81% of the richest country's standard of living.

Finally, it is important to distinguish between the standard of living and productivity. If this paper is correct that the standard of living in the poorest countries is only 88% of the level as conventionally measured, this does not necessarily mean that productivity is correspondingly lower (though it might be). So it does not necessarily follow that the poorest countries will take proportionately longer to catch up. Measuring productivity correctly raises similar issues to measuring the standard of living. For the latter, the issue is whether tastes are homothetic, for the former whether there are input-biased economies of scale or input-biased technical progress in production. These are different issues though conceptually they can be resolved in a similar way (Oulton, 2012). The data underlying the ICP come from the expenditure side of the national accounts. To study productivity we need to employ a comparably detailed dataset from the output side.

Tables

Table 1
Real household consumption per head for 146[a] countries:
effect of different deflators, summary statistics (poorest country (DRC) = 1.0)

	Deflator				
Statistic	*Exchange rate*	*World Bank PPP*	*Multilat-eral PPP (EKS Fisher)*	*Bilateral PPP (own weights)*	*Bilateral PPP (U.S. weights)*
Mean	70.7	50.3	49.9	46.6	49.6
Median	22.3	27.6	26.7	27.3	25.1
S.D.	101.0	54.5	53.5	46.6	56.4
Minimum	1.0	1.0	1.0	1.0	1.0
Maximum	397.4	235.9	223.9	190.6	247.8

a. 145 countries when exchange rate used as deflator (Zimbabwe is missing).

Notes Poorest country is Democratic Republic of Congo (DRC), richest is U.S. Household consumption is sum of Basic Headings 1-102, 104 & 105: see Appendix Table A1 for the list of Basic Headings. "World Bank PPP" is the World Bank's PPP for Individual Consumption by Households. The other PPPs are my own. The bilateral PPP with own weights uses each country's expenditure shares in turn to weight the individual PPPs. The bilateral PPP with U.S. weights uses just U.S. budget shares to weight the individual PPPs.

Source Columns 2 and 3: World Bank (2008). Columns 4, 5 and 6: unpublished World Bank spreadsheet and own calculations.

Table 2
Nominal expenditures, total of 146 countries, 2005

Expenditure category	*US$ millions*	*% of GDP*
Gross Domestic Product (GDP)	44,308,655	100.0
Actual Individual Consumption (AIC)	30,589,668	69.0
1. Food and non-alcoholic beverages	*3,732,593*	*8.4*
2. Alcoholic beverages, tobacco and narcotics	*770,785*	*1.7*
3. Clothing and footwear	*1,347,848*	*3.0*
4. Housing, water, electricity, gas and other fuels	*5,150,837*	*11.6*
5. Furnishings, household equipment and maintenance	*1,462,563*	*3.3*
6. Health	*3,889,634*	*8.8*
7. Transport	*3,188,073*	*7.2*
8. Communication	*687,049*	*1.6*
9. Recreation and culture	*2,345,884*	*5.3*
10. Education	*2,352,264*	*5.3*
11. Restaurants and hotels	*1,850,520*	*4.2*
12. Miscellaneous goods and services	*3,825,619*	*8.6*
13. Net purchases from abroad	*-14,001*	*0.0*
Individual Consumption Expenditure by Households (ICHH)	*26,387,370*	*59.6*
Individual Consumption Expenditure by Government (ICG)	*3,891,326*	*8.8*
Individual Consumption by NPISH	*310,972*	*0.7*
Collective Consumption Expenditure by Government (CCG)	3,795,101	8.6
Gross Fixed Capital Formation (GFCF)	9,570,631	21.6
Machinery and equipment	3,351,597	*7.6*
Construction	5,293,992	*11.9*
Other products	925,042	*2.1*
Changes in Inventories and Valuables (CIV)	297,773	0.7
Balance of Exports and Imports (BXM)	55,481	0.1

Source Final Report, Table 3 (World Bank, 2008).
Notes Expenditures converted to U.S. dollars using official exchange rates. AIC is the total of expenditure on the 13 product groups. NPISH expenditure is derived as AIC *minus* ICH *minus* ICG. GDP = AIC + CCG + GFCF + CIV + BXM.

Table 3
ICP regions

ICP region	*Number of countries*	*Population (millions)*
Africa	47	756
Asia/Pacific	23	3,346
West Asia	11	176
South America	10	366
CIS	10	247
OECD-Eurostat	45	1,238
Total	146	6,128

Source World Bank (2008).

Table 4
Number of countries reporting zero expenditure for selected Basic Headings, in descending order

BH Number	*Basic Heading*	*Number of countries*
98	Prostitution	81
76	Combined passenger transport	53
106	Net purchases abroad	44
103	FISIM	42
72	Passenger transport by railway	22
90	Games of chance	20
92	Package holidays	20
75	Passenger transport by sea and inland waterway	16
104	Other financial services n.e.c.	15
87	Veterinary and other services for pets	14
7	Pork	11
86	Gardens and pets	10
31	Wine	9
42	Miscellaneous services relating to the dwelling	9
77	Other purchased transport services	9
101	Social protection	9
30	Spirits	8
32	Beer	7
48	Repair of furniture, furnishings and floor coverings	7
54	Major tools and equipment	7
83	Repair of audio-visual, photographic and information processing equipment	7
105	Other services n.e.c.	7

Source Unpublished World Bank spreadsheet.

Table 5
The 11 countries recording the largest number of zero expenditures for Basic Headings within Household Consumption (BH 1-105).

Country	*ICP region*	*Number of zeros*
Comoros	Africa	42
Angola	Africa	26
Djibouti	Africa	21
Tanzania	Africa	19
Maldives	Asia/Pacific	18
Zambia	Africa	13
Bhutan	Asia/Pacific	13
Lao PDR	Asia/Pacific	11
Ethiopia	Africa	10
Rwanda	Africa	10
Bangladesh	Asia/Pacific	10
TOTAL		193

Source Unpublished World Bank spreadsheet.

Table 6
Effect of adding additional groups of background variables on the explanatory power of the demand system model

		Model I		*Model II*		*Model III*		*Model IV*	
Background variable group	*No. of variables in group*	*Mean R^2*	*Change*	*Mean R^2*	*Change*	*Mean R^2*	*Change*	*Mean R^2*	*Change*
None	0	0.3716	-	0.3588	-	0.3810	-	0.3800	-
Religion	4	0.4067	*0.0351*	0.3951	*0.0363*	0.4160	*0.0350*	0.4156	*0.0356*
Climate	5	0.4425	*0.0358*	0.4310	*0.0359*	0.4517	*0.0357*	0.4515	*0.0359*
Health	3	0.4626	*0.0201*	0.4523	*0.0213*	0.4716	*0.0199*	0.4712	*0.0196*
Culture	7	0.5141	*0.0515*	0.5054	*0.0531*	0.5228	*0.0513*	0.5234	*0.0522*
Urbanisation	1	0.5190	*0.0050*	0.5105	*0.0051*	0.5278	*0.0050*	0.5287	*0.0053*
Policy	1	0.5260	*0.0069*	0.5176	*0.0071*	0.5340	*0.0062*	0.5346	*0.0059*
Demography	2	0.5367	*0.0107*	0.5289	*0.0113*	0.5446	*0.0105*	0.5449	*0.0103*
Inequality	2	0.5507	*0.0140*	0.5434	*0.0146*	0.5600	*0.0154*	0.5601	*0.0152*
ICP region	5	0.5791	*0.0284*	0.5722	*0.0287*	0.5888	*0.0289*	0.5890	*0.0289*

Note
Explanatory power is measured by the mean R^2 across 100 regressions in which the dependent variable is the share of each Basic Heading in total Household Consumption. All regressions included 24 principal components of the 99 log relative prices and a constant as well as the expenditure variables (deflated by conventional PPPs). Estimation is by OLS.

Source Unpublished World Bank spreadsheet and own calculations.

Table 7
Regression results for models of household demand: poorest country (DRC) is base

	Model I		*Model II*		*Model III*		*Model IV*	
Background variables included?	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Number of cases where variable is significant at 5% level (out of 100):								
z or w_1	19	35	18	30	13	32	18	31
y or w_2	-	-	-	-	16	13	12	16
Number of *raw* negative compensated shares	5159	3792	5171	3706	5319	3767	5081	3675
Mean of negative *raw* compensated shares, %	-0.64	-0.40	-0.64	-0.33	-0.67	-0.42	-0.69	-0.35
Number of zero compensated shares	157	100	163	116	165	78	188	116
Mean R^2	0.5789	0.3719	0.5791	0.3706	0.5840	0.3808	0.5695	0.3795

Notes Each model fits a set of share equations for the 100 Basic Headings included in Household Consumption. See text for description of models and background variables. 141 countries in sample. Estimation method: OLS. Results reported are after 60 iterations. In addition to the variables in the table, all regressions include a constant and 24 principal components of log relative prices. The total number of compensated shares is 100 x 141 = 14,100. Mean R^2 is average across 100 regressions.

Source Unpublished World Bank spreadsheet and own calculations.

Table 8
Real household consumption per capita for 141 countries:
comparison of Konüs PPPs and conventional PPPs as deflators, summary statistics

(A) Konüs indices: poorest country (DRC) is base and reference

	Background variables level	*Mean*	*Median*	*S.D.*	*Minimum*	*Maximum*
Model I	DRC	54.6	24.6	60.5	1.0	**243.6**
	World average	*54.8*	*24.5*	*60.6*	*1.0*	***244.2***
	Excluded	*45.4*	*23.1*	*48.1*	*1.0*	***196.7***
Model II	DRC	58.4	26.4	64.8	1.0	**261.5**
	World average	*58.5*	*26.1*	*65.1*	*1.0*	***263.0***
	Excluded	*45.5*	*24.1*	*47.5*	*1.0*	***195.3***
Model III	DRC	52.9	24.4	58.5	1.0	**237.5**
	World average	*53.5*	*24.4*	*59.2*	*1.0*	***240.3***
	Excluded	*46.2*	*23.8*	*48.5*	*1.0*	***197.1***
Model IV	DRC	56.0	26.0	61.8	1.0	**249.6**
	World average	*56.8*	*26.0*	*63.0*	*1.0*	***254.6***
	Excluded	*48.8*	*25.0*	*51.8*	*1.0*	***212.2***

(B) Konüs indices: richest country (U.S.) is base, poorest country (DRC) is reference

	Background variables level	*Mean*	*Median*	*S.D.*	*Minimum*	*Maximum*
Model I	U.S.	66.4	27.1	75.2	1.0	**307.7**
	World average	*65.4*	*24.5*	*73.8*	*1.0*	***302.3***
	Excluded	*53.7*	*28.6*	*58.0*	*1.0*	***244.3***
Model II	U.S.	59.3	24.0	67.3	1.0	**277.5**
	World average	*59.3*	*26.1*	*67.2*	*1.0*	***277.2***
	Excluded	*55.3*	*29.7*	*59.7*	*1.0*	***250.5***
Model III	U.S.	69.0	28.1	78.3	1.0	**320.5**
	World average	*68.1*	*24.4*	*77.1*	*1.0*	***315.8***
	Excluded	*53.4*	*28.2*	*57.6*	*1.0*	***241.3***
Model IV	U.S.	59.8	24.5	67.3	1.0	**275.6**
	World average	*59.8*	*26.0*	*67.1*	*1.0*	***274.7***
	Excluded	*54.1*	*28.9*	*58.4*	*1.0*	***243.6***

Table 8, continued

Notes
Each index uses the same nominal total, household consumption (HC) per capita in local currency units, but deflators vary. Household consumption is sum of expenditure on Basic Headings 1-102, 104 & 105: see Appendix Table A1 for the list of Basic Headings.
Konüs indices Konüs indices are HC per capita deflated by a Konüs price index estimated by a chained Törnqvist index using *compensated* shares as weights; the compensated shares use the utility level of either the *poorest* country (the DRC) or the *richest* country (the U.S.). Alternative estimates of the compensated shares are derived from four regression models, I-IV: see text for full description. The compensated shares are calculated with the background variables set to *either* the levels found in the base country *or* to world average levels *or* excluded altogether (including from the regressions).

Source Unpublished World Bank spreadsheet and own calculations. See Appendix Table A4 for detailed results for each of the 141 countries.

Table 9
Real household consumption per capita for 141 countries:
comparison of Konüs PPPs and conventional PPPs as deflators, summary statistics
(poorest country is reference, i.e. DRC = 1; base country is *either* the DRC *or* the U.S.)

(A) Konüs indices: poorest country (DRC) is base and reference

HC per head	*Background variables level*	*Mean*	*Median*	*S.D.*	*Min-imum*	*Max-imum*
Model I: $Q^K_{I,DRC}$	DRC	54.6	24.6	60.5	1.0	243.6
Model II: $Q^K_{II,DRC}$	DRC	58.4	26.4	64.8	1.0	261.5
Model III: $Q^K_{III,DRC}$	DRC	52.9	24.4	58.5	1.0	237.5
Model IV: $Q^K_{IV,DRC}$	DRC	56.0	26.0	61.8	1.0	249.6

(B) Konüs indices: richest country (U.S.) is base; DRC is reference

HC per head	*Background variables level*	*Mean*	*Median*	*S.D.*	*Min-imum*	*Max-imum*
Model I: $Q^K_{I,US}$	U.S.	66.4	27.1	75.2	1.0	307.7
Model II: $Q^K_{II,US}$	U.S.	59.3	24.0	67.3	1.0	277.5
Model III: $Q^K_{III,US}$	U.S.	69.0	28.1	78.3	1.0	320.5
Model IV: $Q^K_{IV,US}$	U.S.	59.8	24.5	67.3	1.0	275.6

(C) Conventional indices: DRC is reference

HC per head		*Mean*	*Median*	*S.D.*	*Min-imum*	*Max-imum*
World Bank (multilateral): Q^{WB}	-	51.8	29.0	54.9	1.0	235.9
Conventional multilateral (EKS Fisher): Q^{EKS}	-	51.5	28.2	53.8	1.0	223.9
Bilateral (own weights): Q^P	-	48.0	28.0	46.9	1.0	190.6
Bilateral (U.S. weights): Q^L	-	51.1	26.8	56.8	1.0	247.8
Chained Törnqvist: Q^{ChT}	-	33.5	21.3	30.9	1.0	135.5
Chained Fisher: Q^{ChF}	-	50.1	28.6	51.5	1.0	217.2

Table 9, continued

Notes
Each index (Q) uses the same nominal total, household consumption in local currency units (HC) per capita in 2005, but deflators vary. In symbols, $Q = HC / P$, where the deflator P is either Konüs or conventional; superscripts indicate the type of index and subscripts the model and base, e.g. $Q^K_{IV,US} = HC / P^K_{IV,US}$. HC is the sum of expenditure on Basic Headings 1-102, 104 and 105, 100 products in all: see Appendix Table A1 for the list of Basic Headings. Memo item: HC per capita in the U.S. in 2005 was $29,024.

