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Real output, expenditure and terms of trade across countries: an international input-output approach

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Abstract

In this paper we present a new approach to the derivation of real GDP from the production side. In contrast to Feenstra et al. (2009) we do not rely on international trade unit values to derive PPPs for exports and imports. Instead, we rely on the relationships between prices of goods that can be derived within an international input-output framework. In particular, we make use of the relationship between the output price of a good in an exporting economy, and the import price of the same good by the importing country. In this so-called international input-output (IIO) approach, we use international IO-tables in which imports and exports are broken down by trading partners such that bilateral flows of goods can be distinguished. We show that this new approach delivers estimates for real GDP that are closer to the estimates derived from the output side than those based on unit values.

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1. Introduction

Comparisons of standard-of-living across countries rely heavily on the measurement of real GDP per capita. As such real GDP is a measure of the amount of goods and services that are available for consumption and investment in a country. This real GDP concept from the expenditure side differs fundamentally from real GDP from the production side intended to reflect the productive capacity of the economy. The difference between the two concepts is influenced by a country's terms of trade. An improvement in the prices of exports relative to import prices increases the consumption possibilities of a country without any underlying improvement in its productive potential. In a recent paper, Feenstra et al. (2009) made a carefully distinction between the two measures of real GDP and show that their difference can be large. But whereas there is a large scale international effort to compile comparative GDP from the expenditure side through the International Comparisons Project (ICP), there is much less evidence on real GDP on the output side.

ICP provides real GDP measures for 146 countries in the world using the expenditure approach. These are the cornerstones for extrapolations of GDP provided in the Penn World Tables. The industry-of-origin approach to real GDP has been used in a set of studies at the University of Groningen and recently estimates of real GDP from the output side for a set of 29 OECD countries was released (Inklaar and Timmer, 2009). These estimates require relative prices of output and intermediate inputs at the sectoral level that are only available for a limited set of countries. Feenstra et al. (2009) proposed a short-cut method to the measurement of real output GDP that requires the use of only international and not domestic prices of intermediates and as such is much easier to implement for a larger set of countries. Based on a large cross section of 151 countries in 1996, they found that richer countries enjoyed higher relative export prices while relative import prices were much more equal. They concluded that gaps in expenditure levels across rich and poor countries tend be larger than measured gaps in production as the latter do not take into account differences in the terms of trade.

The problem though is that Feenstra et al. (2009) relies heavily on the use of unit values as a proxy for prices. Unit values are calculated as the ratio of values and quantities. They differ from specification prices that are used in most price surveys such as for the national consumer price indices, or the Purchasing Power Parities (PPPs) in the ICP (International Comparisons Program). Whereas the latter are based on actual price observations of a narrowly specified product, a unit value is an implicit price obtained by dividing value by quantity for a generally broader product category. It has long been recognized that price comparisons based on unit values might suffer from the quality-problem: differences in unit values are driven by both differences in quality of the goods and pure price differences (Lipsey 1994). A vast literature associates cross-country variation in export unit values with variation in product quality, implicitly assuming away cross-country variation in quality-adjusted prices. For example, studies of intra-industry trade and competitiveness of countries simply equate unit value variation with quality variation (e.g. Greenaway, Hine and Milner 1995, Fontagné et al., 2006).

Obviously, the quality problem is positively related to the level of aggregation in the data. One strand of literature tries to minimise the quality problem of unit values by working with the most detailed product level. Timmer and Richter (2009) derive import and export PPPs based on data at a 6-digit level and allow for price differences across various destination markets. They find large differences in relative prices at the 4-, 5- and 6-digit level and across markets. Another strand of literature aims to disentangle price and quality differences through assuming an underlying structure of the determinants of price and quantity of trade flows by imposing a demand system in which consumers' love of variety is included. Hummels and Klenow (2005) show that the relationship between productivity in a country and its export quality crucially depends on the value of the demand elasticities of substitution between varieties. In Hallack and Schott (2009) these elasticities are inferred on the basis of additional information on net trade flows. They find that quality and unit value indices are only weakly positively related and even move in opposite directions for one-third of the countries in the sample. There is no clear relationship between a country's productivity level and the quality of its exports. Lower export values of less developed countries are due to both real price and quality differences with more advanced countries. The general consensus so far is that unit value ratios contain both price and quality differences and are hard to disentangle empirically

