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Price structures, the quality factor, and chaining*

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Abstract. This paper examines alternative approaches to multilateral comparisons based on spatial chains. The ground covered includes a review of the consistency problem for countries with multiple-benchmarks and a discussion of what might give rise to it. While much of our recent work has been with respect to the Penn World Table (PWT), most of this paper will be concerned with benchmark comparisons. In particular we argue that serious consideration be given to spatial chaining as a method of multilateral comparison, but there still remain major problems to solve. The case we make is as much empirical as it is methodological. Our application is to the 115 country 1996 reduced benchmark data. For this data set, we examine spatial linking based upon the spanning tree approach of Robert Hill, but using both price similarity as well as the Paasche-Laspeyres spread as criteria. We go on to describe how we might extend this benchmark over time and space along the lines of PWT.

1. Introduction

It will come as no surprise that at a meeting discussing the first phase of the ICP at the World Bank almost 30 years ago, there were discussions of methods of producing PPPs and international comparisons of real product. At that session Phase I results were presented using many alternative methods: Walsh, EKS, own country weighted binaries, Fishers expressed relative to the United States, Van Yzeren, our beloved G-K method, and the then the still much loved (by others!) exchange rates (KKHS, 1975, p. 75). There was much heated discussion, little of which is memorable except for one remark of Nancy Ruggles that has remained with us. She said that the important thing was not the difference between the various non-exchange rate methods, but that the comparisons get done. That was good enough then, but what about now?

This paper looks at alternative approaches to multilateral comparisons based on spatial chains. The ground covered includes a review of the multiple-benchmark problem and a discussion of what might give rise to it. While much of our recent work has been with respect to the Penn World Table (PWT),

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Part A of this paper discusses the problems posed by multiple benchmark comparisons. In Part B we focus on spatial chaining based on the work and conversations with Robert Hill, Erwin Diewert, Michael Ward, none of whom is implicated in what follows. Part C provides an empirical implementation of a chaining scheme based upon the recent benchmark work for 1996. Part D then looks at the problem of extending this across time and space.

2. Problems posed by multiple benchmark comparisons

This section takes up several problems that have emerged with the availability of benchmark comparisons over a number of years. The issues examined include the reconciliation of national growth rates with the growth rates implied by successive benchmark comparisons; the question of using the latest benchmark as the base for extrapolations; and the relationship of the number of countries included in a benchmark to the resulting estimates.

If per capita GDP in India relative to Korea is 40% in a 1970 benchmark and 35% in a 1975 benchmark, then one inference is that the growth rate per capita in Korea must have been about 5% more than India between 1970 and 1975. Often such an implied result is not consistent with the national growth rates in the two countries, posing a problem to users. Of course, the two estimates of growth rates should not be identical, but it is still disconcerting to producers and users of the data when the differences are as large as they have been in the ICP thus far.

The differences in growth rates arising from the difference in concepts are only part of the explanation for the observed differences. When countries have participated in several benchmark comparisons, there will be the inevitable stochastic differences in the item samples and weights used in the various benchmark purchasing power estimates. This underlies the motivation for the EU system of annual comparisons and for other OECD countries to move towards annual comparisons. However, the experience of the recent OECD comparisons in 1993 and 1996 as well as that of other multiple benchmark pathologies suggests that harmonization of items in the temporal and benchmark price comparisons may be only part of the problem.

Consider the differences in the standings of countries relative to the United States that emerge from the 1993 and 1996 benchmark studies. One of the puzzles of the 1996 OECD comparison is that 16 of 23 countries have higher GDPs per capita relative to the U.S. than in the 1993 benchmark. However, the economies of many OECD countries like Austria and Canada were experiencing low growth between 1993 and 1996 while the US was enjoying respectable growth.[1] It is paradoxical that Canada, for example, moved relative to the US from 77.2 to 79.5 ($US = 100$) between the 1993 and 1996 benchmarks, both

[1] From 1993 to 1996 per capita GDP growth in the US was 8.1% before the revised national accounts numbers for 2000 were released, where the growth is put at 6.4%. It is not clear which should be used for the illustrations above. We have opted for 7.2% as a compromise.

based on the EKS method.[2] This implies that Canada's relative growth rate over the 3 years was 2.9 per cent greater than that of the US. However, its national accounts growth rate was 2.7 percent less than that of the US's national accounts per capita GDP growth. This is a combined difference of over 5.5%. For many of the other OECD countries, the combined differences erred in the same direction: 2.4% for Japan, 1.0% for Belgium, 3.5% for Australia, and 2.7% for Austria.

Several questions flow from this:

i. When there are differences between benchmarks that do not seem consistent with other information, does it make sense to base results on only the latest benchmark?
ii. Does the focus on the US as the numeraire for many comparisons in any way affect our understanding of changes over time?

2.1. Use of the latest benchmark

As to the first question, it has often been official practice to use only the latest benchmark as the basis for current, past and future projection comparisons until the next benchmark becomes available.[3] Use of the latest benchmark is simple and understandable, virtues that should not be taken lightly. Further, those producing the benchmarks try to improve the quality of the data each round so there is a basis for believing the latest benchmark is better than its predecessors. Since most users are likely to use the results to analyze countries' most recent economic experience, it may appear more sensible to base results on the most recent benchmark. To our knowledge there have not been tests to see whether the quality of comparisons has improved from benchmark to benchmark for the OECD. However, we accept these as reasonable positions to defend.

But there are at least two counterarguments. And here we refer only to using the latest benchmark for purposes of forward extrapolations until the next one becomes available. One argument turns on the number of countries in each benchmark, an issue taken up below. The second relates to an implicit assumption involved in opting for the latest benchmark, namely that countries are in international macro-equilibrium from one benchmark to another, something we certainly do not believe has been the case for the United States over the past 25 years [5]. What we mean by not being in international macro-equilibrium is that movements of the real exchange rate of a country significantly depart from PPP movements from benchmark to benchmark.

Table 1 presents data designed to illustrate our point. Column (1) presents an index of the price level of the US expressed relative to the 4 largest EU countries with 1990 equal to 100.[4] If there is a correspondence between movements in exchange rates and relative inflation rates in the US and these countries the index in column (1) of Table 1 would remain around 100. This is clearly not the case. Basically price level fluctuations can occur when relative inflation rates differ, while exchange rates remain the same; or when exchange rates change and relative inflation rates are similar; or some

[2] EKS refers to the method of Eltetö, Köves and Szulc, that in turn was developed by Gini. Several of the comments related to OECD benchmarks have been informed by Scarpetta, Bassanini, Pilat, and Schreyer [ECO/WKC/(2000)21].

[3] The OECD has moved away from this practice since 1993 in that backward extrapolations between two benchmark years take into consideration both sets of results, while forward extrapolations take into account only the latest year benchmark. For example estimates for 1994 and 1995 would take into account both the 1993 and 1996 benchmarks, while estimates after 1996 will be based only on the 1996 benchmark until the 1999 benchmark is completed.

[4] When the US is used as numeraire the price level is taken as 100 and variation from benchmark to benchmark shows up in other countries. To take this into account in Table 1 we first express the price level of the US relative to the four largest countries in the European Union that have participated in all of the benchmark comparisons, namely France, Germany, Italy and the UK. In this method of presentation, the US price level can vary from benchmark to benchmark; and a glance at Column (1) of Table 1 shows that it most certainly does vary.

Table 1
Movements of the US price level and measures of the US exchange rate

Benchmark year	Index of US price level to EU4 (1990 = 100) (1)	Effective real rate of exchange (1990 = 100) (2)	$ Rate to SDR (3)
1970	169.6	Not available	1.00
1975	126.2	129.5	1.21
1980	104.2	117.4	1.30
1985	174.1	170.6	1.02
1990	100.0	100.0	1.36
1993	103.3	100.5	1.40
1996	98.4	98.6	1.45

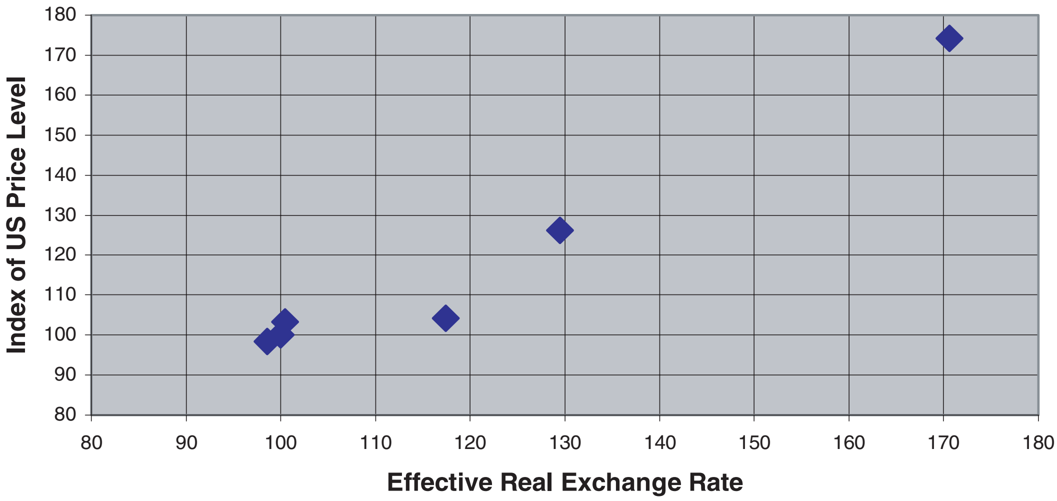

Fig. 1. Relation of US price level to real exchange rate.

combination of the two.

The other two columns in Table 1 provide measures of the US exchange rate and suggest that the price level movements of the United States are primarily related to exchange rate movements. Column 2 is the real effective exchange rate of the US$ as estimated by IMF, which is a measure of changes in the dollar prices at exchange rates of goods that the United States buys and sells, weighted by country specific exports and imports. When the effective exchange rate rises, it means the relative costs of importing goods has fallen and the cost of exporting has risen. Column 3 is the nominal rate of the US$ to the Special Drawing Rights (SDR) of the IMF. These relationships are also represented in Figs 1 and 2.

In both Figs 1 and 2 the index of the US price level relative to the four EU countries is on the vertical axis. In Fig. 1, the real exchange rate beginning with the 1975 benchmarks, is on the horizontal axis, and there is a strong positive relationship ($r = 0.98$). In Fig. 2, the exchange rate or the US$ to the SDR is on the horizontal axis, and we find that there is a strong negative relationship ($r = -0.97$) with the index of the US price level. So not only is the index of the US price level not flat across benchmarks, but it is driven by movements in exchange rates.