Konüs indices Konüs indices are HC per capita deflated by a Konüs price index estimated by a chained Törnqvist index using *compensated* shares as weights; the compensated shares use the utility level of either the *poorest* country (the DRC) or the *richest* country (the U.S.). Alternative estimates of the compensated shares are derived from four regression models, I-IV, with background variables included: see text for full description.

Conventional indices "World Bank (multilateral)" is HC per capita deflated by the World Bank's PPP for Individual Consumption by Households. "Bilateral (own weights)" is HC per capita deflated by a Paasche price index which uses each country's *actual* shares in turn to weight the PPPs. "Bilateral (U.S. weights)" is HC per capita deflated by a Laspeyres price index which uses *actual* U.S. shares. "Conventional multilateral" is HC per capita deflated by my own estimate of a multilateral (EKS Fisher) price index for HC, again employing *actual* shares.

Source
Unpublished World Bank spreadsheet from the 2005 ICP and own calculations: see Appendix Tables A2 and A4 for individual results for each of the 141 countries.

Table 10
Correlation coefficients between the standard of living estimates under Models I-IV

	Base	*Poorest (DRC)*				*Richest (U.S.)*			
Base	*Model*	*I*	*II*	*III*	*IV*	*I*	*II*	*III*	*IV*
Poorest	*I*	1.0000							
Poorest	*II*	1.0000	1.0000						
Poorest	*III*	0.9999	0.9999	1.0000					
Poorest	*IV*	0.9999	0.9999	0.9999	1.0000				
Richest	*I*	0.9957	0.9956	0.9956	0.9949	1.0000			
Richest	*II*	0.9959	0.9958	0.9957	0.9951	1.0000	1.0000		
Richest	*III*	0.9956	0.9955	0.9954	0.9948	1.0000	1.0000	1.0000	
Richest	*IV*	0.9956	0.9955	0.9955	0.9949	1.0000	0.9999	1.0000	1.0000

Note Background variables included. "Standard of living" is nominal household consumption per head deflated by a Konüs price index.

Source Appendix Table A4.

Charts

Chart 1

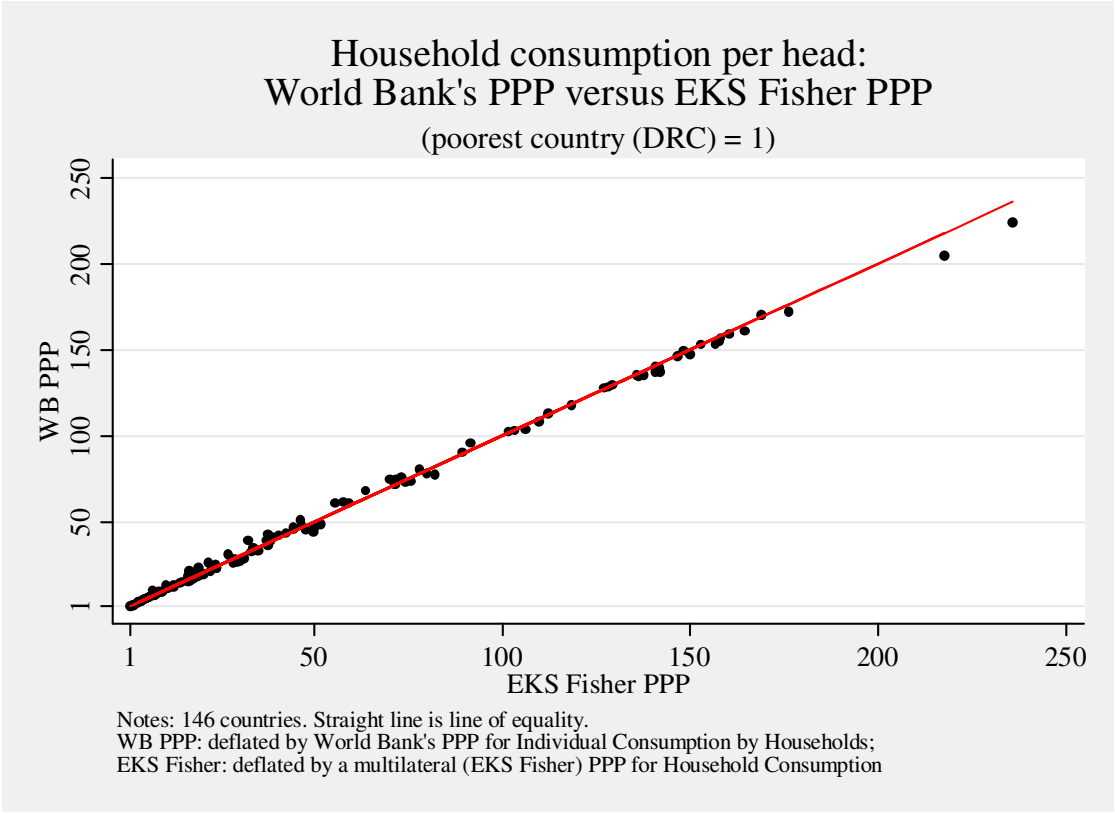


Chart 2

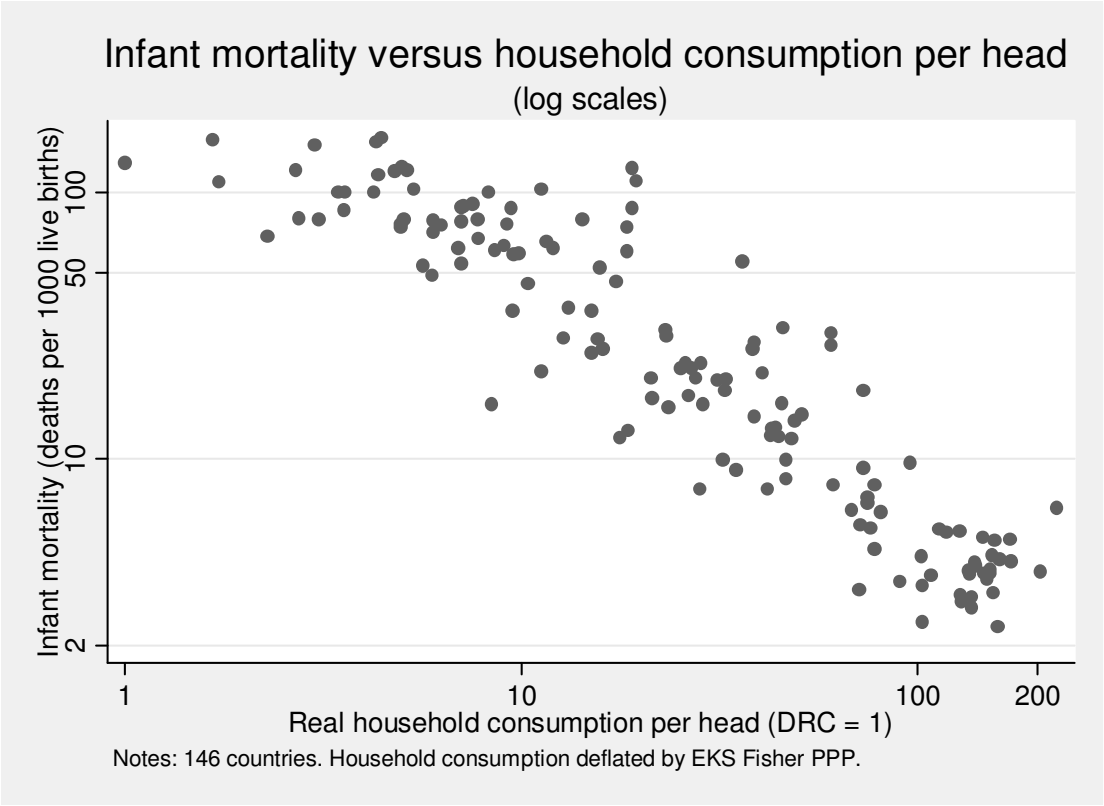

Infant mortality versus household consumption per head
(log scales)
Infant mortality (deaths per 1000 live births)
2
10
50
100
1
10
100
200
Real household consumption per head (DRC = 1)
Notes: 146 countries. Household consumption deflated by EKS Fisher PPP.

Chart 3

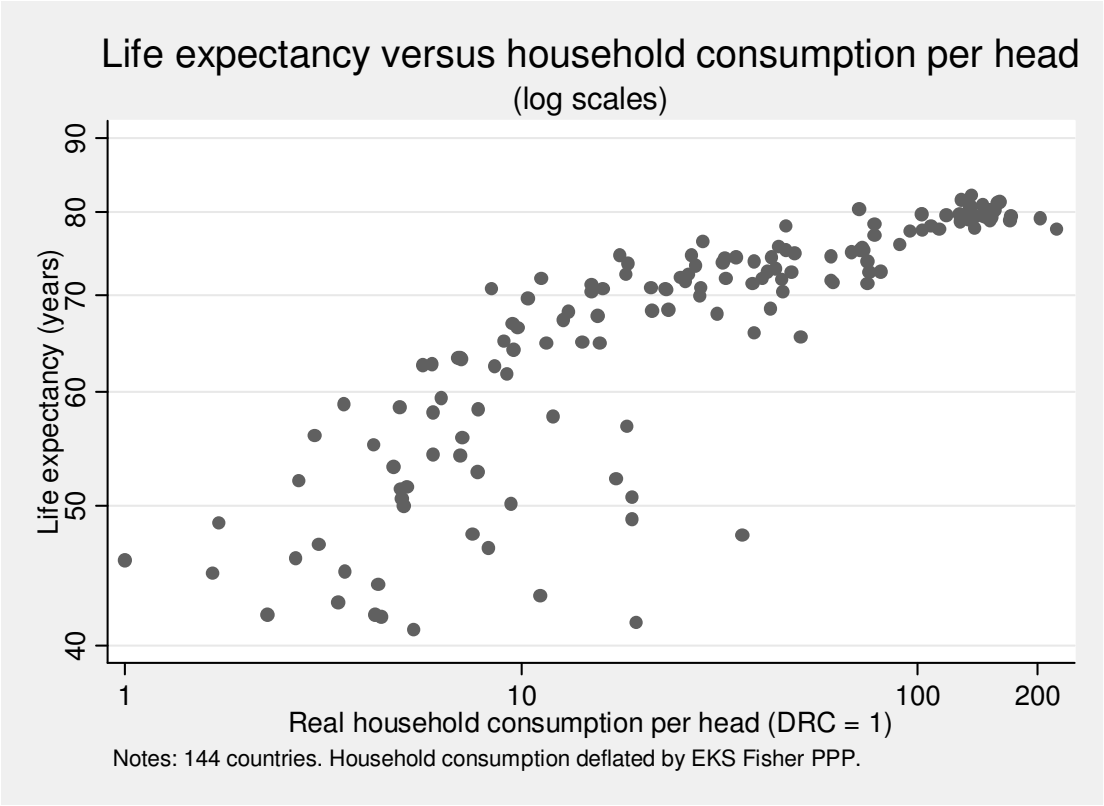

Life expectancy versus household consumption per head
(log scales)
Life expectancy (years)
40
50
60
70
80
90
1
10
100
200
Real household consumption per head (DRC = 1)
Notes: 144 countries. Household consumption deflated by EKS Fisher PPP.

Chart 4

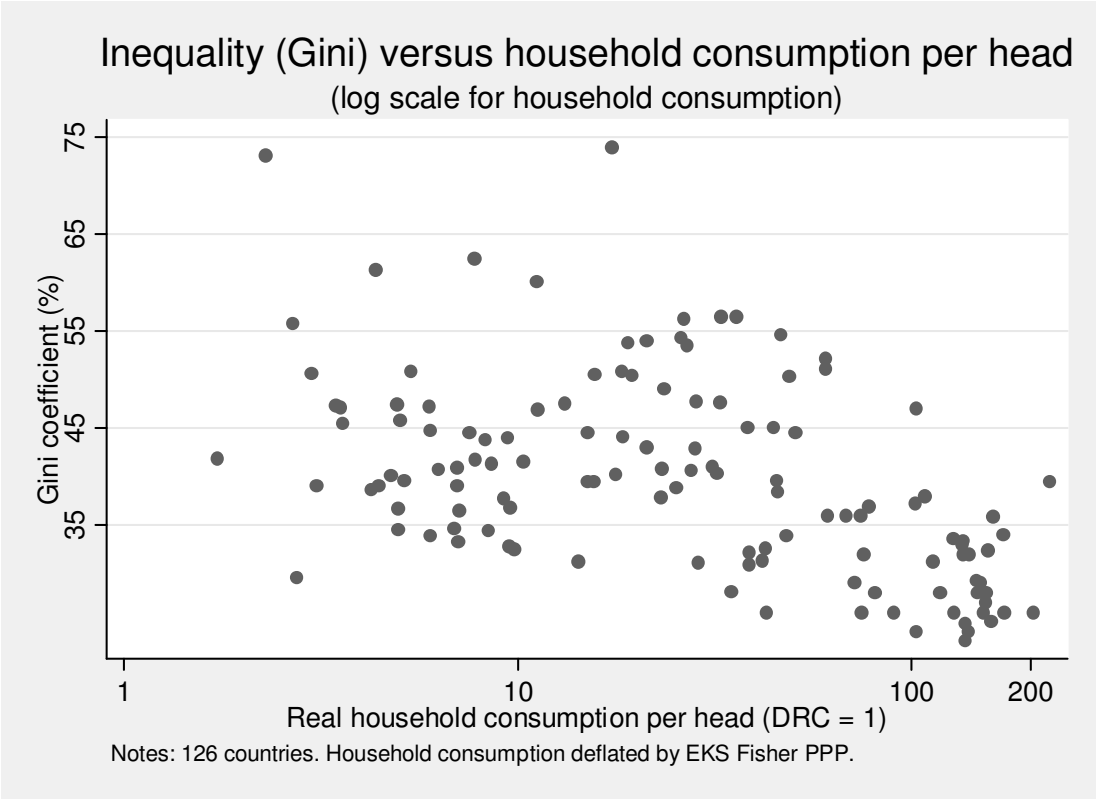

Inequality (Gini) versus household consumption per head
(log scale for household consumption)
Gini coefficient (%)
75
65
55
45
35
1
10
100
200
Real household consumption per head (DRC = 1)
Notes: 126 countries. Household consumption deflated by EKS Fisher PPP.