In this paper, we develop a novel approach to the derivation of import and export PPPs that does not rely on the use of unit values. In the unit-value approach from Feenstra et al. (2009), import and export prices for a set of countries are derived independently from each other. Instead, we rely on the relationships between prices of goods that can be derived within an international input-output framework. In particular, we make use of the relationship between the output price of a good in an exporting economy, and the import price of the same good by the importing country. In this so-called international input-output (IIO) approach, we use international IO-tables in which imports and exports are broken down by trading partners such that bilateral flows of goods can be distinguished. Export prices are assumed to be equal to domestic output prices and these are estimated by combining data on purchasers' prices of goods from the ICP with data on domestic trade and transportation margins. In this way, we can rely on relative prices of specified products collected in the ICP and avoid the use of unit values and associated quality problems to derive export and import PPPs. We show that this new approach delivers estimates for real production GDP that are closer to the estimates derived from the output side than those based on trade unit values. With a greater availability of international input-output tables from the WIOD-project, this method can be applied to a larger set of countries and over time in the near future.

The remainder of the paper proceeds as follows. In Section 2 we outline our methodology to derive PPPs and reference prices for domestic final demand, exports and imports in an extended Geary-Khamis framework. Section 3 described the data sources used and Section 4 presents results. Section 5 concludes.

2. Measurement of Real GDP

In this outline of our methodology we follow the notation of Feenstra et al. (2009) as closely as possible. Suppose there are i=1,..,M final goods that may also be used as intermediate inputs, and there are another i= M+1, ..,M+N goods that are exclusively intermediate inputs. To relate domestic demand, international trade and production of these goods we rely on a supply-use framework. Supply-use tables are the basic building block of statistics collected in the National Accounts. In this framework the fundamental equality is between the total demand and total supply of each good, both in quantities and in nominal values. For each country j = 1,..,C denote final domestic demand by q_{ij}, intermediate demand by z_{ij}, output by y_{ij}, exports by x_{ij} and imports by m_{ij} for all i. We assume that all of the quantities are non-negative. Total demand in country j is given by $q_{ij} + x_{ij} + z_{ij}$ and total supply by $y_{ij} + m_{ij}$. Hence the equality between demand and supply is

$$q_{ij} + x_{ij} + z_{ij} = y_{ij} + m_{ij}, \quad \forall i. \qquad (1)$$

Let *p* denote prices such that $p_{ij}^q, p_{ij}^z, p_{ij}^y, p_{ij}^x$ and p_{ij}^m denote corresponding prices in country j for the various goods. These prices will differ across the various uses and supply, but are not independent from each other. For example prices of domestic production and consumption and exports are related, and these relationships will later on play an important role in identifying terms-of-trade. Multiplying the elements in (1) each by their price we obtain the second equality between supply and use in nominal terms[1]

$$p_{ij}^q q_{ij} + p_{ij}^x x_{ij} + p_{ij}^z z_{ij} = p_{ij}^y y_{ij} + p_{ij}^m m_{ij}, \quad \forall i. \qquad (2)$$

Summing over all goods, and rearranging terms, we obtain

$$\sum_{i=1}^{N+M}\left(p_{ij}^q q_{ij} + p_{ij}^x x_{ij} - p_{ij}^m m_{ij}\right) = \sum_{i=1}^{N+M}\left(p_{ij}^y y_{ij} - p_{ij}^z z_{ij}\right), \quad \forall i. \qquad (3)$$

The left-hand side of this equation is equal to nominal GDP measured from the expenditure side: it is the sum of final domestic demand plus exports minus imports. The right-hand side is equal to nominal GDP measured from the production side: it is the sum over "net output" of all goods, that is gross output minus intermediate demand.

[1] Ignoring net taxes on products that should be added to the right-hand side.