This divergence from a flat relationship is what we mean by a country not being in macro-international equilibrium. The most striking instance of course is 1985 when Fed policies supported a very strong

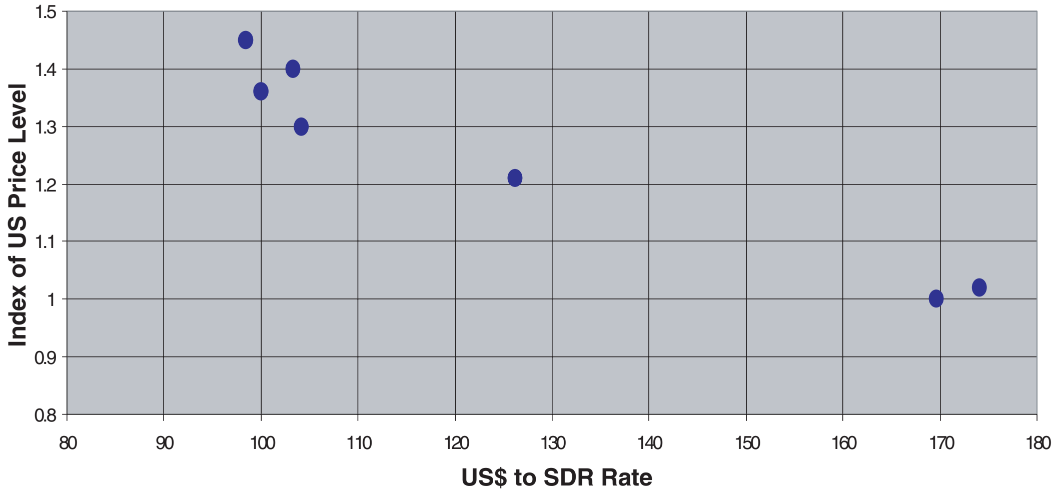

Fig. 2. Relation of US price level to US$ per SDR rate.

dollar. Many would say this was at the cost of a world recession and the creation of a rust belt in the Midwest.[5] The bottom line is that there are major movements in the principal measures of the nominal and real value of the dollar that in timing are associated with significant discrepancies between the US price levels in different benchmarks. Why this occurs we leave to others or to other papers.[6] For now we simply note that if a country as central to comparisons as the US can have significant departures in its price level from that which has been the normal expectation in ICP work, then it does raise questions about using only the latest benchmark.

In our own work we have used a reconciliation approach that went by the much maligned term, consistentization. This disparagement notwithstanding, consistentization did reconcile national growth rates with implied growth rates of multiple benchmarks in a sensible way. It made use of information of past benchmarks as well as current benchmarks, which seems a reasonable thing to do. In practice though, this proved difficult to implement.[7]

[5]This is strikingly revealed in a research report of the OECD that shows the maximum and minimum values of the price levels observed in various benchmarks relative to the US. What this report shows is that for the benchmarks from 1980–1996, the maximum PPP values to the US$ for the 22 OECD countries that participated in the 1985 benchmark are all observed for 1985. Though it is not shown here, this would also be true if the 1975 and 1970 benchmarks comparisons were considered. However, as indicated in Table 1, the index of the US price level in 1970 was very near the 1985 level; for what it is worth, 1970 was still the quasi-fixed exchange rate era.

[6]A line of explanation runs as follows. Fluctuations in the price level index are larger in amplitude than in the exchange rate measures, perhaps because the former covers all of GDP, not just traded goods. Looking at the 1980, 1985 and 1990 benchmarks, we believe something like the following was occurring. The large appreciation of the dollar between 1980 and 1985 had the effect of reducing the prices of tradables relative to non-tradables in the US, a Dutch disease type of disequilibrium. In the literature the relative downward movement in the prices of tradables is termed a beachhead effect of the dollar appreciation. Thus 1985 was not an equilibrium year, with the US enjoying a temporary increase in income through a terms of trade effect, that reversed itself by the end of the 1980s. For more, see Heston and Summers [5, p. 366–367].

[7]It was also hard to sell the idea of modifying country growth rates to countries, international organizations, and to men or women of affairs. Therefore in our recent uses of consistentization we have not modified country growth rates, but only the different benchmark estimates.

2.2. Number of countries

Clearly a major issue over the years has been that the number of countries has typically increased from benchmark to benchmark in the EU and OECD comparisons. But this is an element that is likely to remain a characteristic of the EU and OECD benchmarks for some years down the line. And of course it is the basis for the “fixity” convention of the EU and OECD. This convention calls for the results for subgroups like the EU to retain their intercountry relationships when they are included in a larger entity like the OECD.

To our knowledge the various aggregation methods are not notably robust with respect to changes in the number of countries. For EKS as usually carried out, the weight of indirect comparisons rises with each country added; or put another way the importance of direct comparisons declines from 100% for two countries to 20% if there are ten countries, to 10% if there are 20 countries, and so forth. In the way we have used G-K in world comparisons we attempted to allow for the increase in the number of countries by using so-called supercountry weights. This was a procedure in which an extra weight was assigned to each participating country that reflected the weight of similar non-participating countries. It still seems the right thing to do in principle, but in practice, there may remain substantial differences between the price structures of new countries and those of the countries that previously represented them in earlier benchmarks.

2.3. Data quality and other comparison difficulties

Related to the increase in the number of countries is the fact that the benchmark data for new countries in a group are usually of lower quality both initially, and often later too. One reason is that the first countries undertaking purchasing power comparisons joined or were chosen because of the higher quality of their statistical systems. Other factors affecting the quality of data and its comparability across countries in all benchmarks is the fact that the number of products and services and their quality are changing more rapidly than in the past. As is discussed in Heravi, Heston and Silver [4] this has typically been handled by choosing items for comparisons that are of somewhat dated technology because they will be the common denominator across the countries. This is not obviously the appropriate choice.

A related quality problem concerns comparing like with like. To the extent possible one would like to compare goods and services from comparable outlets. In Beijing one may get a haircut in a hotel, an exclusive shop, a stall, and in the summer on the street. Clearly one does not want the average price of a haircut in China to compare the average price in Finland, but rather to hold the outlet constant, and aggregate the ratios in some appropriate way. This is a common problem in services, like the transport and medical areas, but it is also very important in commodities too.[8] In fact the “new good” problem so common in time-to-time indexes has its direct counterpart in spatial comparisons. There are many instances where items are common in some countries and not others, usually because markets are income sensitive, or factor price differences lead to the prevalence of lower-tech items being common in poorer countries for the same purposes that higher-tech items are used in more affluent countries. Despite rapid globalization, differences in income and size of markets mean that new or technologically more sophisticated products will be common in some countries and not common typically in others. If it is an item that is a passing fad, a case can be made for not trying to use it for spatial comparisons.

[8] A well known growth economist looked at our medical price parities for the 1980 benchmark and made the following comment. He said that based on those parities, he would have his neurosurgery done in Kenya. While we did not take that as a wholly friendly comment, it does point up well the new or income-sensitive product, or service problem in the spatial context.

But often there are items much more or much less available or of much different quality in poorer countries compared to more affluent countries. This will show up in both consumer goods and services and also producers durables. If one is to carry out strict matching, it is necessary to use common denominator items.[9] Austria has given a great deal of thought to the kinds of quality adjustments in the comparisons for the Group 2 countries in Europe as one way to deal with this problem. Services may be the least well covered in national statistics in time-to-time indexes, and they are an increasing share of consumption. The problems of comparing non-priced services over time or across space are even more problematic.

These problems are in the nature of the data collected. Couldn't one improve comparisons by collecting better service price data or to try harder to add new goods to existing price collection lists? The answer of course is "Yes" if the resources are available and this exercise has a priority in the statistical programs of the countries involved. But consider the problem of comparing priced-services, which provides a possible bridge on how to compare non-priced services. In fact, as poor as comparisons of service prices are in high income countries, they are still much better than those in low income countries, where very few service prices are collected for either temporal or spatial indexes. We do not see this situation improving in the near future.

2.4. The bottom line of this section

These remarks suggest that new benchmark comparisons are put together with (i) different and usually larger groups of countries than in the past; and (ii) with price inputs that may be quite weak in some countries and in some expenditure headings. Further, in addition to new goods issues, there are systematic problems of quality differences in goods and services across countries as well. Current methods of aggregation probably amplify the effects of data errors, quality differences and new countries, rather than compensate for them. The combined effect is to make it difficult to make good benchmark comparisons and hard to reconcile multiple benchmark comparisons. What to do? We do not have all the answers, but we will argue in the next section why chaining may be a helpful approach to some of these questions.

3. Spatial chaining

In this section we discuss one method of spatial chaining proposed by Robert Hill. We explore some reasons why this kind of approach may help overcome some problems of quality control that have been difficult in spatial comparisons. We also propose an alternative version of Hill's spanning tree namely use of price similarity indexes (SIM) which we believe provides a better basis for a spatial chain than Paasche-Laspeyre Spreads (PLS).

The spanning tree approach to chaining that Robert Hill [7,8] has explored involves several dimensions. First, it provides a path by which to chain over space that involves the minimum number of binary comparisons to link all countries in a comparison. The particular path Hill has chosen in his work minimizes the sum of the Paasche-Laspeyres Spread (PLS). In this way each country is linked to at least one other country and some countries may be linked to several countries.

[9] In Heravi, Heston and Silver [4] we have raised the question of using virtual prices in this case. While this may sound like using a pile driver to pound a pin, there are some approaches to the use of virtual prices to obtain parities that may be surprisingly manageable and even reasonable and transparent.

In the Hill version one country may become a star for several other countries. However, there is an important difference between this type of star country and those familiar from past practice, such as the role of Austria in the Group 2 comparisons in Europe. In the spanning tree version there is a similarity in economic structure of the countries linked to a star country, whereas that has not been the characteristic of links in the ICP in the past. For example, Japan is not a very good link in terms of economic similarity between ESCAP and OECD countries.

Also note that if one were adopting the Hill approach and there were political reasons for country groups, these might be accommodated. For example, suppose that the EU wished only to use binaries involving its countries. There would be no problem in accommodating such a constraint within the spanning tree approach. It would simply mean in Hill's framework that the spatial chain did not minimize the PLS across all countries, but it might still be a perfectly plausible chain.