Chart 5

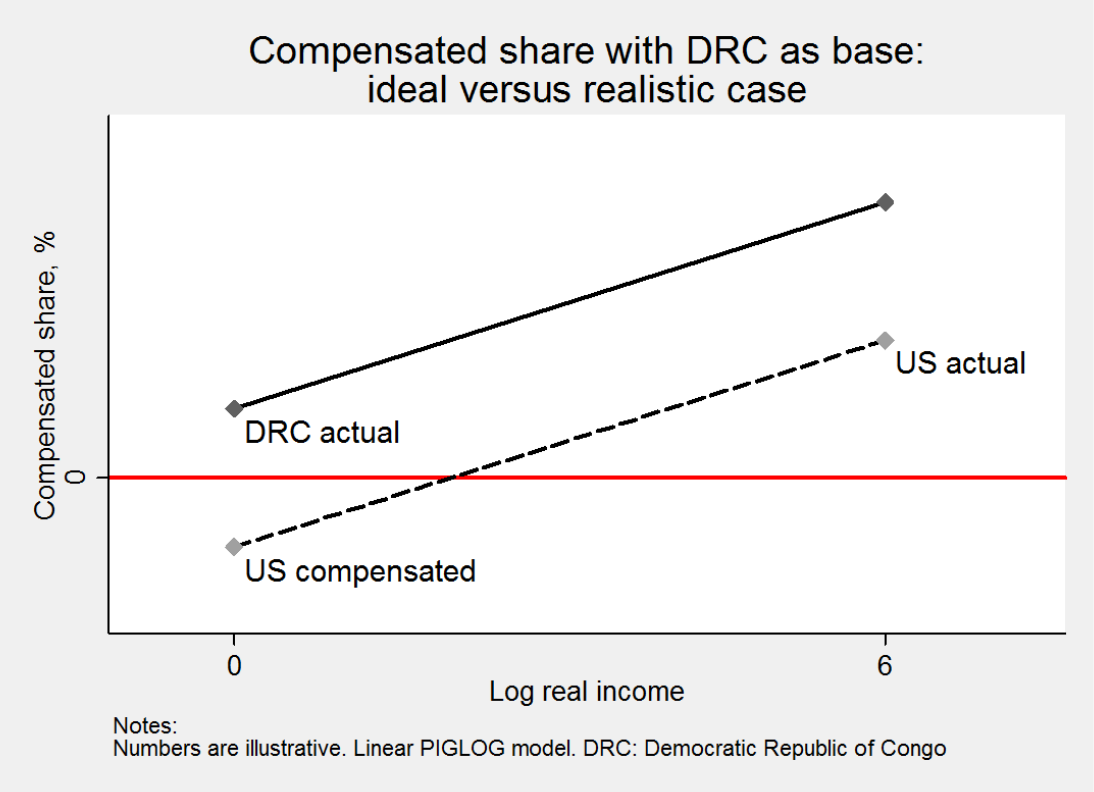

Compensated share with DRC as base:
ideal versus realistic case
Compensated share, %
0
DRC actual
US actual
US compensated
0
6
Log real income
Notes:
Numbers are illustrative. Linear PIGLOG model. DRC: Democratic Republic of Congo

Chart 6

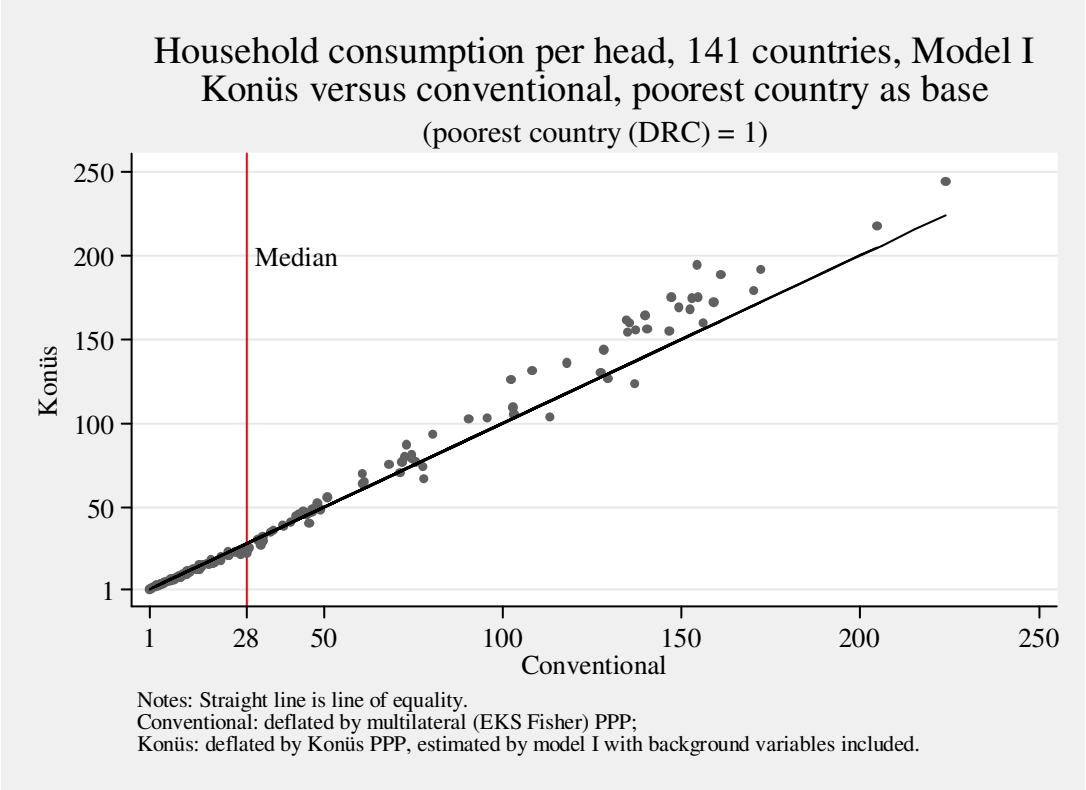

Household consumption per head, 141 countries, Model I
Konüs versus conventional, poorest country as base
(poorest country (DRC) = 1)
Konüs
250
200
150
100
50
1
Median
1
28
50
100
150
200
250
Conventional
Notes: Straight line is line of equality.
Conventional: deflated by multilateral (EKS Fisher) PPP;
Konüs: deflated by Konüs PPP, estimated by model I with background variables included.

Chart 7

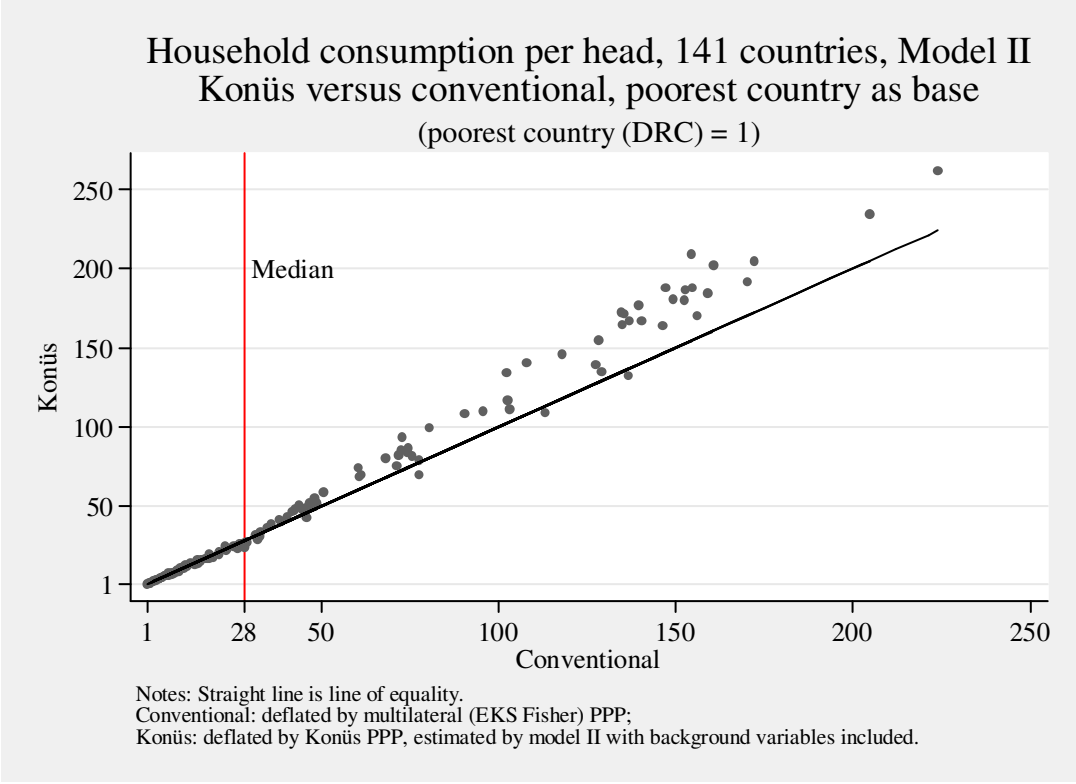

Household consumption per head, 141 countries, Model II
Konüs versus conventional, poorest country as base
(poorest country (DRC) = 1)
Median
Konüs
Conventional
1
28
50
100
150
200
250
Notes: Straight line is line of equality.
Conventional: deflated by multilateral (EKS Fisher) PPP;
Konüs: deflated by Konüs PPP, estimated by model II with background variables included.

Chart 8

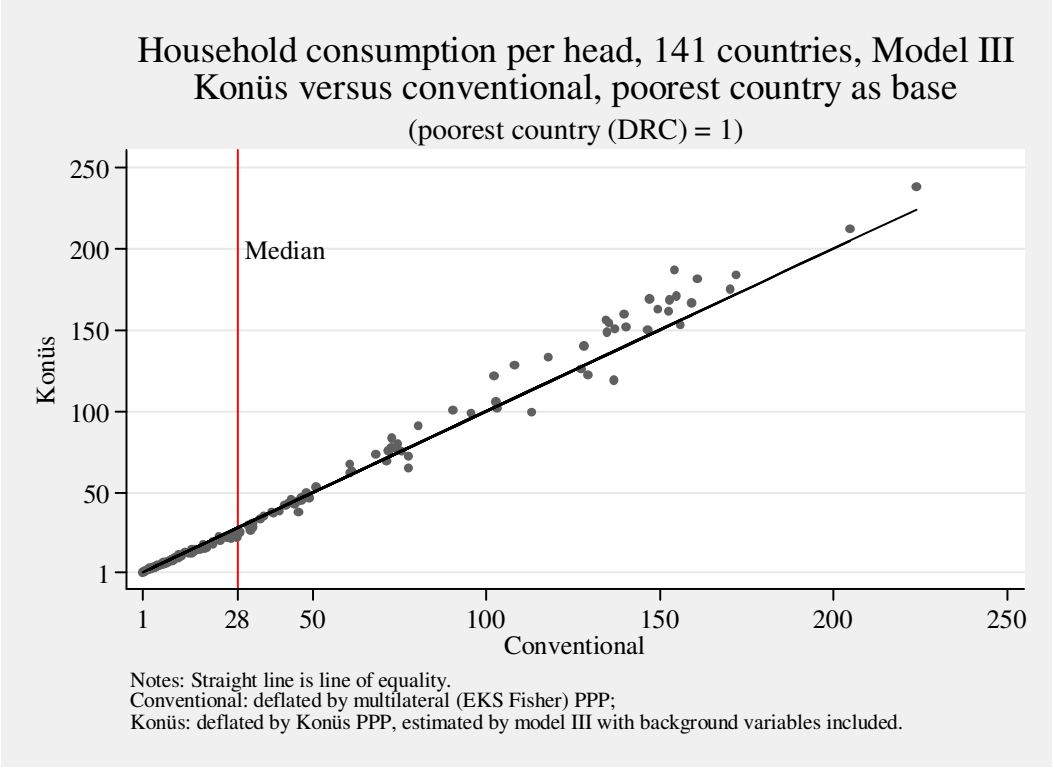

Household consumption per head, 141 countries, Model III
Konüs versus conventional, poorest country as base
(poorest country (DRC) = 1)
Konüs
Conventional
Median
250
200
150
100
50
1
1
28
50
100
150
200
250
Notes: Straight line is line of equality.
Conventional: deflated by multilateral (EKS Fisher) PPP;
Konüs: deflated by Konüs PPP, estimated by model III with background variables included.