The various prices of a good in the supply-use framework are not independent from each other. An important distinction made is that between the basic price, which is the price received by the producer of the good, and purchasers' price, which is the price to be paid by the consumer. The difference between the basic and purchasers' price of a good is determined by net taxes, trade and transportation margins, which we will refer to as domestic margins from here on. Let r_{ij}^{D} denote the margins on product i, consumed and produced in country j. Then, following the conventions of the System of National Accounts (SNA, 1993) the output price of a good is related to the final domestic demand price in the following way:

$$p_{ij}^{y} = \frac{1}{\left(1 + r_{ij}^{D}\right)} p_{ij}^{q}, \quad \forall i. \qquad (4)$$

The margins r_{ij}^{D} can be called domestic margins as they are related to the trading of the product in the country itself. Margins are also added when a good is internationally traded. Following the SNA, this is the difference between the export price of a good, measured on a f.o.b. (free on board) basis and the price of the same good when entering the territory of the destination country, measured c.i.f. (including cost, insurance and freight).[2] Let r_{ijk}^{T} denote the international margins on product i exported from country k to country j, then the price of good i imported by country j from country k (p_{ijk}^{m})is

$$p_{ijk}^{m} = \left(1 + r_{ijk}^{T}\right) p_{ijk}^{x}, \quad \forall i \qquad (5)$$

where p_{ijk}^{x} is the price of good i exported by country k to country j. Then we can define the import price of product i in country j as a weighted average over import prices from all countries k=1,…,C exporting to country j

$$p_{ij}^{m} = \sum_{k=1}^{C} w_{ijk} \left(1 + r_{ijk}^{T}\right) p_{ijk}^{x}, \quad \forall i \qquad (6)$$

where the weights are given by the share of country k in total imports of product i in j

$$w_{ijk} = \frac{q_{ijk}^{m} p_{ijk}^{m}}{\sum_{k=1}^{C} q_{ijk}^{m} p_{ijk}^{m}}, \quad \forall i \qquad (7)$$

We will use identities (4) and (6) later on to identify export and import prices.

[2] F.o.b. price is net of tariffs and freight, including any subsidy to the buyer but not to the seller.

By deflating nominal GDP with a GDP price index, a measure of real GDP can be derived. Following equation (2) this can be done in two ways: from the production side and from the expenditure side. In the first case one would need prices of output and intermediate demand, while in the latter prices of final domestic demand, exports and imports are needed. International comparisons of output and intermediate input prices are scarce, in particular for non-OECD countries, but in our section on validation we will make use of existing work on OECD countries from Inklaar and Timmer (2009).

As an alternative, deflation from the expenditure side has been tried. Building upon on-going work in the Penn World Tables, Feenstra et al. (2009) introduced an augmented Geary Khamis (GK) system to derive PPPs for both final domestic demand, export and import. In the GK-system average "reference prices" for goods and purchasing power parities (PPPs) are obtained by solving a set of simultaneous equations. In the PWT this system is normally only applied to goods for final domestic demand which does not lead to a true measure of real GDP. Instead, we follow the augmented GK-system proposed by Feenstra et al. (2009) that also includes reference prices for imports and exports as follows:

$$\pi_i^q = \sum_{j=1}^{C} (p_{ij}^q PPP_j^o) q_{ij} \Big/ \sum_{j=1}^{C} q_{ij}, \quad i = 1,..,M \tag{8}$$

$$\pi_i^x = \sum_{j=1}^{C} (p_{ij}^x PPP_j^o) x_{ij} \Big/ \sum_{j=1}^{C} x_{ij}, \quad i = 1,..,M+N \tag{9}$$

$$\pi_i^m = \sum_{j=1}^{C} (p_{ij}^m PPP_j^o) m_{ij} \Big/ \sum_{j=1}^{C} m_{ij}, \quad i = 1,..,M+N \tag{10}$$

and

$$PPP_j^o = \frac{\sum_{i=1}^{N+M} \left(p_{ij}^q q_{ij} + p_{ij}^x x_{ij} - p_{ij}^m m_{ij} \right)}{\sum_{i=1}^{M} \pi_i^o q_{ij} + \sum_{i=1}^{M+N} (\pi_i^x x_{ij} - \pi_i^m m_{ij})}, \quad \forall j. \tag{11}$$