What does one do with a binary chain when one has it? The chain simply provides an order for binaries. The next step is translate the binaries into a common real measure like the US$ building up through the established chain. Hill has shown the results one would get if one performed the indicated binary comparisons, which would of course be transitive at the GDP level. We carry out the same exercise in the empirical section and discuss alternatives in the concluding section.

The result of this chain binary might in our view be a more reasonable approach than Gini-EKS as typically applied. Why? In addition to EKS being anything but transparent in its operation, there is a much more fundamental point. If there are systematic differences in quality across countries that extend to many commodity groups and to both priced and non-priced services, then many direct binaries are flawed. If they are included in EKS, they influence the final result similarly to less flawed binaries. If there are poor quality data for some of the countries, then following the spanning tree approach reported in this paper, they might also influence the resulting tree, a question we take up later in the paper.

One could modify EKS to recognize the likely systematic differences in data quality or item qualities across countries. To a limited extent that is what the OECD has done in building up its 1996 comparison from four groups of countries.[10] A way to use EKS that would meet some of the systematic data problems is to give very little weight to doubtful binaries. In fact one can think of the spanning tree method, if you like, as an extreme pruning of binaries based on the economic proximity of countries.[11]

Also, Hill has suggested that the spanning tree could be implemented as a resource-saving device since one could reduce the multilateral character of the price collection. However, as Hill and others have noted, the spanning tree will not necessarily be stable over time, so the resource savings may not be great. However, this temporal instability in the spanning tree is not really a major drawback to its use, except as a precise guide to what binary comparisons to emphasize in some future benchmark. However, as a guide to similarity of economies, the spanning tree approach seems to have considerable merit, including one feature not yet discussed. Before developing that feature, namely spatial chaining and quality of goods, we want to discuss another candidate criteria for spanning trees, namely price similarity.

[10] The OECD has retained fixity for various subgroups of countries. While this was originally done to maintain only one set of EU comparisons, it has the effect of eliminating the effect of a number of indirect binary comparisons in an EKS for a larger group of countries.

[11] Unfortunately, the actual spanning tree method can not make claims that it uses only the binaries to countries closest to it in the PLS sense. For example Barbados may be the most closely linked by PLS to Jamaica, and less so to Belize. However, if Jamaica is closer to Brazil than to Barbados, and Brazil is a star to other countries, then Barbados may be only directly linked to Belize and not be directly linked to Jamaica, even though Jamaica is the country with which its PLS is least. Hill [7] sets out why links beginning with any particular country like Barbados, that would involve a direct link to Jamaica, are only one of a set of spanning trees.

3.1. Paasche-laspeyere spread (PLS) and price similarity (SIM) indexes

As a way of summarizing how closely countries resemble each other in price structure, we have in previous work used similarity indexes. These are the raw correlation coefficient between the vector of price parities across the basic headings of each possible pair of countries weighted by the importance of the basic heading. The similarity of prices is given by:

$$S_p = \sum_{i=1}^{m} w_i pp_{ij} pp_{ik} \Bigg/ \sqrt{\sum_{i=1}^{m} w_i pp_{ij}^2 \sum_{i=1}^{m} w_i pp_{ik}^2}$$

S_p is the price similarity index between country j and k, and pp_{ij} is the price-parity in price level form for the i'th heading in country j, expressed as a deviation from the average value for the heading.[12] This version is termed SIM-NORM be low to distinguish it from SIM, that depends on the base country chosen. The weight for each of the m headings, w_i, is defined as:

$$w_i = \frac{(\mathrm{exp}_{ij} + \mathrm{exp}_{jk})}{2}$$

where exp is a country's heading expenditure share.[13] For each pair of countries, the average of their expenditure shares is used as the heading weight.

The price similarity index, a raw correlation coefficient, will range between 0 and 1. It will be close to 1 for pairs of countries whose relative prices across headings are close together, and will be less for pairs of countries with quite different price structures. It will not necessarily bear a close negative relationship to the PLS because relative quantities enter into the PLS while the similarity index reflects only prices. Our reasons for also using the price similarity index is that we believe it contains more relevant information for spatial chaining than the PLS. This is because we believe that many of the errors entering into the generation of heading parities are correlated and that this will show up in the similarity indexes. This argument is developed below.

3.2. Spatial chaining and data quality

There are three factors that systematically affect the heading parities across different groups of countries. First, the quality of many priced services is hard to hold constant across countries, while there is

[12] We are indebted to Erwin Diewert and Jim Cuthbert for pointing out that in an earlier version of this paper, the definition of the similarity index was not base-country invariant. In that version, the parity for each heading was expressed as the national currency units per US dollar, with the entry for the US for each heading being 1.0. and we have also presented those results below. However, because changing base country does affect the spanning tree path and the resulting multilateral comparisons, we felt it important to go with a definition of the similarity index that was base country invariant. In the present version each country's price level for a heading is expressed relative to that of the simple average of all the countries. As discussed below in the text, there are alternative measures of price, and or price and quantity similarity that might be used as criteria for spanning trees. This is clearly an area for further research.

[13] This definition of the weight is different from the one used in KHS (1982). Previously we had used the world average expenditure real share for each heading that came from total world expenditures from a G-K aggregation. We believe now that the average shares of each pair of countries at their national prices is a more appropriate weight. Also in KHS (1982) we did not use the heading parities, but rather the heading parities divided by the overall parity of the country so that it was a relative price that depended upon an overall PPP. We did this to provide an easy way for the US, the numeraire, to also have a similarity index with each country. And each country would have a similarity index with the world average, or Earthea, as we termed the world price structure. This was not done in the present paper, however. As noted in the previous footnote, some earlier versions of our similarity index were not base-country invariant.

no satisfactory way to measure non-priced services. It is generally thought that this tends to produce parities for these headings that are too low and real expenditure shares that are too high for lower income countries.

Second, where it is difficult to match like with like across countries, it is felt that the quality of commodities in poorer countries tend to be lower than the corresponding quality in richer countries. For example, bulk rice sold in supermarkets in richer countries is likely to be more uniform and contain less foreign matter than bulk rice in a rural or urban market in a poorer country.

Third, we believe that the usual practice of matching across quite different economies often produces inappropriate comparisons that may err in either direction. For example, suppose beer prices are compared with Heineken in the can as a common denominator specification. For low income countries where import duties or restrictions often push up the price compared to what would be the case without restrictions, then using Heineken prices will raise the heading parities of such countries. We believe that more commonly errors run in the other direction, namely that in order to obtain matches it is necessary to choose common denominator items that tend to understate parities in lower income countries. It is also likely that the patterns will be similar across basic headings. That is, if parities for alcoholic beverages are overstated and those for electrical machinery understated, this will occur for the same groups of countries.

One further point should be made. The PLS will be affected for those headings in low-income countries where the parities are understated or overstated. If the Heineken effect dominates alcoholic beverages, then the true quantity consumed is larger than obtained by dividing expenditure ratios by price ratios for that heading. And for a heading like electrical machinery, the true quantity is less than appropriate for the heading. Whatever the merits of the PLS as a criterion on an analytical level, it seems to us that the similarity index is more likely to pick up these systematic variations in heading parities than the PLS.

4. An empirical application

The empirical application relates to 1996 where 32 heading parities and expenditure shares were put together for 115 countries from various regional comparisons by the World Bank. The underlying data set combined the benchmark comparisons of the EU, OECD, and other European and former Soviet Union countries for 1996, a total of 52 countries; The World Bank then updated the 1993 benchmark ICP comparisons for 14 ESCAP countries, 22 African countries, 12 Caribbean countries and 8 ECWA countries to 1996 and combined these with the results for 9 South American countries for 1996. (The total of 117 double counts Japan in the OECD and ESCAP and Egypt in Africa and ECWA). The data then combine ICP benchmark comparisons in different regions for either 1993 or 1996, with the former being brought forward to 1996. The linking of the various regions was done in different ways, usually with a link country like Japan for ESCAP, and the United States for Africa, and the Western Hemisphere.

For this data set, six multilateral results are reported, each an index of per capita Domestic Absorption as a percent of the United States. These are (1) Fisher indexes with the US as the only node or star country; (2) EKS; (3) supercountry-weighted G-K; (4) a binary chain based on the Paasche-Laspeyres Spread (PLS); and two binary chains based upon the price similarity indexes, (5) with the United States as base country (SIM-US) and (6) with row-normalized price parities (SIM-NORM). In order to make estimates for the three spatial chain approaches it is necessary to first obtain the minimum spanning trees.

There are 6555 (115*114/2) possible links for each chain, that is, half the matrix of possible binaries. The first 114 links to join all countries without creating a closed loop form the minimum spanning tree or chain for the PLS and SIM-US and SIM-NORM indexes. Before reporting these results we would

Table 2
Countries and ISO (International Organization for Standardization) codes

Country	ISO code	Country	ISO code	Country	ISO code
Albania	ALB	United Kingdom	GBR	Netherlands	NLD
Argentina	ARG	Georgia	GEO	Norway	NOR
Armenia	ARM	Guinea	GIN	Nepal	NPL
Antigua & Barbuda	ATG	Greece	GRC	New	NZL
Australia	AUS	Grenada	GRD	Oman	OMN
Austria	AUT	Hong Kong	HKG	Pakistan	PAK
Azerbaijan	AZE	Croatia	HRV	Panama	PAN
Belgium	BEL	Hungary	HUN	Peru	PER
Benin	BEN	Indonesia	IDN	Philippines	PHL
Bangladesh	BGD	Ireland	IRL	Poland	POL
Bulgaria	BGR	Iran	IRN	Portugal	PRT
Bahrain	BHR	Iceland	ISL	Qatar	QAT
Bahamas	BHS	Israel	ISR	Romania	ROM
Belarus	BLR	Italy	ITA	Russia	RUS
Belize	BLZ	Jamaica	JAM	Senegal	SEN
Bermuda	BMU	Jordan	JOR	Singapore	SGP
Bolivia	BOL	Japan	JPN	Sierra Leone	SLE
Brazil	BRA	Kazakhstan	KAZ	Slovakia	SVK
Barbados	BRB	Kenya	KEN	Slovenia	SVN
Botswana	BWA	Kyrgyzstan	KGZ	Sweden	SWE
Canada	CAN	St. Kitts & Nevis	KNA	Swaziland	SWZ
Switzerland	CHE	Korea	KOR	Syria	SYR
Chile	CHL	Lebanon	LBN	Thailand	THA
Cote d'Ivoire	CIV	St. Lucia	LCA	Tajikistan	TJK
Cameroon	CMR	Sri Lanka	LKA	Turkmenistan	TKM
Congo	COG	Lithuania	LTU	Trinidad &Tobago	TTO
Czech Republic	CZE	Luxembourg	LUX	Tunisia	TUN
Germany	DEU	Latvia	LVA	Turkey	TUR
Dominica	DMA	Morocco	MAR	Tanzania	TZA
Denmark	DNK	Moldova	MDA	Ukraine	UKR
Ecuador	ECU	Madagascar	MDG	Uruguay	URY
Egypt Africa	EGY	Mexico	MEX	Unite States	USA
Spain	ESP	Macedonia	MKD	Uzbekistan	UZB
Estonia	EST	Mali	MLI	St.Vincent & Grenadines	VCT
Finland	FIN	Mongolia	MNG	Venezuela	VEN
Fiji	FJI	Mauritius	MUS	Vietnam	VNM
France	FRA	Malawi	MWI	Yemen	YEM
Gabon	GAB	Nigeria	NGA	Zambia	ZMB
				Zimbabwe	ZWE

like to provide some representation of the chains that make up the spanning trees, not a transparent task. To facilitate the reader in using Table 3 and Figs 3–5 where only ISO country codes are used, Table 2 provides the ISO country codes and country names alphabetically (see Appendix).