Chart 9

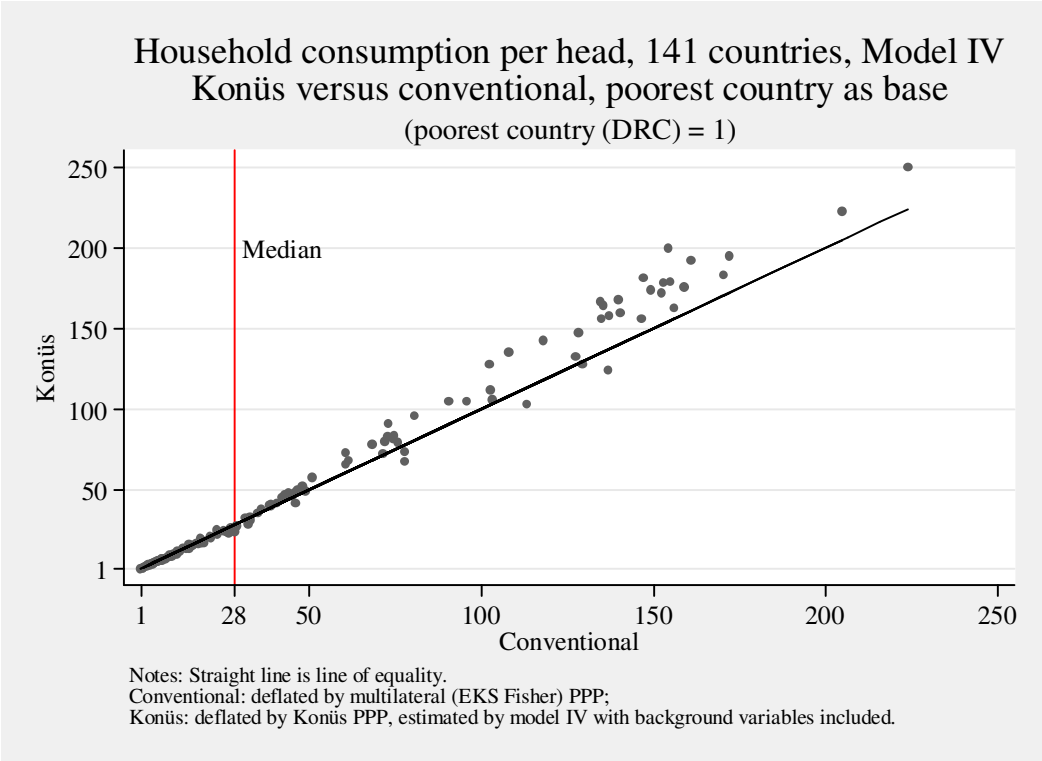
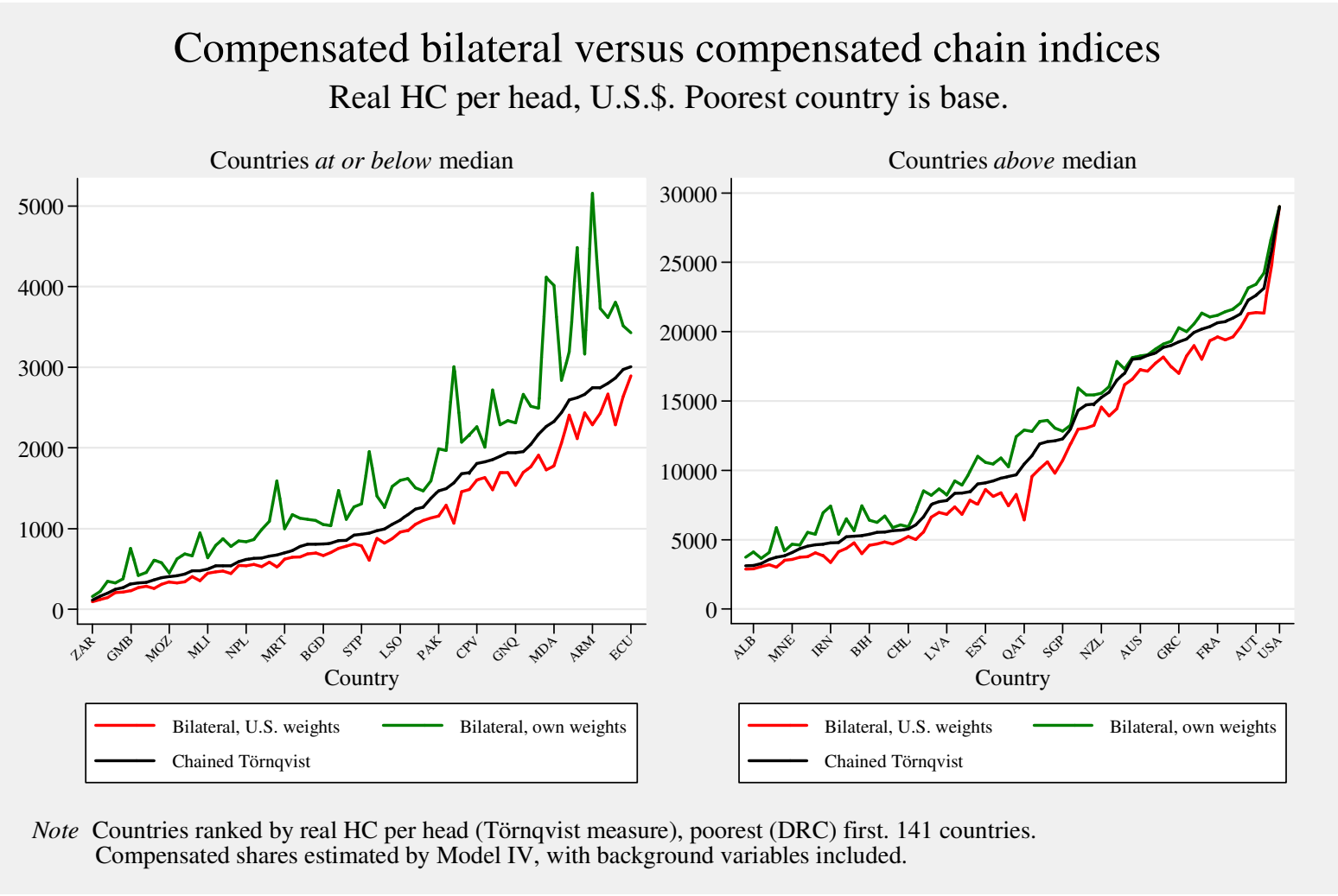
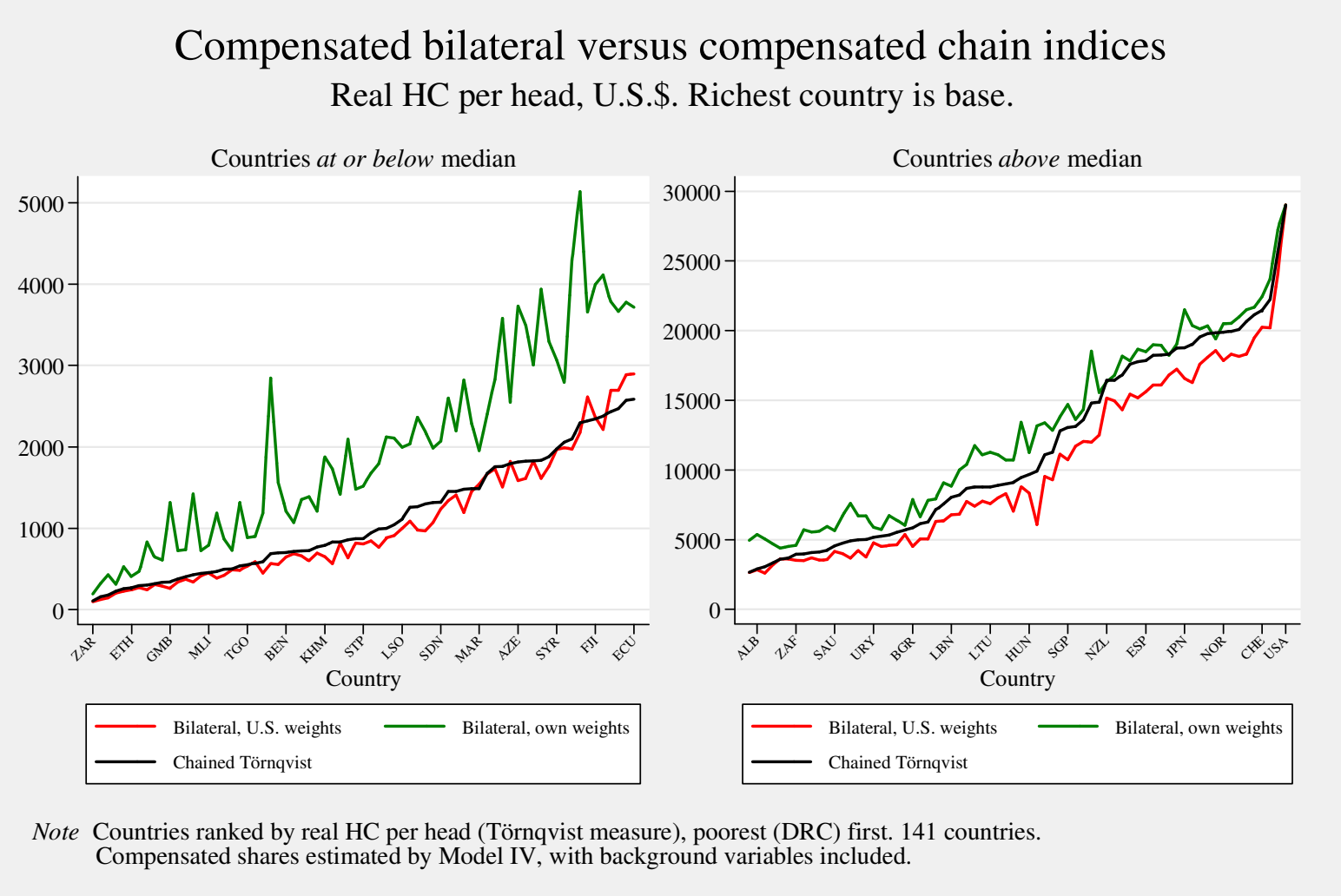

Household consumption per head, 141 countries, Model IV
Konüs versus conventional, poorest country as base
(poorest country (DRC) = 1)
Konüs
Conventional
Median
250
200
150
100
50
1
1
28
50
100
150
200
250
Notes: Straight line is line of equality.
Conventional: deflated by multilateral (EKS Fisher) PPP;
Konüs: deflated by Konüs PPP, estimated by model IV with background variables included.

Chart 10



Note Countries ranked by real HC per head (Törnqvist measure), poorest (DRC) first. 141 countries.
Compensated shares estimated by Model IV, with background variables included.

Chart 11



Note Countries ranked by real HC per head (Törnqvist measure), poorest (DRC) first. 141 countries.
Compensated shares estimated by Model IV, with background variables included.

Chart 12

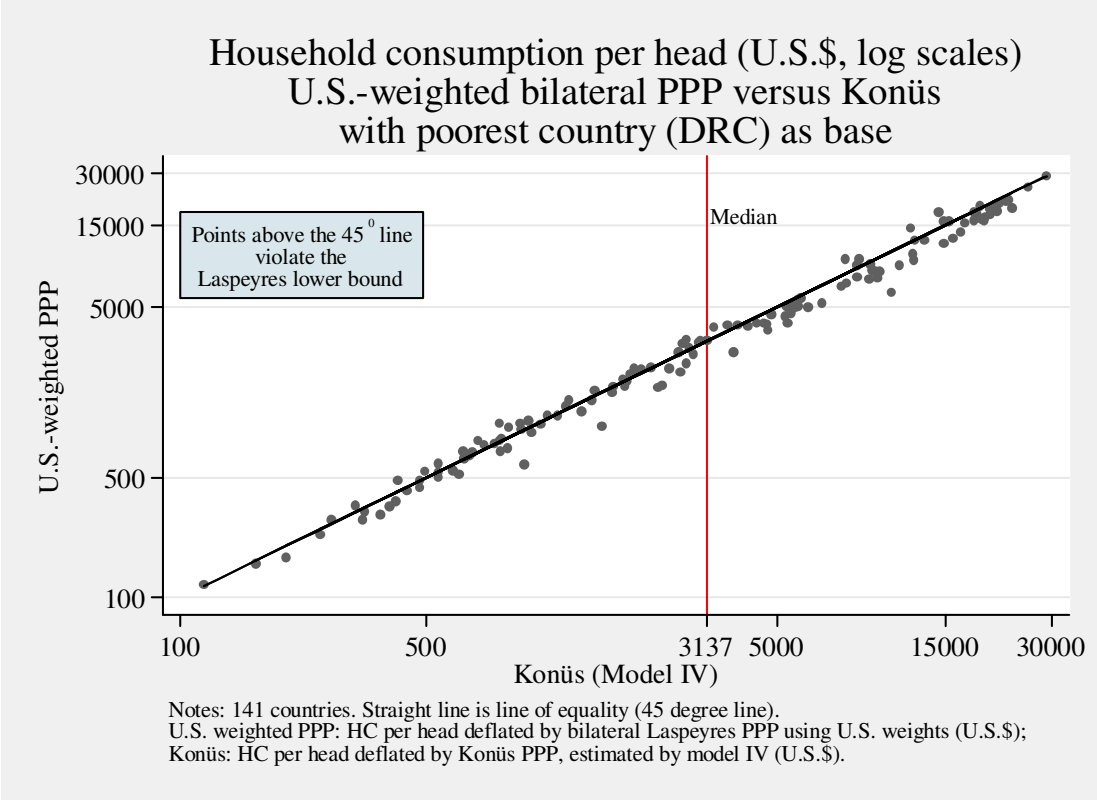
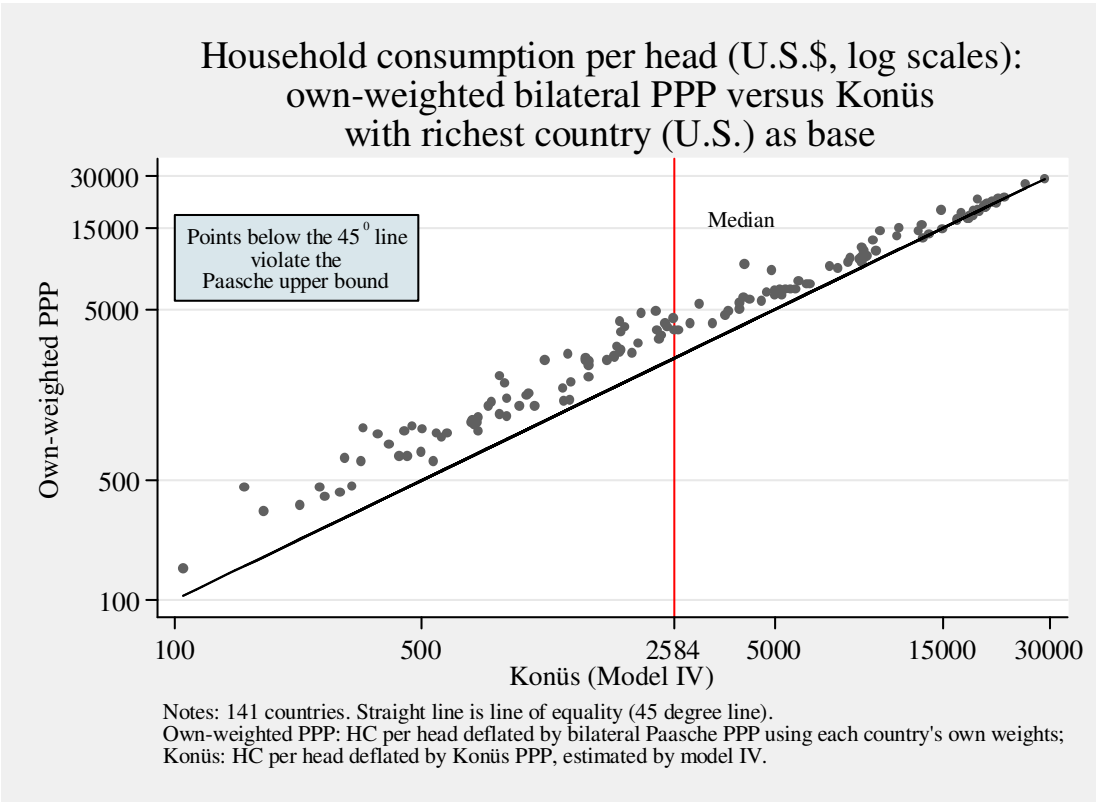

Household consumption per head (U.S.$, log scales)
U.S.-weighted bilateral PPP versus Konüs
with poorest country (DRC) as base
30000
15000
5000
500
100
U.S.-weighted PPP
Points above the 45 ° line
violate the
Laspeyres lower bound
Median
100
500
3137
5000
15000
30000
Konüs (Model IV)
Notes: 141 countries. Straight line is line of equality (45 degree line).
U.S. weighted PPP: HC per head deflated by bilateral Laspeyres PPP using U.S. weights (U.S.$);
Konüs: HC per head deflated by Konüs PPP, estimated by model IV (U.S.$).