In equation (8) we construct domestic reference prices for final goods (π_i^q) and in equations (9) and (10) we construct reference prices for exports and imports (π_i^x and π_i^m). In these equations, the national prices *p* are deflated by the PPPs and then averaged across countries. The PPPs are obtained from equation (11) as the ratio of nominal to real GDP, where real GDP is evaluated using the references prices and nominal GDP as defined in equation (2). Feenstra et al. (2009) show that this system has a solution under non-negativity of quantities and mild restrictions on the size of import shares. In our application these assumptions hold and solutions were obtained after less than ten iterations.

Based on the reference prices, one can easily derive the PPPs for domestic final demand, export and imports as follows:

$$PPP_j^q = \frac{\sum_{i=1}^{M} p_{ij}^q q_{ij}}{\sum_{i=1}^{M} \pi_i^o q_{ij}}, \qquad (12a)$$

$$PPP_j^x = \frac{\sum_{i=1}^{M+N} p_{ij}^x x_{ij}}{\sum_{i=1}^{M+N} \pi_i^x x_{ij}}, \qquad (12b)$$

$$PPP_j^m = \frac{\sum_{i=1}^{M+N} p_{ij}^m m_{ij}}{\sum_{i=1}^{M+N} \pi_i^m m_{ij}}. \qquad (12c)$$

3. Data sources

To estimate the reference prices and PPPs, we combine a number of international sources to create a dataset of prices and nominal values of expenditure, import and export for our set of 42 countries. This set of countries is determined by the availability of international input-output data and contains all major countries in the world together covering more than 80% of world output and more than 90% of world trade. Goods are grouped into 41 product categories given in Appendix Table 3. For each country and product group a vector of prices and values of final domestic demand, imports and exports is derived and structured as indicated in Figure 1.

The values in national currencies are derived from national IO-tables. Final domestic demand consists of household consumption, government consumption and investment as given in the Use table. Nominal values of exports and imports of each product group are taken from the corresponding columns in the Use and Supply table. Our data refers to the year 2005. As for some countries IO-tables wer eonly available for a year close to 2005, we normalised nominal GDP (in national currency) to the total from ICP.

For the PPPs we need to have relative prices of final domestic demand, exports and imports. As discussed above, the same good can have different prices depending on use and source of supply. In our approach we rely on fixed relationships between these prices as described in the system of National Accounts.[3] An important distinction is between the basic price of a good when sold by the producer (ex-factory gate), and the purchasers' price paid by the user. The prices for final domestic demand are purchasers' prices paid by final consumers. Relative price levels for final domestic demand are collected through the International Comparisons Program (ICP) from the World Bank, United Nations, OECD and Eurostat. We use the price data for 110

[3] Although obviously prices of goods can differ in prices for a variety of reasons, we are using data that is collected wihtin the SNA and hence must obey these relationships by construction.

detailed basic headings that are underlying the calculation of real GDP by the World Bank (2008) and allocate these to the set of 41 goods as indicated in Appendix Tables 2 and 3.[4]

The relative prices of exports and imports are less straightforward and their derivation is the main novelty of our approach. The export price of a good is much closer to the domestic basic price of the good than the purchaser's price. While goods for final domestic demand flow through the wholesale and retailing systems, goods destined for export have only some wholesale trade margins from the plant to the port of exporting. The latter is relatively small, and we neglect this for now. We derive the basic price of goods by "peeling off" the domestic margin from the purchasers' prices for final domestic demand. Using equation (4), we define

$$PPP_{ij}^{x} = \frac{\left(1+r_{i,US}^{D}\right)}{\left(1+r_{ij}^{D}\right)} PPP_{ij}^{q}, \quad \forall i. \qquad (13)$$