4.1. The character of the chains

Table 3 in the Appendix shows the pairs of countries that make up the spanning trees based upon PLS and Similarity (SIM-US) with the US as base, and the base country invariant version, SIM-NORM. Each pair of countries represents a link in the spanning tree chain. For readability, the countries in the table are sorted alphabetically by their three-letter ISO codes with each of the 114 pairs repeated with the second country first. Thus, there are 114 *2 = 228 links in Table 3 for the 115 countries. For example, if Belgium and France form a link, the BEL-FRA pair is listed before the FRA-BEL link. This makes

Table 3, continued

	LP spread		Similarities (US)		Similarities (NORM)	
223	1 YEM	SYR	YEM	KNA	VNS	IRN
224	2 ZMB	SWZ	1 ZMB	TZA	2 YEM	BOL
225	ZMB	ZWE	4 ZWE	CMR	YEM	KNA
226	3 ZWE	BWA	ZWE	MUS	1 ZMB	ZWE
227	ZWE	COG	ZWE	NGA	2 ZWE	PER
228	ZWE	ZMB	ZWE	TUN	ZWE	ZMB
Total links	228		228		228	

it easier to find all the links to any one particular country. The total number of links for each country are given to the left of the country code. Figures 3–5 are graphical representations of the three spanning trees.

In the PLS tree, the pair with the lowest Paasche-Laysperes spread is Peru and Ecuador, while the highest spread is between Georgia and Barbados. In the SIM-US tree, the highest similarity index is between France and Belgium, with the lowest between Turkmenistan and Belarus. For the final graph, SIM-NORM, the highest and lowest pairs in the tree are Spain and Greece and Belize and the Bahamas. Note that this rank does not correspond exactly to the spread or similarity index rank, since pairs of countries with a high index are excluded if they form a closed loop in the chain. The PLS tree required going to the 2114th ranked pair (out of the 6555 possible pairs), the SIM-US tree to the 2291st pair and the standardized SIM-NORM to the 2208th pair.

Looking at the number of links in Table 3 for the PLS, there is some good news and bad news. The good news about Albania is that its links are all geographically close; the bad news is that it has four links so, like Uzbekistan with five links, it is numerically important in the chain in Europe and the former Soviet Union, when it is unlikely that the quality of its statistical base is as strong as countries like Hungary, which only has two links. The same problem exists in other world areas. Spain in the EU has the most links: five, but data quality in Spain and Greece, with four links, is probably lower than the Netherlands, which has only one link. Similar anomalies exist in Africa, where Tanzania has six links, the most of any country in Table 3, and chains the region to Asia and the Middle East. Is the situation any better with the chaining using price similarity indexes? The answer is probably no. Chile and Spain both have seven links, while Bolivia, Ecuador, Peru and Ukraine each have five links for the SIM-NORM spanning tree. And with the exception of Ukraine, the links are widely spread across the world regions.

The fact that countries with weaker statistical systems may play an important role in spatial chaining is clearly a limitation on the using spanning trees based on mechanical rules such as those applied in generating Table 3. This is clearly an area where more research needs to be carried out, including investigation of alternative criteria for generating spatial chains. One direction would be to use other definitions of similarity such as those suggested by Allen and Diewert [1], Theil [12], and Cuthbert [2] to generate spatial chains. Constraints might also be introduced into the spanning tree approach so as reduce the possibility that countries with weaker statistics enter into say, more than 2 comparisons. However, for present purposes we will concentrate on how good a multilateral comparison can be generated from the three spatial chains in Table 3.

4.2. *The results*

Once the links in the trees are determined, we must work backwards to obtain the corresponding binaries for those 114 pairs of countries relative to the United States. For example, in the SIM-US tree

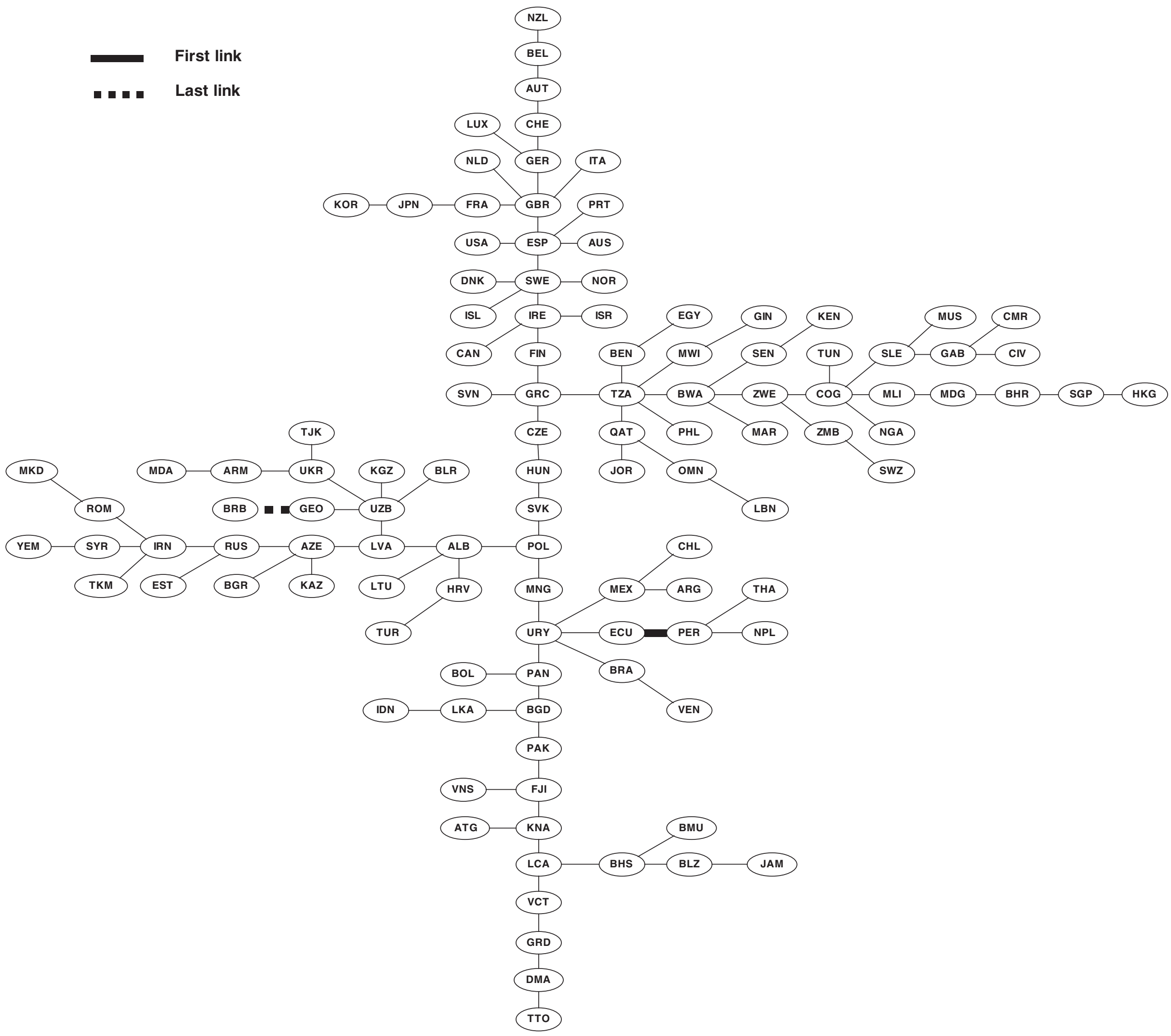

Fig. 3. PLS tree.

we take the Germany relative to the US Fisher binary (1.357) as the SIM tree binary since this is the only US link. But Germany is linked to Luxembourg, so the SIM binary for Luxembourg relative to the US (1.297) is obtained by multiplying the LUX-GER Fisher (0.955) by the GER-USA Fisher. The Netherlands and Switzerland are also linked to Germany in the SIM-US tree, so their SIM-US binary relative to the US would be obtained in the same manner. A more 'distant' country, such as Morocco, requires traversing more links in order to obtain the Morocco-USA binary for the SIM-US tree. In this way binary comparisons for Domestic Absorption may then be compared for the 3 spanning trees and US based Fisher binary estimates and the EKS and G-K multilateral results.

These results are presented in Table 4. The direct Fisher binaries were applied to nominal per capita Domestic Absorption in 1996 dollars, and are ranked in decreasing magnitude relative to the United States (column 1). The EKS, G-K and the binaries from the three chain indexes are shown in columns 2–6. All are indexed with the United States equal to 100.