Chart 13


Household consumption per head (U.S.$, log scales):
own-weighted bilateral PPP versus Konüs
with richest country (U.S.) as base
Own-weighted PPP
30000
15000
5000
500
100
Points below the 45 0 line
violate the
Paasche upper bound
Median
100
500
2584
5000
15000
30000
Konüs (Model IV)
Notes: 141 countries. Straight line is line of equality (45 degree line).
Own-weighted PPP: HC per head deflated by bilateral Paasche PPP using each country's own weights;
Konüs: HC per head deflated by Konüs PPP, estimated by model IV.

Data Appendix

A.1 The World Bank dataset

I received a spreadsheet on 3rd July 2008 from the World Bank entitled "Final detailed results-Researchers.xls", which contains some of the unpublished data underlying their published results. This dataset consisted of expenditures and corresponding PPPs for each of the 129 Basic Headings which make up GDP; the expenditures and PPPs were for each of the 146 countries that were eventually included in the ICP. That is, there were in all (146 x 129 =) 18,834 PPPs and the same number of expenditures, with no missing values. The expenditures are expressed in local currency units and the PPPs as local currency units per U.S. dollar. In addition, the spreadsheet included population and official exchange rates.

The next section of this Data Appendix gives a full description of the additional, background variables employed in the analysis of demand, together with their sources.

The final section consists of a set of detailed tables. Table A1 lists the Basic Headings (names and codes) and the product groups of the data that I was sent. Note that this list does not correspond exactly to the official classification scheme (World Bank, 2008, Appendix C) since some Basic Headings within Individual Consumption by Government were omitted and expenditures on them distributed to other Basic Headings within Individual Consumption by Households: see section 6.1 for details.

Table A2 lists all the 146 countries that were eventually included in the 2005 ICP, ordered alphabetically within each of the six ICP region (see Table 3 for the regions). The names are the official ones, which are not always the more familiar ones. Thus "Congo, Dem. Rep." is the Democratic Republic of Congo (DRC). Table A2 also gives Household Consumption per head (see section 6.2 for the exact definition) as measured using five different deflators: the official exchange rate, the World Bank's PPP for Individual Consumption by Households, and three deflators that I estimated myself: a multilateral EKS Fisher PPP, a bilateral PPP constructed using each country's expenditure weights, and a bilateral PPP using U.S. expenditure weights. The reference country for Household Consumption per head is the DRC.

Table A3 shows the cross country means and standard deviations of the budget shares of each of the 100 Basic Headings included in my definition of Household Consumption.

Table A4 lists the 141 countries included in the analysis of consumer demand; as explained in the text, five of the original 146 countries — Angola, Comoros, Djibouti, Tanzania and Maldives— were omitted as their expenditure data were judged unreliable. Table A4 also shows Household Consumption deflated by Konüs PPPs estimated by the four different models (models I-IV). The DRC is always the reference country here but the base country is either the DRC or the U.S.

A.2 Background variables

Two criteria were employed for selecting socio-economic variables: (a) relevance and (b) availability for all (or almost all) the 146 (later 141) countries. The chosen variables fell into the following broad groups:

1. *Climate (5 variables)*
    a. Rainfall (centimetres per year, in logs)
    b. Proportion of frost days (number of frost days ÷ 365)
    c. Minimum temperature (degrees Celsius)
    d. Maximum temperature (degrees Celsius)
    e. Distance from the equator (degrees latitude North or South of the equator ÷ 90)

Sources: The first four variables come from the TYN CY 1.1 dataset and were downloaded from the Tyndall Centre at the University of East Anglia on October 30 2008. (http://www.cru.uea.ac.uk/~timm/cty/obs/TYN_CY_1_1_text.html). These measures are area-weighted averages for each country (30 year averages, using 1 degree squares): see Mitchell *et al*. (2003). (Population-weighted averages would have been more suitable for my purposes but these do not seem to be available). Distance from the equator comes from the unpublished appendix to Hall and Jones (1999), downloaded from http://elsa.berkeley.edu/~chad/HallJones400.asc on 14th December 2008.

2. *Religion (4 variables)*
    a. Proportion of population that is Christian (ratio)
    b. Proportion of population that is Muslim (ratio)
    c. Proportion of population that is Buddhist (ratio)

d. Proportion of population that is Hindu (ratio)

Source: Barro's dataset on religious adherence, http://www.economics.harvard.edu/faculty/barro/files/religion%20adherence%20data.xls, downloaded from his website on 7th November 2008. The proportion Christian is the sum of the proportions Catholic, Protestant, Orthodox and Other Christian. These four variables sum to less than one: the omitted categories are Jewish, Eastern religions, Other religions and Non-religious.

3. *Hegemony and culture (7 dummy variables)*
    a. U.S. hegemony (= 1 if subject to U.S. hegemony, 0 otherwise: 11 Latin American countries including Mexico plus Liberia and the Philippines)
    b. Russian hegemony (= 1 if subject to Russian hegemony, 0 otherwise: the 18 countries which were either under the domination of the Soviet Union or are the successor states to the Soviet Union).
    c. U.K. hegemony (= 1 if subject to U.K. hegemony, 0 otherwise: 39 countries)
    d. French hegemony (= 1 if subject to French hegemony, 0 otherwise: 25 countries)
    e. Belgian hegemony (= 1 if subject to Belgian hegemony, 0 otherwise: 3 countries)
    f. Portuguese hegemony (= 1 if subject to Portuguese hegemony, 0 otherwise: 8 countries)
    g. Arab culture (= 1 if a country is predominantly Arab in language and ethnicity, 0 otherwise: 15 countries)

Sources: General knowledge, judgement, and the *CIA World Fact Book*.

4. *Health (3 variables)*
    a. Life expectancy at birth (years)
    b. Infant mortality (rate per thousand live births)
    c. Public expenditure on health as a percentage of GDP

Source: World Development Indicators (WDI). These and other data were downloaded from the World Bank's World Development Indicator (WDI) database (http://go.worldbank.org/6HAYAHG8H0) on 12 August 2008: Life expectancy for females is higher than for males in all but three of our 146 countries, but the gap is fairly small, except for Russia (an amazing 13.5 years), the CIS and the Baltic states.

5. *Education (3 variables)*
    a. Proportion of population over 25 with at most primary education (ratio)
    b. Proportion of population over 25 with at most secondary education (ratio)
    c. Proportion of population over 25 with higher education (ratio)
    d. Proportion of population over 25 with no schooling (ratio); omitted in regressions

Source: Cohen and Soto (2007). The Cohen-Soto educational database was downloaded from http://www.oecd.org/dataoecd/33/13/2669521.xls on 10th January 2009. The Cohen-Soto data were available for only 81 countries out of the 146 in our sample. An additional 24 countries, making 105 in all, were extrapolated from World Development Indicators (WDI). The procedure was to regress the Cohen-Soto measures on similar WDI ones, then use the regression to predict a Cohen-Soto measure for the 24 countries where WDI was known but Cohen-Soto was missing.

6. *Urbanisation (1 variable)*
    a. Urban population as percentage of total. Source: WDI.

7. *Policy (1 variable)*
    a. Openness: 100 x (exports plus imports)/GDP, adjusted for population size.

Source: Penn World Table 6.2. The size adjustment consisted of regressing the PWT openness variable on log population, log population squared, and log population cubed, then taking the residual from this regression as the measure of size-adjusted openness. In practice the size adjustment makes little difference.

8. *Demography (2 variables)*
    a. Proportion of population aged under 15 (ratio)
    b. Proportion of population aged over 64 (ratio)

Source: World Development Indicators. The 2005 value was chosen where available, otherwise the year closest to 2005. The missing variable is the proportion of population aged 15-64.

9. *Inequality (2 variables)*
    a. $W_1 = \ln(G) - I$

b. $W_2 = J - 2I\ln(G) + [\ln(G)]^2$

Here $G = 10$, $I = -\sum_{g=1}^{g=10} w_g \ln w_g$, and $J = \sum_{g=1}^{g=G} w_g (\ln w_g)^2$ where w_g is the share of the *g*th decile in aggregate income; *I* is the share-weighted average of log shares (entropy) and *J* is a kind of second moment. Decile shares were used to calculate *I* and *J* since these were the most detailed available. Source: UNU-WIDER World Income Inequality Database, version 2.0c (May 2008), downloaded from http://www.wider.unu.edu/research/Database/en_GB/database/ on 13 August 2008; version 2b is described in UNU-WIDER (no date; c. 2008). For 114 countries, data exist for all decile shares. For a further 9 countries, there is data for the first and 10th decile shares. The missing decile shares for these 9 countries were interpolated by regressing the share of decile 2 (3,4,...,9) on deciles shares 1 and 10 plus the ICP region dummies for 114 countries and using this regression to predict decile shares 2-9 for the other 9 countries. This still left the problem of estimating the decile shares for the remaining 23 countries where they are completely missing. These shares were extrapolated by means of a regression approach. I regressed each decile share in turn on a battery of variables and used the regression equation to predict values of the decile shares for the 23 missing countries. The battery of variables consisted of the Gini coefficient (when available), public health expenditure as a percentage of GDP, infant mortality (these three variables from the WDI), the demographic and climate variables (see above), the ICP region dummies, and a "mining" dummy, equal to 1 if I judged a country's economy to be dominated by extractive industries (oil, diamonds or tin; 17 countries fell into this category). One country, Macao, could not be extrapolated by this method because some or all of the background variables were missing. This was filled in by using the results for Hong Kong.

10. World Bank ICP region (5 dummy variables)

A set of 6 dummy variables, one for each ICP "region", each taking the value 1 if a country fell into that region, 0 otherwise. The regions are: Africa, Asia/Pacific, West Asia, South America, Commonwealth of Independent States (CIS), and OECD-Eurostat; the latter is omitted in the regressions. These dummy variables correspond only roughly to geography. For example, Mexico is in the OECD-Eurostat region, not in the South American one, and OECD-Eurostat includes countries from North America (e.g. the U.S.), the Middle East (Israel) and East Asia (Japan and Korea). But the ICP regions did their work independently of each other (though under World Bank supervision and coordination), so it is possible that there are methodological differences between them which the region dummies will pick up.

Thus there are in all 30 “background” variables which I have been able to find and which might arguably influence spending patterns independently of prices and incomes. This number rises to 33 variables if the three educational variables (available even after some extrapolation for only 105 countries) are also included.

A.3 Appendix Tables

Table A1

Basic Headings and product groups in the 2005 ICP

Basic Heading number	*Basic Heading code*	*Basic Heading name*	*Product group number*	*Product group code*	*Product group name*
1	1101111	Rice	1	110100	Food and nonalcoholic beverages [29 Basic Headings]
2	1101112	Other cereals and flour			
3	1101113	Bread			
4	1101114	Other bakery products			
5	1101115	Pasta products			
6	1101121	Beef and veal			
7	1101122	Pork			
8	1101123	Lamb, mutton and goat			
9	1101124	Poultry			
10	1101125	Other meats and preparations			
11	1101131	Fresh or frozen fish and seafood			
12	1101132	Preserved fish and seafood			
13	1101141	Fresh milk			
14	1101142	Preserved milk and milk products			
15	1101143	Cheese			
16	1101144	Eggs and egg-based products			
17	1101151	Butter and margarine			
18	1101153	Other edible oils and fats			
19	1101161	Fresh or chilled fruit			
20	1101162	Frozen, preserved or processed fruits			
21	1101171	Fresh or chilled vegetables			
22	1101172	Fresh or chilled potatoes			
23	1101173	Frozen or preserved vegetables			
24	1101181	Sugar			
25	1101182	Jams, marmalades and honey			
26	1101183	Confectionery, chocolate and ice cream			
27	110119	Food products n.e.c.			
28	110121	Coffee, tea and cocoa			
29	110122	Mineral waters, soft drinks,			
30	1102111	Spirits	2	110200	Alcoholic beverages, tobacco, and narcotics [4 Basic Headings]
31	1102121	Wine			
32	1102131	Beer			
33	110220	Tobacco			
34	1103111	Clothing materials and accessories	3	110300	Clothing and footwear [5 Basic Headings]
35	1103121	Garments			
36	1103141	Cleaning and repair of clothing			
37	1103211	Footwear			
38	1103221	Repair and hire of footwear			
39	110410	Actual and imputed rentals for housing	4	110400	Housing, water, electricity, gas, and other fuels [7 Basic Headings]
40	110430	Maintenance and repair of the dwelling			
41	110440	Water supply and miscellaneous services relating to the dwelling			
42	110442	Miscellaneous services relating to the dwelling			
43	110451	Electricity			

44	110452	Gas			
45	110453	Other fuels			
46	110511	Furniture and furnishings	5	110500	Furniture, household equipment, and routine maintenance of the house [13 Basic Headings]
47	110512	Carpets and other floor coverings			
48	110513	Repair of furniture, furnishings and floor coverings			
49	110520	Household textiles			
50	110531	Major household appliances whether electric or not			
51	110532	Small electric household appliances			
52	110533	Repair of household appliances			
53	110540	Glassware, tableware and household utensils			
54	110551	Major tools and equipment			
55	110552	Small tools and miscellaneous accessories			
56	110561	Non-durable household goods			
57	1105621	Domestic services			
58	1105622	Household services			
59	110611	Pharmaceutical products	6	110600	Health [7 Basic Headings]
60	110612	Other medical products			
61	110613	Therapeutical appliances and equipment			
62	110621	Medical Services			
63	110622	Dental services			
64	110623	Paramedical services			
65	110630	Hospital services			
66	110711	Motor cars	7	110700	Transport [12 Basic Headings]
67	110712	Motor cycles			
68	110713	Bicycles			
69	110722	Fuels and lubricants for personal transport equipment			
70	110723	Maintenance and repair of personal transport equipment			
71	110724	Other services in respect of personal transport equipment			
72	110731	Passenger transport by railway			
73	110732	Passenger transport by road			
74	110733	Passenger transport by air			
75	110734	Passenger transport by sea and inland waterway			
76	110735	Combined passenger transport			
77	110736	Other purchased transport services			
78	110810	Postal services	8	110800	Communication [3 Basic Headings]
79	110820	Telephone and telefax equipment			
80	110830	Telephone and telefax services			
81	110911	Audio-visual, photographic and information processing equipment	9	110900	Recreation and culture [12 Basic Headings]
82	110914	Recording media			
83	110915	Repair of audio-visual, photographic and information-processing equipment			
84	110921	Major durables for outdoor and indoor recreation			