That is, we adjust the expenditure PPP for each country, by the ratio of the margin rates in the country itself and the US, being our benchmark country. The margins for each product group and country can be derived from national Supply tables that provide information on trade and transportation margins at the level of product groups. In fact, this adjusted expenditure PPP has been used as a proxy for output prices by, for example, by Jorgenson, Nishimizu and Kuroda (1987), Lee and Tang (2000) and most recently by Biesebroeck (2009) and Sørenson and Schjerning (2008).[5] Some goods such as agriculture, mining and some manufacurnig goods are only used for intermediate consumption, and in those cases we relied on alternatives. For agriculture, we derived relative prices from FAO unit value data. As these goods are relatively homogeneous, quality problems are assumed to be small. For other goods, we used PPPs from goods that aer smiilar (see Appendix Table 3)

For the derivation of PPPs for imports, we assume that there is a relation between the relative price of the good at time of export, and the relative price of the good upon entering the destination country. As we yet have no information on the international trade margins, we assume that the relative price of exports of a country is equal to the relative prices of imports from that country by others. Using equation (6), we define the import PPP of product i in country j as a weighted average over prices from all countries k=1,…,C exporting to country j

$$PPP_{ij}^{m} = \sum_{k=1}^{C} \left(w_{ijk} PPP_{ijk}^{x} / ER_{k}\right) * ER_{j} \quad \forall i \qquad (14)$$

with ER_k the exchange rate in country k (local currency price of US$) and weights w_{ijk} given by the share of country *k* in total imports of product *i* by *j* (in national currency of country *j*) as in equation (7). These weights are derived from our set of international IO-tables. In these tables, imports are broken down by the country of origin for each product group. These tables have been

[4] Share in final expenditure as given in the ICP-tables is used to weight the basic headings to the product group aggregates.

[5] However, ideally further adjustments are needed for international trade and intermediate use but infeasible, see Hooper (1996) and Timmer and Inklaar (2010).

constructed in the WIOD-project based on a combination of bilateral international trade data from the OECD and national IO-tables from NSIs (see Timmer et al. 2010 for an elaborate discussion). These tables are available for 41 countries and cover a large part of international trade. For imports from countries not covered in this database, we set the price levels to unity.

4. Results

In Table 1 we provide the various relative prices for GDP and its various components derived with our proposed international IO approach. These relative prices are unit free and all normalised on U.S. GDP for which it is unity. The first column shows the relative price for GDP, which can be decomposed into the relative price levels of final domestic demand (column 2), exports (column 4) and imports (column 5). We also report the terms of trade in column 4, defined as the relative price of exports over relative price of imports. A number of observations can be made.

First, the price levels for final domestic demand reflect the well-known (static) Penn effect, as relative prices tend to be higher in richer countries. In fact, they are close to the PPPs for final demand that are derived in the expenditure approach used by the ICP, with a correlation of 0.83. As in Feenstra et al. (2009), the inclusion of separate prices for traded goods only has a small impact on the estimated PPPs for final goods.

Second, relative prices of exports differ greatly across countries, and much more so than imports. The standard deviation of import prices is less than one-third of that of export prices, reflecting the fact that import baskets are much more similar across countries than export baskets. The highest export price levels are found for Denmark, Ireland, Japan, Luxembourg and Norway, while the lowest are found for China, India, Indonesia and Russia. But also countries such as Argentina, Bulgaria, Latvia, Romania and Taiwan have export price levels that are more than a quarter below the average. In contrast, especially European countries enjoy relatively high export price levels.

The terms of trade are obtained by dividing the export and import price levels and are given in column 3. As import prices vary relatively little, differences in terms of trade are mainly driven by the difference in export price levels. Bulgaria, China, India, Indonesia and Russia have levels of less than 0.7 indicating that their export PPPs are well below their import PPPs. On the other hand, Denmark, Finland, Ireland, Japan, New Zealand and Norway benefit from very high terms of trade (1.3 or higher). These terms of trade seem to be related with the level of GDP per capita. In Figure 2, we plot these variables for our set of countries, together with the OLS regression line. There is a strong positive relationship: countries with higher GDP per capita levels also enjoy higher TOT. The slope coefficient on GDP per capita is significantly positive (at the 1% level) and about 35 per cent of the variation of the TOT is explained.