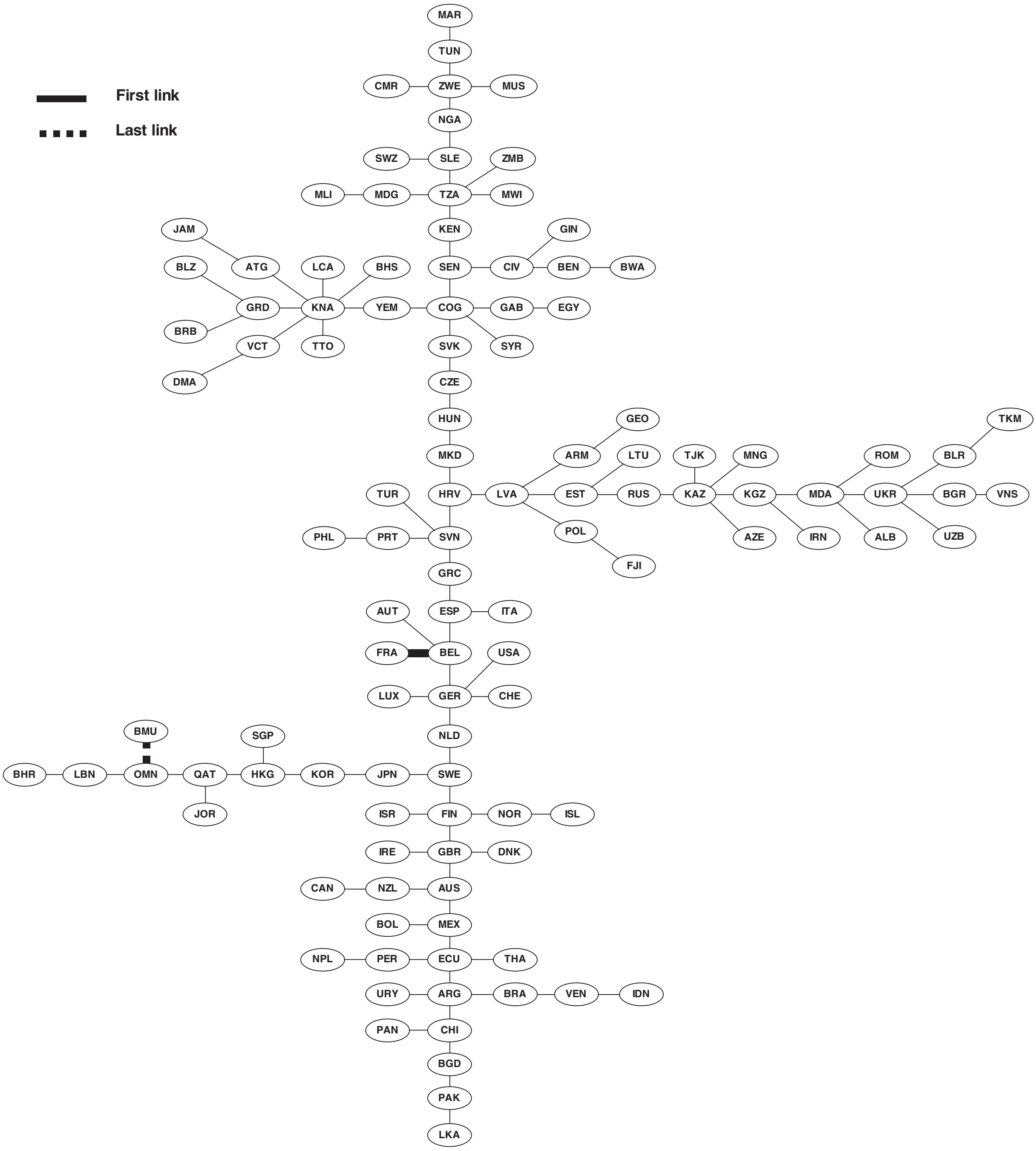

Fig. 4. SIM-US tree.

The only exploration of Table 4 that we attempt here is to examine the relationship between price levels from the various methods with per capita domestic absorption. We first take as the income measure the per capita domestic absorption based on the direct Fisher binaries with the United States, on the grounds that these are transparent and should not obviously privilege one of the other methods in a regression

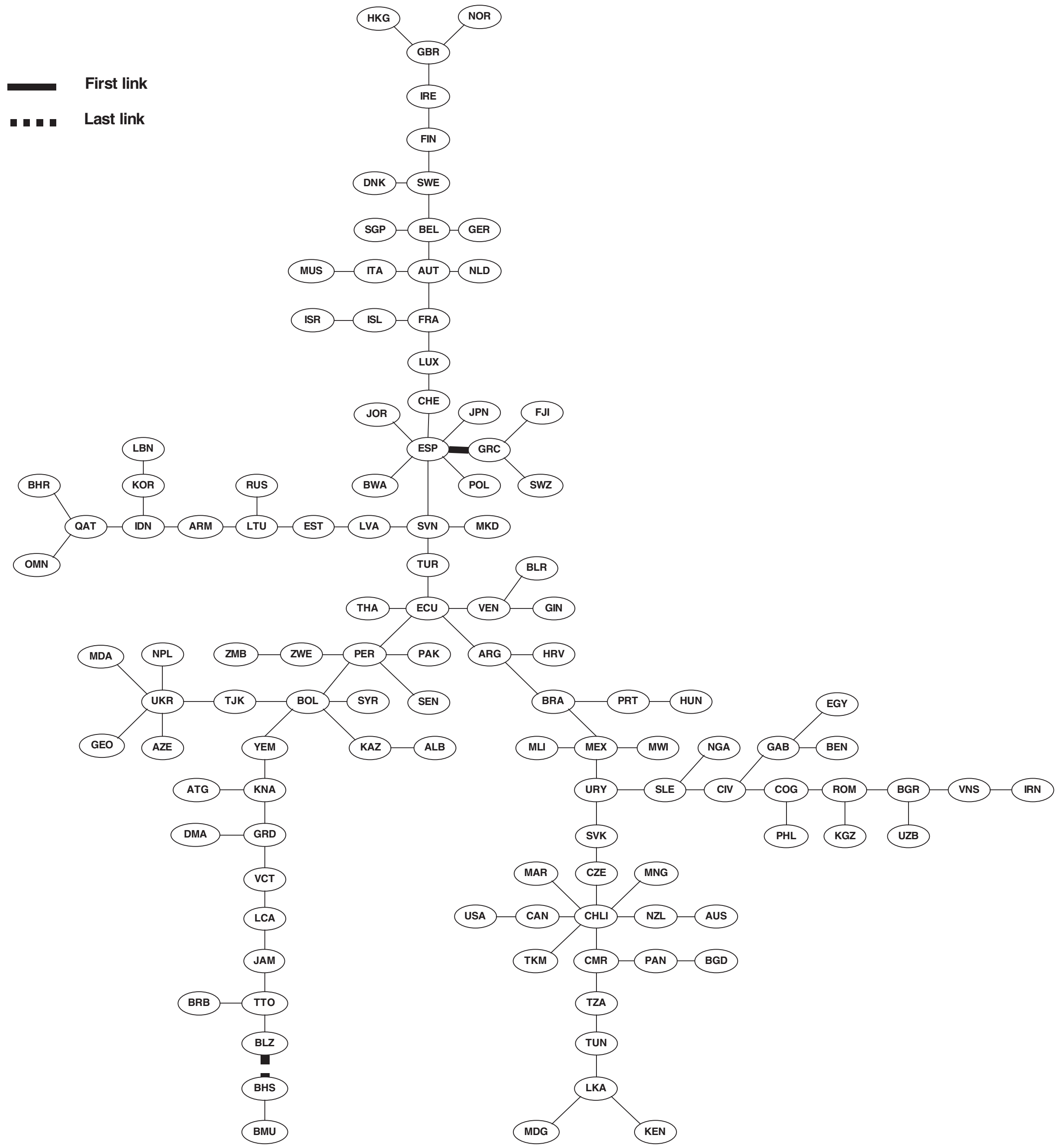

Fig. 5. SIM-NORM tree.

explaining its price level. Using a semi-log form, we regress the price levels of Fisher, EKS, SIM, SIM Norm, PLS and GK on the log of income relative to the US from the Fisher binaries with the US. For each method, the intercept, slope, adjusted correlation and standard error are provided in Table 5.

The variance of the dependent variable is different for each equation reported in Table 5, so we have

Table 4, continued

ISO code	Fisher (1)	Eks (2)	Sim std (3)	Sim us (4)	Lp Spread (5)	Gk (6)	Country name
ZMB	2.9	2.9	3.1	3.1	3.0	3.1	Zambia
YEM	2.9	2.8	2.5	3.3	2.4	3.7	Yemen
TJK	2.8	2.6	2.4	2.7	2.4	3.3	Tajikistan
MLI	2.7	2.9	2.7	3.0	2.9	3.5	Mali
MDG	2.6	2.8	3.0	3.2	3.1	3.0	Madagascar
MWI	2.3	2.4	2.2	2.5	2.2	2.9	Malawi
NGA	2.2	2.2	2.6	2.2	2.3	2.4	Nigeria
TZA	1.7	1.8	2.4	2.1	1.8	1.9	Tanzania

taken the residual error as a criterion with which to examine the results. At first glance, the SIM-US and SIM-NORM chain performs slightly better than either the PLS chain or other methods. However, the margins are small and the criterion is one of several that might be used to judge alternative methods. In Table 4 we are basically looking at how tight the relationship is between per capita domestic absorption and the price level across countries.

This positive relationship has been consistent in all benchmarks, and is probably the single most important finding of the ICP. But at least since 1975, this relationship has been marked by a fair amount of variance. So the fact that the similarity chains have marginally better fits with the price level we take as encouraging but that is all. The PLS chain also performs nearly as well, so the results in Table 5 reinforce our main conclusion that the spanning tree chains show promise as multilateral methods.

Figure 6 summarizes the quantitative results reported in Table 4. The ratio of the per capita income of each country from the various methods to the US based Fisher has been averaged by quartiles. The results in Fig. 6 indicate that the G-K has a systematic relation with higher income estimates in the first two quartiles compared to other methods. There is a slight downward drift in the PLS chain, and fairly flat relationships for the EKS and SIM-US. The SIM-NORM has a spike in the 2nd quartile but is otherwise similar to all the other indexes except the G-K.

5. Conclusion

In this section we will briefly summarize the results thus far and sketch how we would apply the technique proposed here in the Penn World Table (PWT) exercise that extends benchmark estimates over time and space.

5.1. *Estimates at the component level*

The empirical results showed few differences between the EKS and the PLS and SIM chains. We argued that the similarity chains show a marginally better performance over the other indexes in the income-price level relationship. We would not make much of this.