85	110931	Other recreational items and equipment			
86	110933	Gardens and pets			
87	110935	Veterinary and other services for pets			
88	110941	Recreational and sporting services			
89	110942	Cultural services			
90	110943	Games of chance			
91	110950	Newspapers, books and stationery			
92	110960	Package holidays			
93	111000	Education	10	111000	Education
94	111110	Catering services	11	111100	Restaurants and hotels [2 Basic Headings]
95	111120	Accommodation services			
96	111211	Hairdressing salons and personal grooming Establishments	12	111200	Miscellaneous goods and services [10 Basic Headings]
97	111212	Appliances, articles and products for personal care			
98	111220	Prostitution			
99	111231	Jewellery, clocks and watches			
100	111232	Other personal effects			
101	111240	Social protection			
102	111250	Insurance			
103	111261	FISIM			
104	111262	Other financial services n.e.c			
105	111270	Other services n.e.c.			
106	111300	Net purchases abroad	13	111300	Balance of expenditures of residents abroad and expenditures of nonresidents on the economic territory
107	130221	Compensation of employees	14		Individual consumption expenditure by government: Health [5 Basic Headings]
108	130222	Intermediate consumption			
109	130223	Gross operating surplus			
110	130224	Net taxes on production			
111	130225	Receipts from sales			
112	130421	Compensation of employees	15		Individual consumption expenditure by government: Education [5 Basic Headings]
113	130422	Intermediate consumption			
114	130423	Gross operating surplus			
115	130424	Net taxes on production			
116	130425	Receipts from sales			
117	140111	Compensation of employees	16		Collective consumption expenditure by government [5 Basic Headings]
118	140112	Intermediate consumption			
119	140113	Gross operating surplus			
120	140114	Net taxes on production			
121	140115	Receipts from sales			

122	150110	Metal products and equipment	17		Expenditure on gross fixed capital formation [6 Basic Headings]
123	150120	Transport equipment			
124	150210	Residential buildings			
125	150220	Non-residential buildings			
126	150230	Civil engineering works			
127	150300	Other products			
128	160000	Change in inventories and valuables	18		Changes in inventories and valuables
129	180000	Balance of exports and imports	19		Balance of exports and imports
		GDP			Total

Source World Bank. This listing is shorter than the one in World Bank (2008, Appendix C) since some BHs within Individual Consumption Expenditure by Government for which no expenditures or PPPs were included in the unpublished World Bank spreadsheet have been omitted: see text for more detail.
Note The numbering of the Basic Headings and of the Product groups is my own; all other terms follow World Bank usage.

Table A2
Real household consumption per head in 146 countries:
effect of different deflators (poorest country is reference, i.e. DRC = 1.0)

		Deflator				
Country and ICP region	*World Bank 3-letter code*	*Exchange rate*	*World Bank PPP*	*Multilat-eral (EKS Fisher)*	*Bilateral PPP (own weights)*	*Bilateral PPP (U.S. weights)*
Africa						
Angola	AGO	5.9	4.5	4.3	4.3	4.4
Benin	BEN	5.6	7.1	7.1	6.9	6.7
Botswana	BWA	19.4	19.6	19.1	19.9	18.3
Burkina Faso	BFA	3.8	5.5	5.1	4.8	4.6
Burundi	BDI	1.1	1.8	1.7	2.2	1.5
Cameroon	CMR	8.2	9.9	9.4	9.0	8.7
Cape Verde	CPV	22.3	16.9	16.1	16.6	15.9
Central African Republic	CAF	4.0	4.6	4.3	4.6	3.7
Chad	TCD	5.0	5.3	5.0	4.2	5.2
Comoros	COM	6.8	6.1	5.6	6.3	5.4
Congo, Dem. Rep.	ZAR	1.0	1.0	1.0	1.0	1.0
Congo, Rep.	COG	6.5	6.1	6.0	5.8	6.1
Côte d'Ivoire	CIV	7.1	7.7	7.5	7.2	7.0
Djibouti	DJI	6.9	7.6	7.0	8.5	6.1
Equatorial Guinea	GNQ	23.9	19.3	19.0	24.2	17.3
Ethiopia	ETH	1.5	3.2	2.8	2.6	2.4
Gabon	GAB	23.7	18.8	18.5	19.1	18.7
Gambia, The	GMB	2.0	3.6	3.6	6.6	3.0
Ghana	GHA	4.7	6.4	6.3	7.2	6.0
Guinea	GIN	2.6	4.2	4.3	6.1	3.5
Guinea-Bissau	GNB	2.3	2.9	2.7	3.0	2.4
Kenya	KEN	5.3	8.1	7.7	8.9	7.2
Lesotho	LSO	9.1	11.3	11.2	16.6	9.8
Liberia	LBR	1.3	1.7	1.7	3.0	1.3
Madagascar	MDG	2.9	5.0	4.9	6.8	4.1
Malawi	MWI	2.3	3.2	3.1	4.5	2.6
Mali	MLI	4.1	5.0	4.8	4.5	4.7
Mauritania	MRT	5.4	7.6	7.0	6.3	7.0
Mauritius	MUS	44.8	49.7	43.9	39.4	43.1
Morocco	MAR	15.3	16.4	15.0	13.1	14.5
Mozambique	MOZ	2.9	3.9	3.5	3.0	3.1
Namibia	NAM	21.3	17.9	17.3	17.7	17.2
Niger	NER	2.4	3.2	3.0	2.8	2.7
Nigeria	NGA	7.3	8.2	8.3	8.1	8.9

Rwanda	RWA	2.5	4.0	3.6	4.3	2.9
Sao Tomé and Principe	STP	8.7	9.6	9.0	9.9	8.2
Senegal	SEN	7.6	9.0	8.6	7.8	8.4
Sierra Leone	SLE	3.4	4.7	4.4	5.3	4.1
South Africa	ZAF	40.6	37.7	36.0	35.7	34.3
Sudan	SDN	9.5	12.6	12.0	12.2	12.1
Swaziland	SWZ	18.0	20.5	19.5	25.9	17.9
Tanzania	TZA	3.5	5.5	5.0	3.9	4.8
Togo	TGO	4.9	6.1	6.0	6.2	5.6
Tunisia	TUN	24.5	30.3	27.6	25.8	26.1
Uganda	UGA	3.2	5.2	5.0	6.3	4.3
Zambia	ZMB	5.2	5.5	5.4	6.5	4.7
Zimbabwe	ZWE	n.a.	2.6	2.3	2.4	2.0
Asia/Pacific						
Bangladesh	BGD	4.1	7.0	7.0	7.7	6.1
Bhutan	BTN	7.4	11.9	11.6	9.7	10.4
Brunei Darussalam	BRN	78.1	80.1	77.8	72.8	80.8
Cambodia	KHM	4.5	7.7	7.8	9.5	6.6
China	CHN	8.4	11.3	11.2	11.3	11.2
Fiji	FJI	33.3	24.2	23.5	21.9	23.0
Hong Kong, China	HKG	180.5	129.4	129.2	120.4	135.3
India	IND	5.1	9.6	9.6	10.2	7.8
Indonesia	IDN	10.3	16.0	15.5	15.5	14.4
Iran, Islamic Rep.	IRN	20.2	44.5	45.8	56.2	38.5
Lao PDR	LAO	3.7	7.0	6.9	7.4	5.7
Macao, China	MAC	85.9	71.4	71.3	67.2	75.1
Malaysia	MYS	27.7	33.2	32.1	27.4	32.2
Maldives	MDV	14.5	12.7	12.8	18.7	11.5
Mongolia	MNG	6.3	9.7	9.5	10.6	8.8
Nepal	NPL	3.4	6.1	6.0	6.2	4.5
Pakistan	PAK	7.4	14.2	14.2	16.4	12.1
Philippines	PHL	9.7	14.8	15.0	16.7	13.7
Singapore	SGP	140.8	106.1	103.2	101.8	104.0
Sri Lanka	LKA	10.8	18.1	17.8	17.2	15.5
Taiwan, China	TWN	118.3	112.2	113.3	125.6	121.9
Thailand	THA	18.9	29.0	28.2	24.8	27.4
Vietnam	VNM	4.6	8.3	8.4	12.2	6.3
West Asia						
Bahrain	BHR	93.6	74.2	72.6	68.1	62.0
Egypt, Arab Rep.	EGY	12.7	24.2	23.1	23.0	22.7
Iraq	IRQ	6.9	10.6	10.4	9.6	9.9
Jordan	JOR	24.5	23.7	25.2	24.9	24.4

Kuwait	KWT	132.4	91.5	95.7	98.7	80.4
Lebanon	LBN	61.0	55.5	60.6	62.6	63.1
Oman	OMN	51.0	44.6	46.7	43.2	43.1
Qatar	QAT	113.5	75.7	73.0	94.5	51.2
Saudi Arabia	SAU	45.1	38.9	40.6	37.1	38.7
Syrian Arab Republic	SYR	13.0	18.4	18.6	18.3	18.9
Yemen, Rep.	YEM	6.3	8.8	9.2	8.9	9.2
South America						
Argentina	ARG	36.0	51.5	48.8	46.1	46.5
Bolivia	BOL	8.1	17.0	15.7	17.2	13.5
Brazil	BRA	34.1	35.2	32.7	32.0	33.1
Chile	CHL	51.8	50.0	46.6	43.3	48.0
Colombia	COL	22.0	28.5	26.5	27.4	25.8
Ecuador	ECU	22.2	29.6	27.0	24.8	27.1
Paraguay	PRY	11.6	22.5	21.2	20.7	18.5
Peru	PER	23.4	31.2	28.5	29.4	26.9
Uruguay	URY	44.8	47.8	44.8	42.7	42.9
Venezuela, RB	VEN	31.3	34.9	32.6	30.3	33.4
CIS						
Armenia	ARM	14.1	21.9	26.1	32.0	19.9
Azerbaijan	AZE	9.1	16.4	18.4	18.7	14.3
Belarus	BLR	19.9	37.7	42.5	42.2	34.1
Georgia	GEO	12.4	19.2	23.2	31.5	17.7
Kazakhstan	KAZ	23.7	32.4	38.8	60.8	31.0
Kyrgyz Republic	KGZ	5.1	10.8	13.2	18.1	8.5
Moldova	MDA	9.5	16.6	21.3	28.0	14.7
Russian Federation	RUS	33.0	46.5	50.8	45.9	45.0
Tajikistan	TJK	3.1	7.0	9.8	13.3	5.1
Ukraine	UKR	13.7	27.3	31.3	35.5	23.2
OECD-Eurostat						
Albania	ALB	25.1	28.0	28.8	27.3	26.8
Australia	AUS	245.0	146.7	146.4	125.4	152.6
Austria	AUT	294.0	176.3	172.2	149.0	181.2
Belgium	BEL	261.4	150.1	147.1	132.4	154.8
Bosnia and Herzegovina	BIH	35.4	42.6	42.9	39.4	39.2
Bulgaria	BGR	33.0	46.7	48.0	48.2	42.5
Canada	CAN	246.8	158.2	156.1	131.6	165.7
Croatia	HRV	80.4	71.5	71.7	64.6	70.1
Cyprus	CYP	217.3	148.2	149.4	124.5	148.1
Czech Republic	CZE	85.0	89.4	90.3	88.0	86.8
Denmark	DNK	322.5	141.8	139.6	120.5	141.5
Estonia	EST	77.0	73.2	75.7	66.8	75.3

Finland	FIN	259.6	128.3	128.1	111.4	130.4
France	FRA	269.4	153.0	152.9	131.7	159.9
Germany	DEU	267.6	157.0	152.5	135.8	161.3
Greece	GRC	197.0	136.6	134.7	115.4	137.2
Hungary	HUN	80.6	78.0	80.6	72.2	75.1
Iceland	ISL	397.4	160.3	159.0	132.1	163.3
Ireland	IRL	287.4	140.8	140.3	118.1	148.6
Israel	ISR	138.4	101.9	102.3	93.7	100.3
Italy	ITA	235.1	137.9	135.0	113.0	136.9
Japan	JPN	275.8	141.9	136.8	143.8	153.0
Korea, Rep.	KOR	105.6	82.1	77.8	83.3	81.6
Latvia	LVA	53.9	57.6	61.3	57.6	58.2
Lithuania	LTU	62.7	70.1	74.4	62.7	69.0
Luxembourg	LUX	367.1	217.7	204.7	176.7	212.7
Macedonia, FYR	MKD	26.8	37.5	38.8	37.5	33.9
Malta	MLT	137.1	118.6	118.0	97.2	115.8
Mexico	MEX	62.6	59.5	60.7	59.2	55.7
Montenegro	MNE	31.6	33.7	34.9	33.2	32.6
Netherlands	NLD	269.3	158.0	154.4	141.1	162.3
New Zealand	NZL	214.5	127.0	127.3	109.4	134.9
Norway	NOR	358.5	157.2	154.8	136.6	160.3
Poland	POL	63.5	63.8	68.1	66.3	61.9
Portugal	PRT	152.3	109.8	108.0	90.2	107.4
Romania	ROM	39.8	44.9	45.6	43.0	42.7
Serbia	SRB	31.9	40.7	41.9	41.5	37.3
Slovak Republic	SVK	65.2	71.7	74.6	75.3	68.3
Slovenia	SVN	127.7	103.5	102.6	85.9	104.4
Spain	ESP	203.6	135.8	135.5	112.4	137.9
Sweden	SWE	270.4	140.8	137.1	124.2	140.4
Switzerland	CHE	368.9	164.6	160.8	146.8	178.3
Turkey	TUR	42.4	38.2	38.3	38.3	33.8
United Kingdom	GBR	303.9	169.0	170.4	139.3	173.6
United States	USA	353.6	235.9	223.9	190.6	247.8

Notes Countries are ordered alphabetically within each of the six ICP regions. Poorest country is Democratic Republic of Congo (DRC), richest is U.S. Household consumption is sum of Basic Headings 1-102, 104 & 105: see Appendix Table A1 for the list of Basic Headings. "World Bank PPP" is the World Bank's PPP for Individual Consumption by Households (which is similar but not identical to my definition of household consumption). The other PPPs are my own calculations based on 104 PPPs and corresponding expenditures covering my definition of household consumption. The bilateral PPP with own weights uses each country's expenditure shares in turn to weight the individual PPPs. The bilateral PPP with U.S. weights uses U.S. expenditure shares to weight each country's individual PPPs.

Source Columns 3 and 4: World Bank (2008). Columns 5, 6 and7: unpublished World Bank spreadsheet and own calculations.