There is one aspect of the chains that seem to us a major advantage over EKS, namely disaggregation. The weakness of the present build-up of aggregates by the EU is that the way in which the aggregates relate to each other is unclear. With the spatial chain, one can certainly do at least as well as EKS with respect to the components.

Suppose we have a PLS or SIM chain. Then just as we have generated at the GDP level a set of transitive measures across the countries, we can do the same for components. This has not been carried

Table 5
Regression of price levels on per capita DA

	Intercept (std. error)	Loge of per capita DA (std. error)	RMSE	Adj R^2
Fisher	−1.421	0.243	0.300	0.412
	(0.234)**	(0.027)**		
EKS	−1.388	0.239	0.291	0.419
	(0.227)**	(0.026)**		
SIM-Norm	−1.522	0.255	0.289	0.455
	(0.225)**	(0.026)**		
SIM-US	−1.454	0.245	0.283	0.445
	(0.221)**	(0.026)**		
LP-Spread	−1.401	0.242	0.298	0.412
	(0.232)**	(0.027)**		
GK	−1.522	0.248	0.278	0.461
	(0.216)**	(0.025)**		
Model df = 113				

$^{**}Pr > |t| < 0.0001.$

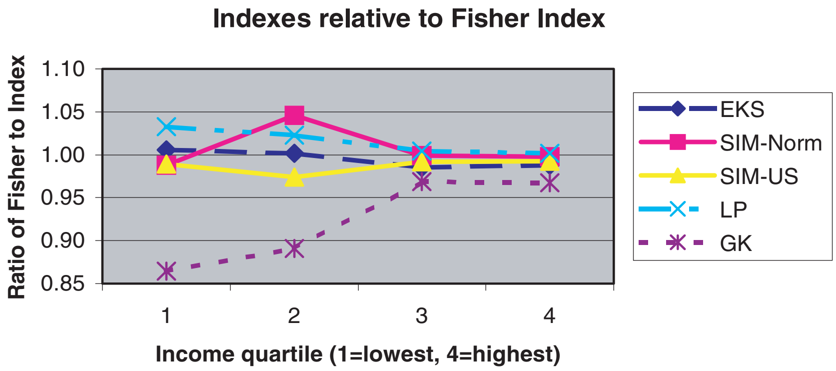

Fig. 6. Mean ratio of fisher indexes to other methods.

out here but it certainly can be done. What then? One would be faced with the usual question of how to build up GDP, by adding up the components, or by applying the component shares to the GDP total. However, note that it makes perfectly good economic sense to add up components obtained in this way. And our first thought is that this would be the way to go. It would then provide a transitive matrix of real values that was additive.

However, we acknowledge that adding up the components would not preserve fixity for a subgroup of countries, even if that subgroup had built up its comparison based on only binaries within the subgroup. But if we accept the GDP total from such a chain and apply the shares built up from the binary, we do preserve fixity at the GDP level. Further the shares in this case will not correspond to national price shares and will in fact have some analytic meaning. So if fixity is a strong consideration for a group, this way of handling components would preserve it.

5.2. *Extensions over time and space*

If we applied the chains at the component level, we would have a set of inputs comparable to those that have been used to build up PWT in the past. Extension to non-benchmark countries, while not without substantial error, would be straightforward. What about extensions over time?

Clearly there would be no problem carrying out extrapolations at the GDP level. In PWT we have made extensions over time for the components of C, I and G, in both current and constant prices. Without going into detail, the constant price procedure that we have used could be applied straightforwardly to the components generated from a PLS or SIM chain.

With respect to current price extensions over time, we also believe the present procedures could be applied. In PWT we have made current price comparisons in non-benchmark years by extrapolating heading parities back and forth over time.[14] This could be readily carried out with either the PLS or SIM chains. In any given year the binary Fisher matrix could be calculated at an aggregated level, and a set of current price comparisons produced. It would also be possible to re-do the spanning tree each year, but right now that sounds excessive.

5.3. Some caveats

This paper offers support for spatial chaining as a basis for multilateral comparisons that at first examination appears comparable to alternative aggregation methods. However, this is hardly the last word on how to do multilateral comparisons.[15] Rather along with the work of others on similarity indexes and spatial chaining, we regard this as a beginning in this area of research. Some of the issues that need to be explored further are below.

Our comparisons of spatial chains were based on PLS and on price similarity measures. Other price similarity measures should also be investigated, as well as quantity similarity indexes. Paasche-Laspeyeres spreads are one way of combining price and quantity structures and Cuthbert [3] has offered an alternative that also warrants investigation.

Other problems connecting with the spanning tree approach require further research. What is troublesome in the procedure, which Hill has also mentioned, is that often countries can take a pivotal position in the estimation, even when it is known that their database is not strong. In his work for 1996 OECD countries for example, Hill [9, p. 14] found using the PLS that several countries had three links but that the country with the most links, six, was Greece. On many criteria including overlap of items with other countries, Greece is not obviously the country to play a central role.

However, the logic of the minimum spanning tree approach is such that the links between large groups of countries may be any country, regardless of other characteristics that might or might not make them suitable for that role. Can one introduce other constraints into the derivation of the spanning tree that will lead to more plausible spatial chains? This is clearly a priority area of research that needs to be carried out before we can use spatial chaining as a multilateral approach to replace existing methods

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[14] The extrapolation of heading parities requires deflators of the given and numeraire country at the appropriate component level. In practice, this has only been done in PWT at the level of C, I, and G because of the lack of more detailed deflators for a large number of countries.

[15] The following anecdote suggests why the discussion of methods of aggregation will not go away quickly. One of the consultants seconded to us in Phase III of the ICP by the then U.K. Ministry of Overseas Development was Harry (Angus) Fell who did work in Sri Lanka. Some years later I (AH) met Angus, then long retired, in Hong Kong where he was consulting on national accounts. He asked me if we were still using the Genghis Khan method, and after a double-take, I realized he meant the G-K method. I then asked him if when I was long retired I would still be worrying about index number problems. He just smiled.

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Table 3
Spanning tree links

	LP spread			Similarities (US)			Similarities (NORM)		
1	4	ALB	HRV	1	ALB	MDA	1	ALB	KAZ
2		ALB	LTU	4	ARG	BRA	3	ARG	BRA
3		ALB	LVA		ARG	CHI		ARG	ECU
4		ALB	POL		ARG	ECU		ARG	HRV
5	1	ARG	MEX		ARG	URY	2	ARM	IDN
6	2	ARM	MDA	2	ARM	GEO		ARM	LTU
7		ARM	UKR		ARM	LVA	1	ATG	KNA
8	1	ATG	KNA	2	ATG	JAM	1	AUS	NZL
9	1	AUS	ESP		ATG	KNA	4	AUT	BEL
10	2	AUT	BEL	3	AUS	GBR		AUT	FRA
11		AUT	CHE		AUS	MEX		AUT	ITA
12	4	AZE	BGR		AUS	NZL		AUT	NLD
13		AZE	KAZ	1	AUT	BEL	1	AZE	UKR
14		AZE	LVA	1	AZE	KAZ	4	BEL	AUT
15		AZE	RUS	4	BEL	AUT		BEL	GER
16	2	BEL	AUT		BEL	ESP		BEL	SGP
17		BEL	NZL		BEL	FRA		BEL	SWE
18	2	BEN	EGY		BEL	GER	1	BEN	GAB
19		BEN	TZA	2	BEN	BWA	1	BGD	PAN
20	3	BGD	LKA		BEN	CIV	3	BGR	ROM
21		BGD	PAK	2	BGD	CHI		BGR	UZB
22		BGD	PAN		BGD	PAK		BGR	VNS
23	1	BGR	AZE	2	BGR	UKR	1	BHR	QAT
24	2	BHR	MDG		BGR	VNS	2	BHS	BLZ
25		BHR	SGP	1	BHR	LBN		BHS	BMU
26	3	BHS	BLZ	1	BHS	KNA	1	BLR	VEN
27		BHS	BMU	2	BLR	MDA	2	BLZ	BHS
28		BHS	LCA		BLR	TKM		BLZ	TTO
29	1	BLR	UZB	1	BLZ	GRD	1	BMU	BHS
30	2	BLZ	BHS	1	BMU	OMN	5	BOL	KAZ
31		BLZ	JAM	1	BOL	MEX		BOL	PER
32	1	BMU	BHS	2	BRA	ARG		BOL	SYR
33	1	BOL	PAN		BRA	VEN		BOL	TJK
34	2	BRA	URY	1	BRB	GRD		BOL	YEM
35		BRA	VEN	1	BWA	BEN	3	BRA	ARG
36	1	BRB	GEO	1	CAN	NZL		BRA	MEX
37	4	BWA	MAR	1	CHE	GER		BRA	PRT
38		BWA	SEN	3	CHI	ARG	1	BRB	TTO
39		BWA	TZA		CHI	BGD	1	BWA	ESP
40		BWA	ZWE		CHI	PAN	2	CAN	CHI
41	1	CAN	IRE	3	CIV	BEN		CAN	USA
42	2	CHE	AUT		CIV	GIN	2	CHE	ESP
43		CHE	GER		CIV	SEN		CHE	LUX
44	1	CHI	MEX	1	CMR	ZWE	7	CHI	CAN
45	1	CIV	GAB	5	COG	GAB		CHI	CMR
46	1	CMR	GAB		COG	SEN		CHI	CZE
47	5	COG	MLI		COG	SVK		CHI	MAR
48		COG	NGA		COG	SYR		CHI	MNG
49		COG	SLE		COG	YEM		CHI	NZL
50		COG	TUN	2	CZE	HUN		CHI	TKM
51		COG	ZWE		CZE	SVK	3	CIV	COG
52	2	CZE	GRC	1	DMA	VCT		CIV	GAB
53		CZE	HUN	1	DNK	GBR		CIV	SLE
54	2	DMA	GRD	4	ECU	ARG	3	CMR	CHI