Table A3
Cross-country unweighted means and standard deviations of budget shares (100 Basic Heading within Household Consumption, 141 countries)

Number	*Basic Heading*	*Mean (%)*	*S.D.*
1	Rice	2.490	4.250
2	Other cereals and flour	2.484	3.833
3	Bread	1.503	1.533
4	Other bakery products	0.599	0.473
5	Pasta products	0.370	0.365
6	Beef and veal	1.665	1.657
7	Pork	0.590	0.793
8	Lamb, mutton and goat	0.751	1.195
9	Poultry	1.214	0.984
10	Other meats and preparations	1.159	1.294
11	Fresh or frozen fish and seafood	1.376	1.638
12	Preserved fish and seafood	0.619	1.016
13	Fresh milk	1.105	1.887
14	Preserved milk and milk products	0.959	1.026
15	Cheese	0.554	0.732
16	Eggs and egg-based products	0.523	0.508
17	Butter and margarine	0.475	0.772
18	Other edible oils and fats	1.121	1.180
19	Fresh or chilled fruit	1.495	1.148
20	Frozen, preserved or processed fruits	0.316	0.533
21	Fresh or chilled vegetables	2.408	1.924
22	Fresh or chilled potatoes	1.531	2.710
23	Frozen or preserved vegetables	0.582	0.927
24	Sugar	0.873	1.197
25	Jams, marmalades and honey	0.146	0.160
26	Confectionery, chocolate and ice cream	0.581	0.437
27	Food products n.e.c.	1.492	1.686
28	Coffee, tea and cocoa	0.679	0.779
29	Mineral waters, soft drinks, fruit and vegetable juices	1.065	0.676
30	Spirits	0.513	0.651
31	Wine	0.417	0.491
32	Beer	0.983	1.577
33	Tobacco	1.576	1.036
34	Clothing materials and accessories	0.704	0.840
35	Garments	3.653	1.691
36	Cleaning and repair of clothing	0.205	0.282
37	Footwear	1.214	0.712
38	Repair and hire of footwear	0.053	0.081
39	Actual and imputed rentals for housing	9.963	4.880

40	Maintenance and repair of the dwelling	0.942	1.206
41	Water supply and miscellaneous services relating to the dwelling	0.675	0.579
42	Miscellaneous services relating to the dwelling	0.431	0.506
43	Electricity	1.719	1.104
44	Gas	0.654	0.573
45	Other fuels	1.494	1.507
46	Furniture and furnishings	1.157	0.760
47	Carpets and other floor coverings	0.209	0.247
48	Repair of furniture, furnishings and floor coverings	0.087	0.169
49	Household textiles	0.462	0.381
50	Major household appliances whether electric or not	0.687	0.546
51	Small electric household appliances	0.180	0.253
52	Repair of household appliances	0.109	0.183
53	Glassware, tableware and household utensils	0.460	0.348
54	Major tools and equipment	0.115	0.151
55	Small tools and miscellaneous accessories	0.226	0.233
56	Non-durable household goods	1.121	0.746
57	Domestic services	0.571	0.633
58	Household services	0.157	0.303
59	Pharmaceutical products	2.018	1.379
60	Other medical products	0.282	0.568
61	Therapeutical appliances and equipment	0.322	0.450
62	Medical Services	1.096	0.937
63	Dental services	0.477	0.488
64	Paramedical services	0.411	0.441
65	Hospital services	1.287	1.539
66	Motor cars	2.436	1.829
67	Motor cycles	0.235	0.521
68	Bicycles	0.117	0.204
69	Fuels and lubricants for personal transport equip.	2.484	1.702
70	Maintenance and repair of personal transport equip.	1.120	0.942
71	Other services in respect of personal transport equip.	0.335	0.486
72	Passenger transport by railway	0.309	0.316
73	Passenger transport by road	2.219	2.178
74	Passenger transport by air	1.070	0.765
77	Other purchased transport services	0.263	0.781
78	Postal services	0.094	0.103
79	Telephone and telefax equipment	0.277	0.321
80	Telephone and telefax services	2.232	1.505
81	Audio-visual, photographic and i.p. equipment	0.862	0.673
82	Recording media	0.173	0.168
83	Repair of audio-visual, photographic and i.p. equipment	0.090	0.229
84	Major durables for outdoor and indoor recreation	0.158	0.245
85	Other recreational items and equipment	0.363	0.386

86	Gardens and pets	0.276	0.355
87	Veterinary and other services for pets	0.071	0.198
88	Recreational and sporting services	0.541	0.617
89	Cultural services	1.000	0.896
90	Games of chance	0.530	0.903
91	Newspapers, books and stationery	0.883	0.648
93	Education	3.345	2.460
94	Catering services	3.828	3.042
95	Accommodation services	0.859	1.059
96	Hairdressing salons and personal grooming estabs.	0.605	0.514
97	Appliances, articles and products for personal care	1.225	0.767
99	Jewellery, clocks and watches	0.446	0.512
100	Other personal effects	0.305	0.322
101	Social protection	1.485	2.061
102	Insurance	0.978	1.044
104	Other financial services n.e.c.	0.626	0.748
105	Other services n.e.c.	0.807	0.757
	Mean over 100 Basic Headings	1.000	1.198
	Standard deviation	0.960	0.847

Note Household consumption consists of 100 Basic Headings within Basic Headings 1-102, 104 and 105; see Table A1 and text for details.

Source Unpublished World Bank spreadsheet and own calculations.

Table A4
Konüs indices of the standard of living:
real household consumption (HC) per head in 141 countries
(poorest country is the reference country: DRC = 1.0)

	Base country							
	Poorest (DRC)				*Richest (U.S.)*			
ICP region and country	*Model I*	*Model II*	*Model III*	*Model IV*	*Model I*	*Model II*	*Model III*	*Model IV*
Africa								
Benin	6.6	7.2	6.6	6.7	7.1	6.6	7.3	6.7
Botswana	17.0	18.2	16.5	17.6	18.2	16.4	18.7	17.0
Burkina Faso	4.6	5.0	4.6	4.6	4.9	4.7	5.1	4.7
Burundi	1.7	1.7	1.7	1.7	1.6	1.6	1.7	1.7
Cameroon	8.9	9.6	8.9	9.1	9.8	9.0	10.0	9.0
Cape Verde	15.5	16.4	14.9	15.6	17.4	15.5	18.1	15.9
Central African Republic	4.1	4.2	4.1	4.1	4.1	4.0	4.2	4.1
Chad	4.7	5.0	4.6	4.7	5.1	4.9	5.7	5.1
Congo, Dem. Rep.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Congo, Rep.	5.4	5.8	5.3	5.5	5.7	5.4	6.0	5.4
Côte d'Ivoire	6.8	7.4	6.8	7.0	7.3	6.8	7.5	6.8
Equatorial Guinea	16.0	17.2	15.5	16.8	18.7	16.7	19.6	17.4
Ethiopia	2.8	2.9	2.9	2.8	2.7	2.6	2.7	2.5
Gabon	15.9	17.0	15.4	16.8	18.5	16.7	19.3	17.4
Gambia, The	2.7	2.7	2.7	2.7	3.4	3.3	3.4	3.2
Ghana	5.8	6.2	5.7	5.8	7.0	6.6	7.1	6.5
Guinea	3.7	3.9	3.7	3.8	3.6	3.5	3.7	3.6
Guinea-Bissau	2.3	2.4	2.3	2.3	2.7	2.6	2.7	2.4
Kenya	7.0	7.6	7.0	7.1	7.6	7.1	7.9	7.3
Lesotho	9.5	10.2	9.2	9.5	11.3	10.5	11.8	10.6
Liberia	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Madagascar	4.1	4.4	4.1	4.1	4.6	4.4	4.8	4.5
Malawi	3.1	3.1	3.1	3.2	3.0	2.9	3.0	2.9
Mali	4.2	4.5	4.2	4.3	4.6	4.3	4.7	4.3
Mauritania	6.0	6.5	6.0	6.1	7.2	6.7	7.5	6.9
Mauritius	47.6	50.5	45.5	47.8	55.8	50.1	57.2	49.9
Morocco	15.4	16.2	14.9	15.8	15.1	13.6	15.6	14.1
Mozambique	3.4	3.5	3.4	3.5	3.2	3.0	3.2	3.0
Namibia	15.8	16.8	15.1	16.4	18.1	16.3	18.7	16.7
Niger	2.9	2.9	2.8	2.9	2.9	2.8	2.9	2.8
Nigeria	6.9	7.4	6.8	6.9	8.2	7.7	8.7	7.9
Rwanda	3.3	3.5	3.3	3.4	3.2	3.1	3.4	3.2

Sao Tomé and Principe	8.0	8.7	8.0	8.0	8.9	8.3	9.3	8.3
Senegal	7.5	8.1	7.5	7.4	8.6	8.1	9.0	8.3
Sierra Leone	3.5	3.8	3.5	3.6	4.0	4.0	4.1	3.8
South Africa	36.1	38.6	35.4	37.5	41.8	36.6	43.0	37.5
Sudan	10.8	11.6	10.5	11.0	13.2	12.2	14.0	12.6
Swaziland	16.5	17.6	15.9	16.9	19.1	17.4	20.1	17.8
Togo	5.3	5.8	5.4	5.5	5.5	5.2	5.6	5.2
Tunisia	24.2	25.9	24.1	25.7	26.2	23.2	26.8	23.5
Uganda	4.6	4.9	4.5	4.7	4.5	4.2	4.5	4.2
Zambia	5.1	5.4	5.0	5.1	5.0	4.7	5.1	4.8
Zimbabwe	2.1	2.2	2.1	2.2	2.1	2.2	2.2	2.2
Asia/Pacific								
Bangladesh	7.1	7.6	7.0	7.0	7.4	6.9	7.7	6.9
Bhutan	11.9	12.9	11.5	11.9	13.3	12.3	14.2	12.5
Brunei Darussalam	66.3	69.9	64.7	67.0	96.0	85.0	99.1	84.5
Cambodia	6.3	6.7	6.3	6.3	7.8	7.2	8.3	7.5
China	10.7	11.6	10.4	10.7	12.9	11.8	13.6	11.9
Fiji	21.2	23.0	20.9	22.4	24.6	22.0	25.6	22.3
Hong Kong, China	126.3	134.8	121.9	127.7	178.8	159.3	185.0	159.8
India	8.6	9.3	8.6	8.6	10.2	9.3	10.7	9.4
Indonesia	14.2	15.0	13.7	14.6	15.0	13.5	15.8	14.1
Iran, Islamic Rep.	39.8	42.7	37.9	41.3	51.0	45.3	52.7	46.5
Lao PDR	5.8	6.1	5.7	5.7	6.6	6.1	7.1	6.6
Macao, China	70.4	75.3	68.9	72.2	92.0	81.8	96.0	83.5
Malaysia	27.5	29.1	26.9	28.4	35.1	30.7	36.6	31.7
Mongolia	7.9	8.5	7.8	7.9	10.4	9.5	10.9	9.5
Nepal	5.3	5.7	5.3	5.3	5.8	5.5	6.0	5.6
Pakistan	12.6	13.2	12.2	12.7	14.8	13.4	15.7	14.0
Philippines	12.5	13.3	12.2	13.0	14.9	13.5	15.7	13.8
Singapore	105.0	111.3	101.5	106.0	139.2	123.8	144.4	123.9
Sri Lanka	15.5	16.8	15.0	16.0	17.9	16.4	18.5	16.7
Taiwan, China	103.1	108.9	99.1	103.0	156.9	138.4	163.6	140.6
Thailand	22.9	24.5	22.7	23.7	27.6	24.8	28.8	25.3
Vietnam	7.3	7.9	7.3	7.4	8.3	7.8	9.0	8.1
West Asia								
Bahrain	79.8	85.7	77.2	82.7	96.3	85.1	100.1	86.6
Egypt, Arab Rep.	23.3	24.8	22.7	24.8	24.0	21.7	25.4	22.6
Iraq	10.1	10.9	9.8	10.2	12.9	11.6	13.9	12.0
Jordan	23.0	25.0	22.6	24.2	24.6	22.0	25.2	22.0
Kuwait	102.8	109.7	98.5	104.8	121.7	106.7	126.3	107.1
Lebanon	69.8	74.3	67.4	72.4	83.0	74.9	86.2	76.5

Oman	47.2	50.4	45.1	48.9	58.4	51.8	59.4	52.4
Qatar	86.9	93.3	83.5	90.4	104.9	92.4	109.1	94.2
Saudi Arabia	40.6	42.9	38.1	41.6	48.5	42.9	50.2	43.4
Syrian Arab Republic	17.8	19.1	17.2	18.8	19.6	17.3	20.9	18.8
Yemen, Rep.	8.4	9.0	8.3	8.4	10.5	9.7	11.3	9.9
South America								
Argentina	48.7	51.8	46.6	49.2	63.9	56.7	65.2	58.3
Bolivia	14.3	15.1	13.8	14.5	14.9	13.4	15.6	13.8
Brazil	32.1	33.9	31.3	33.1	38.9	33.6	40.2	34.9
Chile	48.4	51.8	46.7	49.9	59.6	53.4	60.7	54.1
Colombia	21.9	23.6	21.8	23.0	25.4	22.6	26.2	23.1
Ecuador	24.6	26.4	24.4	26.0	27.0	24.0	28.1	24.5
Paraguay	20.1	21.4	19.6	21.1	21.2	18.7	21.9	19.6
Peru	25.6	27.0	25.3	27.0	27.0	23.7	27.8	24.4
Uruguay	44.7	47.5	42.6	45.4	55.2	49.8	56.8	49.2
Venezuela, RB	29.7	31.3	29.0	30.9	38.1	33.0	39.5	34.3
CIS								
Armenia	23.1	24.8	22.9	23.7	23.8	21.6	24.4	21.8
Azerbaijan	18.4	19.8	17.8	19.6	17.6	16.2	18.6	17.2
Belarus	44.3	46.8	42.1	45.7	52.1	46.1	53.8	47.5
Georgia	21.2	22.6	20.8	22.7	21.3	19.1	22.0	19.9
Kazakhstan	38.1	40.3	37.1	40.4	43.0	38.3	44.3	38.9
Kyrgyz Republic	13.3	14.1	12.9	13.6	12.7	11.7	13.5	12.3
Moldova	18.6	19.8	18.2	20.1	18.5	16.5	19.2	17.3
Russian Federation	55.6	59.1	53.5	57.5	65.5	58.3	66.6	59.5
Tajikistan	8.0	8.5	8.0	8.2	8.2	7.4	8.7	7.9
Ukraine	30.3	31.8	29.9	32.3	31.7	27.8	32.7	29.0
OECD-Eurostat								
Albania	25.8	27.2	25.4	27.2	30.4	26.6	31.3	27.4
Australia	154.4	163.5	149.6	155.6	197.2	175.8	205.4	178.1
Austria	191.1	204.6	183.4	194.7	236.7	212.5	246.2	211.2
Belgium	175.2	187.7	169.2	181.0	206.6	185.8	215.6	185.5
Bosnia and Herzegovina	45.4	48.0	43.4	46.7	52.3	46.4	53.7	47.4
Bulgaria	52.0	54.9	49.9	52.4	60.7	53.7	61.8	55.5
Canada	159.4	169.7	152.9	162.4	208.2	186.2	218.0	188.4
Croatia	76.9	82.6	75.6	80.0	90.2	80.5	93.9	82.4
Cyprus	169.3	180.7	162.2	173.9	200.5	179.2	209.2	180.6
Czech Republic	102.2	108.4	100.1	104.5	117.9	104.4	121.8	105.3
Denmark	164.2	176.7	159.2	167.8	192.9	173.5	200.9	173.5
Estonia	76.8	81.8	75.1	79.0	94.9	84.2	99.1	85.4
Finland	143.9	154.8	140.0	147.1	174.5	156.0	181.0	156.2