	LP spread		Similarities (US)		Similarities (NORM)	
55	DMA	TTO	ECU	MEX	CMR	PAN
56	1 DNK	SWE	ECU	PER	CMR	TZA
57	2 ECU	PER	ECU	THA	3 COG	CIV
58	ECU	URY	1 EGY	GAB	COG	PHL
59	1 EGY	BEN	3 ESP	BEL	COG	ROM
60	5 ESP	AUS	ESP	GRC	2 CZE	CHI
61	ESP	GBR	ESP	ITA	CZE	SVK
62	ESP	PRT	3 EST	LTU	1 DMA	GRD
63	ESP	SWE	EST	LVA	1 DNK	SWE
64	ESP	USA	EST	RUS	5 ECU	ARG
65	1 EST	RUS	4 FIN	GBR	ECU	PER
66	2 FIN	GRC	FIN	ISR	ECU	THA
67	FIN	IRE	FIN	NOR	ECU	TUR
68	3 FJI	KNA	FIN	SWE	ECU	VEN
69	FJI	PAK	1 FJI	POL	1 EGY	GAB
70	FJI	VNS	1 FRA	BEL	7 ESP	BWA
71	2 FRA	GBR	2 GAB	COG	ESP	CHE
72	FRA	JPN	GAB	EGY	ESP	GRC
73	3 GAB	CIV	4 GBR	AUS	ESP	JOR
74	GAB	CMR	GBR	DNK	ESP	JPN
75	GAB	SLE	GBR	FIN	ESP	POL
76	5 GBR	ESP	GBR	IRE	ESP	SVN
77	GBR	FRA	1 GEO	ARM	2 EST	LTU
78	GBR	GER	5 GER	BEL	EST	LVA
79	GBR	ITA	GER	CHE	2 FIN	IRE
80	GBR	NLD	GER	LUX	FIN	SWE
81	2 GEO	BRB	GER	NLD	1 FJI	GRC
82	GEO	UZB	GER	USA	3 FRA	AUT
83	3 GER	CHE	1 GIN	CIV	FRA	ISL
84	GER	GBR	2 GRC	ESP	FRA	LUX
85	GER	LUX	GRC	SVN	3 GAB	BEN
86	1 GIN	MWI	3 GRD	BLZ	GAB	CIV
87	4 GRC	CZE	GRD	BRB	GAB	EGY
88	GRC	FIN	GRD	KNA	3 GBR	HKG
89	GRC	SVN	3 HKG	KOR	GBR	IRE
90	GRC	TZA	HKG	QAT	GBR	NOR
91	2 GRD	DMA	HKG	SGP	1 GEO	UKR
92	GRD	VCT	3 HRV	LVA	1 GER	BEL
93	1 HKG	SGP	HRV	MKD	1 GIN	VEN
94	2 HRV	ALB	HRV	SVN	3 GRC	ESP
95	HRV	TUR	2 HUN	CZE	GRC	FJI
96	2 HUN	CZE	HUN	MKD	GRC	SWZ
97	HUN	SVK	1 IDN	VEN	3 GRD	DMA
98	1 IDN	LKA	1 IRE	GBR	GRD	KNA
99	4 IRE	CAN	1 IRN	KGZ	GRD	VCT
100	IRE	FIN	1 ISL	NOR	1 HKG	GBR
101	IRE	ISR	1 ISR	FIN	1 HRV	ARG
102	IRE	SWE	1 ITA	ESP	1 HUN	PRT
103	4 IRN	ROM	1 JAM	ATG	3 IDN	ARM
104	IRN	RUS	1 JOR	QAT	IDN	KOR
105	IRN	SYR	2 JPN	KOR	IDN	QAT
106	IRN	TKM	JPN	SWE	2 IRE	FIN
107	1 ISL	SWE	5 KAZ	AZE	IRE	GBR
108	1 ISR	IRE	KAZ	KGZ	1 IRN	VNS
109	1 ITA	GBR	KAZ	MNG	2 ISL	FRA
110	1 JAM	BLZ	KAZ	RUS	ISL	ISR

	LP spread		Similarities (US)		Similarities (NORM)	
111	1 JOR	QAT	KAZ	TJK	1 ISR	ISL
112	2 JPN	FRA	2 KEN	SEN	2 ITA	AUT
113	JPN	KOR	KEN	TZA	ITA	MUS
114	1 KAZ	AZE	3 KGZ	IRN	2 JAM	LCA
115	1 KEN	SEN	KGZ	KAZ	JAM	TTO
116	1 KGZ	UZB	KGZ	MDA	1 JOR	ESP
117	3 KNA	ATG	7 KNA	ATG	1 JPN	ESP
118	KNA	FJI	KNA	BHS	KAZ	ALB
119	KNA	LCA	KNA	GRD	2 KAZ	BOL
120	1 KOR	JPN	KNA	LCA	1 KEN	LKA
121	1 LBN	OMN	KNA	TTO	1 KGZ	ROM
122	3 LCA	BHS	KNA	VCT	3 KNA	ATG
123	LCA	KNA	KNA	YEM	KNA	GRD
124	LCA	VCT	2 KOR	HKG	KNA	YEM
125	2 LKA	BGD	KOR	JPN	2 KOR	IDN
126	LKA	IDN	2 LBN	BHR	KOR	LBN
127	1 LTU	ALB	LBN	OMN	1 LBN	KOR
128	1 LUX	GER	1 LCA	KNA	2 LCA	JAM
129	3 LVA	ALB	1 LKA	PAK	LCA	VCT
130	LVA	AZE	1 LTU	EST	3 LKA	KEN
131	LVA	UZB	1 LUX	GER	LKA	MDG
132	1 MAR	BWA	4 LVA	ARM	LKA	TUN
133	1 MDA	ARM	LVA	EST	3 LTU	ARM
134	2 MDG	BHR	LVA	HRV	LTU	EST
135	MDG	MLI	LVA	POL	LTU	RUS
136	3 MEX	ARG	1 MAR	TUN	2 LUX	CHE
137	MEX	CHI	5 MDA	ALB	LUX	FRA
138	MEX	URY	MDA	BLR	2 LVA	EST
139	1 MKD	ROM	MDA	KGZ	LVA	SVN
140	2 MLI	COG	MDA	ROM	1 MAR	CHI
141	MLI	MDG	MDA	UKR	1 MDA	UKR
142	2 MNG	POL	2 MDG	MLI	1 MDG	LKA
143	MNG	URY	MDG	TZA	4 MEX	BRA
144	1 MUS	SLE	3 MEX	AUS	MEX	MLI
145	2 MWI	GIN	MEX	BOL	MEX	MWI
146	MWI	TZA	MEX	ECU	MEX	URY
147	1 NGA	COG	2 MKD	HRV	1 MKD	SVN
148	1 NLD	GBR	MKD	HUN	1 MLI	MEX
149	1 NOR	SWE	1 MLI	MDG	1 MNG	CHI
150	1 NPL	PER	1 MNG	KAZ	1 MUS	ITA
151	1 NZL	BEL	1 MUS	ZWE	1 MWI	MEX
152	2 OMN	LBN	1 MWI	TZA	1 NGA	SLE
153	OMN	QAT	2 NGA	SLE	1 NLD	AUT
154	2 PAK	BGD	NGA	ZWE	1 NOR	GBR
155	PAK	FJI	2 NLD	GER	1 NPL	UKR
156	3 PAN	BGD	NLD	SWE	2 NZL	AUS
157	PAN	BOL	2 NOR	FIN	NZL	CHI
158	PAN	URY	NOR	ISL	1 OMN	QAT
159	3 PER	ECU	1 NPL	PER	1 PAK	PER
160	PER	NPL	2 NZL	AUS	2 PAN	BGD
161	PER	THA	NZL	CAN	PAN	CMR
162	1 PHL	TZA	3 OMN	BMU	5 PER	BOL
163	3 POL	ALB	OMN	LBN	PER	ECU
164	POL	MNG	OMN	QAT	PER	PAK
165	POL	SVK	2 PAK	BGD	PER	SEN
166	1 PRT	ESP	PAK	LKA	PER	ZWE

	LP spread		Similarities (US)		Similarities (NORM)	
167	3 QAT	JOR	1 PAN	CHI	1 PHL	COG
168	QAT	OMN	2 PER	ECU	1 POL	ESP
169	QAT	TZA	PER	NPL	2 PRT	BRA
170	2 ROM	IRN	1 PHL	PRT	PRT	HUN
171	ROM	MKD	2 POL	FJI	3 QAT	BHR
172	3 RUS	AZE	POL	LVA	QAT	IDN
173	RUS	EST	2 PRT	PHL	QAT	OMN
174	RUS	IRN	PRT	SVN	3 ROM	BGR
175	2 SEN	BWA	3 QAT	HKG	ROM	COG
176	SEN	KEN	QAT	JOR	ROM	KGZ
177	2 SGP	BHR	QAT	OMN	1 RUS	LTU
178	SGP	HKG	1 ROM	MDA	1 SEN	PER
179	3 SLE	COG	2 RUS	EST	1 SGP	BEL
180	SLE	GAB	RUS	KAZ	3 SLE	CIV
181	SLE	MUS	3 SEN	CIV	SLE	NGA
182	3 SVK	HUN	SEN	COG	SLE	URY
183	SVK	POL	SEN	KEN	2 SVK	CZE
184	SVN	GRC	1 SGP	HKG	SVK	URY
185	5 SWE	DNK	3 SLE	NGA	4 SVN	ESP
186	SWE	ESP	SLE	SWZ	SVN	LVA
187	SWE	IRE	SLE	TZA	SVN	MKD
188	SWE	ISL	2 SVK	COG	SVN	TUR
189	SWE	NOR	SVK	CZE	3 SWE	BEL
190	1 SWZ	ZMB	4 SVN	GRC	SWE	DNK
191	2 SYR	IRN	SVN	HRV	SWE	FIN
192	SYR	YEM	SVN	PRT	1 SWZ	GRC
193	1 THA	PER	SVN	TUR	1 SYR	BOL
194	1 TJK	UKR	3 SWE	FIN	1 THA	ECU
195	1 TKM	IRN	SWE	JPN	2 TJK	BOL
196	1 TTO	DMA	SWE	NLD	TJK	UKR
197	1 TUN	COG	1 SWZ	SLE	1 TKM	CHI
198	1 TUR	HRV	1 SYR	COG	3 TTO	BLZ
199	6 TZA	BEN	1 THA	ECU	TTO	BRB
200	TZA	BWA	1 TJK	KAZ	TTO	JAM
201	TZA	GRC	1 TKM	BLR	TUN	LKA
202	TZA	MWI	1 TTO	KNA	2 TUN	TZA
203	TZA	PHL	2 TUN	MAR	2 TUR	ECU
204	TZA	QAT	TUN	ZWE	TUR	SVN
205	3 UKR	ARM	1 TUR	SVN	2 TZA	CMR
206	UKR	TJK	5 TZA	KEN	TZA	TUN
207	UKR	UZB	TZA	MDG	5 UKR	AZE
208	5 URY	BRA	TZA	MWI	UKR	GEO
209	URY	ECU	TZA	SLE	UKR	MDA
210	URY	MEX	TZA	ZMB	UKR	NPL
211	URY	MNG	3 UKR	BGR	UKR	TJK
212	URY	PAN	UKR	MDA	3 URY	MEX
213	1 USA	ESP	UKR	UZB	URY	SLE
214	5 UZB	BLR	1 URY	ARG	URY	SVK
215	UZB	GEO	1 USA	GER	1 USA	CAN
216	UZB	KGZ	1 UZB	UKR	1 UZB	BGR
217	UZB	LVA	2 VCT	DMA	2 VCT	GRD
218	UZB	UKR	VCT	KNA	VCT	LCA
219	2 VCT	GRD	2 VEN	BRA	3 VEN	BLR
220	VCT	LCA	VEN	IDN	VEN	ECU
221	1 VEN	BRA	1 VNS	BGR	VEN	GIN
222	1 VNS	FJI	2 YEM	COG	2 VNS	BGR