France	174.6	186.3	168.3	177.9	209.2	187.0	218.2	187.9
Germany	168.0	180.1	161.3	171.9	212.9	191.5	222.1	190.6
Greece	161.2	172.3	155.7	166.5	187.9	168.0	194.9	168.9
Hungary	93.2	99.1	90.9	95.6	102.1	90.8	105.6	91.8
Iceland	172.2	184.5	166.5	175.5	210.7	189.2	220.2	189.5
Ireland	156.0	166.7	151.8	159.2	193.0	173.1	201.0	173.9
Israel	125.5	133.7	121.2	127.4	136.1	121.3	140.8	121.6
Italy	153.9	164.0	148.5	155.5	186.1	166.2	192.7	167.1
Japan	123.5	131.9	118.9	123.7	196.9	175.0	206.2	178.2
Korea, Rep.	73.9	78.9	72.0	73.3	98.4	86.8	103.4	89.8
Latvia	64.8	69.4	63.0	67.7	78.7	70.4	81.5	71.8
Lithuania	79.2	84.4	77.6	81.7	92.7	82.1	96.7	83.5
Luxembourg	217.2	234.1	211.8	222.5	273.3	245.9	284.7	243.9
Macedonia, FYR	38.3	40.5	37.0	39.2	44.4	39.5	45.8	40.3
Malta	136.1	145.7	133.1	142.6	158.1	140.8	163.9	141.2
Mexico	63.8	68.2	61.9	65.3	74.3	66.5	76.9	67.9
Montenegro	34.4	36.3	33.5	35.3	41.9	36.3	43.2	37.7
Netherlands	194.5	208.9	186.8	199.5	219.0	197.6	228.4	196.2
New Zealand	130.0	139.1	125.6	132.0	174.6	155.5	180.8	156.1
Norway	175.3	187.4	170.8	178.9	210.0	188.0	218.9	189.0
Poland	74.9	80.3	73.2	78.3	85.4	76.3	88.3	77.8
Portugal	131.2	140.2	128.1	135.2	145.7	129.6	151.0	129.3
Romania	45.9	49.2	44.2	48.1	56.5	50.5	57.8	50.8
Serbia	44.1	46.6	42.0	45.1	49.5	43.8	51.0	45.0
Slovak Republic	81.3	86.4	79.9	83.7	92.5	82.0	96.5	83.4
Slovenia	109.4	117.2	105.7	112.1	139.6	125.0	144.5	124.5
Spain	159.4	171.3	154.1	164.1	189.2	169.5	196.5	169.6
Sweden	155.2	167.0	150.2	157.5	192.5	172.9	200.4	173.2
Switzerland	188.2	202.3	181.1	191.9	228.2	204.9	237.6	203.8
Turkey	38.9	41.3	38.0	40.1	42.7	38.1	44.0	38.7
United Kingdom	178.8	191.0	175.3	183.2	224.0	200.7	233.1	200.9
United States	243.6	261.5	237.5	249.6	307.7	277.5	320.5	275.6

Source Unpublished World Bank spreadsheet and own calculations.

Note A Konüs index of the standard of living is defined as HC deflated by a Konüs price index, the latter estimated by a chained Törnqvist index using compensated shares as weights. Alternative estimates of the compensated shares are derived from four regression models of household demand, models I-IV. The compensated shares are calculated with the background variables set to the levels found in the base country, i.e. either the *poorest* country (the DRC) or the *richest* country (the U.S.). The compensated shares are for the 100 Basic Headings within HC. All models include 24 principal components of log relative prices, background variables, and a constant but differ in the real expenditure variables included: see text for full account.

Table A5
Estimated coefficients and *t* statistics for Models II and IV
(poorest country (DRC) is base)

		Model II		*Model IV*			
BH No.	*Basic Heading*	$\hat{\beta}_i$		$\hat{\beta}_i$		$\hat{\lambda}_i \times 100$	
		Coefficient	*t*	Coefficient.	*t*	Coefficient.	*t*
1	Rice	-0.404	0.36	0.292	0.27	-0.094	1.66
2	Other cereals and flour	-1.146	1.17	-1.331	1.10	0.051	0.81
3	Bread	-0.486	1.40	-0.835	2.22	0.041	1.98
4	Other bakery products	0.010	0.06	0.068	0.46	-0.015	1.57
5	Pasta products	-0.019	0.20	0.002	0.02	-0.006	1.12
6	Beef and veal	0.361	0.79	0.146	0.27	0.029	0.95
7	Pork	-0.201	1.02	-0.172	0.73	-0.003	0.25
8	Lamb, mutton and goat	-0.418	1.08	-0.515	1.15	0.009	0.48
9	Poultry	0.094	0.29	0.171	0.47	-0.017	0.86
10	Other meats and preparations	-0.186	0.67	0.140	0.50	-0.057	2.34
11	Fresh or frozen fish and seafood	0.105	0.25	-0.107	0.27	0.017	0.56
12	Preserved fish and seafood	-0.276	1.38	-0.018	0.08	-0.027	1.76
13	Fresh milk	0.628	1.47	0.210	0.47	-0.013	0.49
14	Preserved milk and milk products	0.111	0.39	-0.086	0.28	-0.016	0.99
15	Cheese	0.125	0.69	0.112	0.63	-0.010	1.00
16	Eggs and egg-based products	0.017	0.14	-0.009	0.08	-0.010	1.35
17	Butter and margarine	0.103	0.48	0.111	0.46	-0.005	0.38
18	Other edible oils and fats	-0.645	2.34	-0.760	2.43	0.035	1.82
19	Fresh or chilled fruit	-0.119	0.36	-0.429	1.27	0.026	1.46
20	Frozen, preserved or processed fruits	-0.151	0.88	-0.088	0.52	0.003	0.28
21	Fresh or chilled vegetables	-0.969	2.38	-1.062	2.10	0.040	1.17
22	Fresh or chilled potatoes	0.041	0.05	-0.361	0.47	0.042	1.22
23	Frozen or preserved vegetables	-0.098	0.24	-0.477	1.13	0.040	2.19
24	Sugar	-0.623	2.34	-0.517	1.87	-0.006	0.38
25	Jams, marmalades and honey	0.018	0.35	0.026	0.48	-0.005	1.10
26	Confectionery, chocolate and ice cream	-0.061	0.56	-0.221	1.96	0.019	3.37
27	Food products n.e.c.	-1.027	2.01	-1.137	2.37	0.028	0.84

28	Coffee, tea and cocoa	0.009	0.04	-0.277	1.01	0.035	1.88
29	Mineral waters, soft drinks, fruit and vegetable juices	0.055	0.29	0.107	0.51	-0.009	0.70
30	Spirits	0.087	0.56	0.121	0.74	-0.007	0.84
31	Wine	0.113	1.04	0.204	1.60	-0.019	2.32
32	Beer	0.955	1.76	0.787	1.61	0.002	0.08
33	Tobacco	-0.328	1.25	-0.205	0.68	-0.018	1.01
34	Clothing materials and accessories	0.275	1.06	0.282	0.96	-0.003	0.20
35	Garments	-0.195	0.42	0.127	0.21	0.014	0.39
36	Cleaning and repair of clothing	0.163	1.67	0.128	1.42	0.003	0.59
37	Footwear	-0.388	1.67	-0.105	0.39	-0.025	1.76
38	Repair and hire of footwear	0.052	2.20	0.037	1.57	0.002	1.30
39	Actual and imputed rentals for housing	0.272	0.45	-0.079	0.11	0.063	1.36
40	Maintenance and repair of the dwelling	-0.142	0.32	0.206	0.39	-0.028	1.34
41	Water supply and miscellaneous services relating to the dwelling	-0.010	0.06	0.021	0.12	-0.003	0.27
42	Miscellaneous services relating to the dwelling	0.235	1.80	0.155	1.07	0.015	1.55
43	Electricity	0.199	0.63	0.195	0.57	0.009	0.49
44	Gas	-0.015	0.09	-0.119	0.68	0.015	1.57
45	Other fuels	-1.043	2.10	-1.353	2.76	0.025	1.00
46	Furniture and furnishings	-0.110	0.50	-0.118	0.52	-0.004	0.44
47	Carpets and other floor coverings	-0.001	0.01	0.001	0.01	-0.002	0.55
48	Repair of furniture, furnishings and floor coverings	-0.039	0.69	-0.082	1.18	0.004	0.99
49	Household textiles	0.031	0.35	0.013	0.12	-0.001	0.08
50	Major household appliances whether electric or not	-0.201	1.02	-0.277	1.27	0.010	1.17
51	Small electric household appliances	-0.008	0.12	-0.020	0.22	0.003	0.61
52	Repair of household appliances	-0.017	0.43	0.020	0.42	-0.007	2.25
53	Glassware, tableware and household utensils	0.051	0.51	0.102	0.97	-0.006	0.89
54	Major tools and equipment	0.056	1.17	0.035	0.71	0.001	0.30

55	Small tools and miscellaneous accessories	0.125	1.73	0.131	1.83	-0.005	0.86
56	Non-durable household goods	0.582	2.57	0.625	2.52	0.001	0.07
57	Domestic services	0.421	2.77	0.393	2.50	-0.003	0.28
58	Household services	-0.061	0.46	-0.098	0.76	0.005	1.05
59	Pharmaceutical products	-0.493	1.45	-0.478	1.12	0.036	1.69
60	Other medical products	-0.133	0.81	-0.128	0.76	-0.003	0.27
61	Therapeutical appliances and equipment	0.235	1.89	0.263	1.85	-0.012	1.28
62	Medical Services	0.603	3.06	0.631	3.11	-0.008	0.59
63	Dental services	0.372	2.51	0.320	2.03	0.004	0.44
64	Paramedical services	0.412	2.77	0.428	2.58	-0.002	0.20
65	Hospital services	0.283	0.60	0.461	0.98	-0.035	1.54
66	Motor cars	0.458	1.04	0.445	0.95	0.005	0.17
67	Motor cycles	0.065	0.52	0.006	0.04	0.010	1.03
68	Bicycles	0.097	0.97	0.115	1.18	-0.002	0.50
69	Fuels and lubricants for personal transport equip.	0.485	1.16	0.405	0.92	-0.012	0.38
70	Maintenance and repair of personal transport equip.	0.068	0.40	0.048	0.29	-0.005	0.34
71	Other services in respect of personal transport equip.	-0.095	0.65	-0.041	0.29	-0.007	0.91
72	Passenger transport by railway	0.055	0.67	0.008	0.09	0.005	0.96
73	Passenger transport by road	0.308	0.52	0.091	0.14	0.049	1.26
74	Passenger transport by air	0.118	0.60	0.046	0.21	-0.002	0.18
77	Other purchased transport services	0.024	0.11	-0.094	0.44	0.000	0.02
78	Postal services	-0.011	0.28	-0.015	0.42	0.000	0.23
79	Telephone and telefax equipment	-0.201	1.82	-0.212	1.75	0.005	0.97
80	Telephone and telefax services	-0.387	0.88	-0.090	0.19	-0.037	1.41
81	Audio-visual, photographic and i.p. equipment	0.022	0.15	0.104	0.62	-0.003	0.28
82	Recording media	0.045	0.99	0.051	1.02	-0.001	0.23
83	Repair of audio-visual, photographic and i.p. equipment	0.052	0.76	0.039	0.57	0.001	0.27
84	Major durables for outdoor and indoor recreation	0.094	1.47	0.071	1.02	-0.002	0.35

85	Other recreational items and equipment	0.096	0.94	0.081	0.81	0.003	0.49
86	Gardens and pets	-0.003	0.03	-0.026	0.25	0.006	0.93
87	Veterinary and other services for pets	0.101	1.60	0.088	1.28	0.001	0.25
88	Recreational and sporting services	0.274	1.94	0.268	1.77	0.002	0.26
89	Cultural services	0.524	2.91	0.426	2.41	0.012	1.05
90	Games of chance	0.200	0.87	0.254	0.97	-0.003	0.24
91	Newspapers, books and stationery	0.013	0.05	0.203	0.92	-0.015	1.61
93	Education	-0.565	0.61	0.126	0.12	-0.049	0.97
94	Catering services	0.037	0.05	0.570	0.74	-0.067	1.64
95	Accommodation services	0.303	1.19	0.292	1.02	0.012	0.59
96	Hairdressing salons and personal grooming estabs.	0.251	1.57	0.281	1.85	-0.009	0.70
97	Appliances, articles and products for personal care	0.308	1.31	0.452	1.61	-0.014	0.79
99	Jewellery, clocks and watches	-0.195	1.53	-0.087	0.67	-0.011	1.27
100	Other personal effects	-0.161	1.14	-0.049	0.37	-0.010	1.71
101	Social protection	0.211	0.43	0.189	0.36	0.014	0.51
102	Insurance	0.240	1.08	0.311	1.27	-0.002	0.14
104	Other financial services n.e.c.	-0.176	0.86	-0.126	0.62	-0.008	0.67
105	Other services n.e.c.	0.157	0.69	0.161	0.72	-0.007	0.46

Source Unpublished World Bank spreadsheet and own calculations.

Note Each model fits a set of share equations for the 100 Basic Headings included in Household Consumption. Equation fitted is (38). 141 countries in sample. Estimation method: OLS, with robust *t* statistics. Results reported are after 60 iterations. In addition to the variables shown, both models include also 24 principal components of the 99 log relative prices, 30 background variables, and a constant. See text for description of models and background variables.

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