Table 4
Per capita DA (Domestic Absorption) relative to United States

ISO code	Fisher (1)	Eks (2)	Sim std (3)	Sim us (4)	Lp Spread (5)	Gk (6)	Country name
LUX	102.7	106.8	102.7	104.2	99.9	108.3	Luxembourg
USA	100.0	100.0	100.0	100.0	100.0	100.0	USA
JPN	85.3	84.4	84.5	83.3	79.6	87.6	Japan
CHE	83.5	83.9	83.5	84.2	80.7	86.2	Switzerland
HKG	83.1	87.6	83.0	85.6	114.4	101.2	Hong Kong
DNK	80.6	82.2	80.8	82.4	78.1	82.8	Denmark
NOR	79.9	81.9	79.6	80.0	77.0	82.6	Norway
ISL	79.7	79.5	79.5	80.2	77.6	79.3	Iceland
CAN	77.8	75.8	77.8	78.1	76.0	77.5	Canada
AUT	77.7	79.5	77.5	78.6	75.8	79.3	Austria
AUS	77.5	78.4	80.6	78.0	76.3	77.4	Australia
BEL	72.4	72.6	72.1	73.0	70.5	71.9	Belgium
GER	72.1	72.8	71.2	72.1	69.1	73.7	Germany
FRA	70.9	70.1	70.4	70.9	67.8	70.1	France
SGP	70.0	78.5	67.5	70.6	94.3	91.7	Singapore
ITA	69.0	69.0	68.5	68.9	67.0	69.5	Italy
GBR	68.7	69.0	69.2	70.0	66.2	68.0	United Kingdom
NLD	68.6	69.0	67.2	68.1	65.4	69.0	Netherlands
ISR	65.3	64.6	63.7	64.2	62.0	64.9	Israel
SWE	64.2	63.6	63.2	63.8	61.1	63.5	Sweden
BMU	61.8	64.6	65.5	64.4	68.1	76.3	Bermuda
NZL	60.8	61.7	63.5	61.5	59.3	61.0	New
FIN	60.6	61.1	60.3	60.9	58.6	60.8	Finland
IRL	55.2	55.9	55.6	56.3	54.1	55.3	Ireland
ESP	52.9	54.2	54.9	54.5	52.9	53.4	Spain
PRT	51.9	53.2	48.3	52.9	51.7	52.8	Portugal
GRC	49.8	50.5	50.6	50.3	49.5	50.1	Greece
KOR	49.6	52.9	48.8	50.6	48.3	58.3	Korea
CZE	48.4	48.0	45.9	48.8	47.5	50.2	Czech Republic
QAT	48.2	47.7	44.8	50.8	56.4	56.7	Qatar
BHS	48.2	47.2	45.5	58.7	47.4	56.4	Bahamas
SVN	46.4	46.7	46.8	46.2	45.4	46.2	Slovenia
BRB	42.0	40.1	39.3	50.0	29.4	67.0	Barbados
MUS	38.3	37.1	37.9	32.7	32.6	46.8	Mauritius
ARG	34.9	36.6	35.9	34.3	38.7	39.3	Argentina
KNA	34.9	33.2	33.3	44.5	36.0	37.8	St. Kitts & Nevis
HUN	34.6	33.9	30.5	34.2	33.3	35.8	Hungary
SVK	34.0	34.2	31.8	33.7	33.3	36.5	Slovakia
URY	30.6	29.3	28.3	27.3	30.8	31.9	Uruguay
OMN	30.1	31.8	26.9	30.4	33.8	43.7	Oman
ATG	29.9	29.0	27.7	37.0	29.9	34.8	Antigua & Barbuda
CHL	28.5	29.7	29.8	27.4	31.4	31.1	Chile
EST	27.6	27.1	26.9	27.1	24.3	29.1	Estonia
BHR	25.1	26.1	28.0	26.8	36.7	31.9	Bahrain
BRA	24.7	24.5	23.8	22.7	25.9	26.9	Brazil
POL	24.6	24.8	23.8	24.7	23.5	26.9	Poland
MEX	24.6	25.0	24.6	23.8	26.8	25.2	Mexico
THA	23.3	25.0	23.7	22.6	25.8	28.9	Thailand
HRV	22.8	21.8	21.8	21.5	19.2	23.8	Croatia
TTO	22.5	22.4	21.7	27.7	21.8	27.4	Trinidad & Tobago
TUR	22.0	23.1	22.5	22.2	20.5	24.1	Turkey
TUN	21.9	21.2	23.3	19.0	19.8	26.2	Tunisia
RUS	21.8	20.9	21.5	21.8	19.6	23.2	Russia

ISO code	Fisher (1)	Eks (2)	Sim std (3)	Sim us (4)	Lp Spread (5)	Gk (6)	Country name
LTU	21.1	20.7	20.7	20.9	18.5	23.0	Lithuania
GRD	20.6	20.1	18.8	25.1	19.8	25.8	Grenada
ROM	20.3	21.1	26.3	23.0	20.4	22.9	Romania
GAB	19.6	17.9	20.4	15.9	16.2	23.0	Gabon
BWA	19.3	19.2	19.9	21.1	18.7	19.9	Botswana
LCA	19.1	18.7	18.7	24.3	19.7	21.5	St. Lucia
LVA	18.9	17.9	18.0	18.1	15.9	20.6	Latvia
PAN	18.8	19.2	21.5	17.5	20.0	19.9	Panama
IRN	18.5	17.4	19.2	16.2	15.4	18.3	Iran
DMA	18.1	17.1	17.4	21.8	18.3	23.2	Dominica
VEN	17.6	17.8	17.4	17.3	19.7	20.4	Venezuela
BLR	17.3	16.9	17.1	17.2	16.1	20.8	Belarus
BLZ	17.3	17.7	17.3	22.9	18.0	21.1	Belize
SWZ	16.9	16.4	16.3	16.5	16.3	19.5	Swaziland
VCT	16.7	15.0	15.0	19.4	15.8	20.0	St. Vincent & Grenadines
FJI	16.4	15.9	16.0	16.0	16.2	16.7	Fiji
PER	15.5	15.3	14.5	13.9	15.9	16.2	Peru
BGR	15.4	15.7	18.3	15.5	14.6	18.3	Bulgaria
KAZ	15.4	15.1	14.0	15.1	13.3	18.4	Kazakhstan
MKD	14.2	13.9	13.9	14.0	13.1	14.9	Macedonia
MAR	14.2	13.4	14.7	12.7	12.3	15.5	Morocco
JAM	12.1	12.1	11.8	16.0	12.7	14.2	Jamaica
PHL	11.9	13.0	17.5	12.9	13.6	13.6	Philippines
LBN	11.9	13.5	13.7	13.7	15.2	20.1	Lebanon
UKR	11.8	11.1	9.7	10.9	9.8	13.8	Ukraine
EGY	11.7	12.3	13.9	10.8	11.3	14.8	Egypt
GEO	11.7	10.7	9.5	11.4	10.0	13.8	Georgia
TKM	11.6	12.1	11.9	12.7	12.5	14.3	Turkmenistan
JOR	11.5	11.9	11.9	14.5	16.1	15.0	Jordan
IDN	11.4	11.9	10.9	11.6	13.9	13.6	Indonesia
LKA	11.3	11.0	11.6	9.6	10.9	11.4	Sri Lanka
ECU	10.6	11.0	10.6	10.1	11.6	11.8	Ecuador
ZWE	10.3	10.2	9.9	9.4	9.6	11.6	Zimbabwe
SYR	10.2	10.7	9.9	12.0	9.5	12.7	Syria
ALB	10.1	11.1	11.4	12.1	10.5	12.5	Albania
KGZ	8.5	8.0	9.2	8.2	7.3	9.6	Kyrgyzstan
ARM	8.1	8.2	8.2	8.5	7.2	10.2	Armenia
UZB	7.9	6.9	7.9	6.6	5.9	8.9	Uzbekistan
BOL	7.9	8.0	7.8	7.4	8.2	8.8	Bolivia
AZE	7.9	7.7	7.1	8.1	7.2	9.1	Azerbaijan
GIN	7.0	7.3	7.0	7.2	6.4	9.9	Guinea
MDA	6.8	6.3	5.6	6.3	5.6	8.2	Moldova
PAK	6.5	6.6	6.2	6.0	6.6	7.0	Pakistan
CIV	5.8	5.7	6.6	5.5	5.2	7.0	Cote d'Ivoire
CMR	5.7	5.7	6.4	5.0	5.3	7.3	Cameroon
COG	5.7	5.6	7.5	6.0	5.5	6.1	Congo
VNM	5.3	5.5	6.4	5.4	5.7	6.2	Vietnam
SEN	5.0	5.0	4.7	5.1	4.6	5.7	Senegal
BGD	4.9	4.9	5.2	4.4	4.8	5.2	Bangladesh
KEN	4.0	4.0	4.0	3.9	3.5	4.5	Kenya
NPL	4.0	4.1	3.4	4.0	4.5	5.4	Nepal
MNG	3.9	3.9	3.7	4.3	3.9	4.3	Mongolia
BEN	3.5	3.4	4.3	3.5	3.2	3.9	Benin
SLE	3.3	2.9	3.1	2.7	2.6	4.2	Sierra Leone