Finally, we provide a comparison of real GDP per capita measured from the expenditure and the production side in columns 6 and 7. Real GDP from the expenditure side is derived by

deflating nominal GDP by the PPP for final domestic demand only, as in the ICP.[6] In general, it will be higher than GDP from the production side when the terms of trade are higher than in the US.[7] Column 8 indicates that more than half of the countries have real GDP levels that are higher when measured from the expenditure side compared to real GDP from the production side. This difference is in particularly large for New Zealand, Luxembourg, Belgium, Ireland and Norway (from 14 up to 35% higher). These are all economies with high terms of trade and at high levels of trade openness to enjoy this advantage (see Appendix Table 2). On the other hand, real GDP from the expenditure side is more than 10% lower than from the production side in Bulgaria, Russian Federation, Taiwan, Latvia and Indonesia.

Our findings of large differences in terms-of-trade and a generally positive relationship with GDP per capita confirm the findings by Feenstra et al. (2009) who used an alternative approach based on trade unit values. But a closer look at the results for each country reveals that the alternative approaches lead to stark differences in real GDP estimates for various countries. In Table 2 we provide a comparison of GDP PPPs based on three alternative: the unit value approach by Feenstra et al., the international input-output approach as introduced in this paper, and the industry-of-origin approach. Results of the latter approach can be considered as the gold-standard for real GDP comparisons from the production side as they are based on deflation of outputs and intermediate inputs by industry, and does rely to a lesser extent on a short-cut for export prices as in the other approaches. The industry-of-origin approach puts a heavy demand on data and hence is only carried out for a limited set of OECD countries. Results for 1997 are taken from Inklaar and Timmer (2009) and compared with updated results from Feenstra et al. (from 1996) and backdated results from this paper (from 2005), recalculated for this smaller group of countries. Extrapolation is based on relative GDP deflators for the various countries from the OECD national accounts statistics.

The first two columns in table 2 show that the results for the short cut methods differ by more than 10 per cent for 14 out of 26 countries. The last two columns of Table 2 provide the percentage deviation from the industry-of-origin approach. Importantly, the results for the international IO approach are closer to those based on the industry-of-origin approach than the unit-value approach in 20 out of the 26 countries. The average (absolute) difference is 9 per cent for the former, while 14 per cent for the latter. This is more remarkable considering that our new 2005 results had to be extrapolated across eight years compared to one year for the unit-value results, which can lead to much greater differences due to changing weights.

Moreover, there seems to be a systematic bias in the results from the unit-value approach, as the deviations increase with a measure of openness of the economy (import plus exports over GDP in national currencies). This is illustrated in Figure 3 for both alternative approaches. Deviations seem to increase for both the unit-value and IIO approach, but the coefficient on

[6] Strictly, the PPPs for final domestic demand should be estimated by a GK-system only involving final demand prices. The differences are small, results available upon request from the authors, see Feenstra et al. (2009) for a similar finding.

[7] But not necessarily so, as this will depend also on the size of exports and imports relative to GDP, see Feenstra et al. (2009), equation 20.

openness is much smaller and more over non-significant (t-value of 1.4) for the latter, while significantly positive for the former (t-value of 2.7). This suggests that the unit-value approach provides more biased estimates for countries with a large share of international trade, that is for those countries for which export and import PPPs matter most.

5. Concluding remarks

In this paper we outlined a new approach to derive real GDP from production side, called the international IO approach. In this approach, we make use of the relationship between the output price of a good in an exporting economy, and the import price of the same good by the importing country. We used international IO-tables in which imports and exports are broken down by trading partners such that bilateral flows of goods can be distinguished. Export prices are assumed to be equal to domestic output prices and these are estimated by combining data on purchasers' prices of goods from the ICP with data on domestic trade and transportation margins. In contrast to the approach by Feenstra et al. (2009), we do not rely on comparisons of unit values of imports and exports across countries that suffer from well-known quality comparability problems. We showed that our results differed significantly from the unit-value approach and were much closer to the real GDP as derived from the industry-of-origin approach. While the latter is considered to be the gold-standard for real output comparisons, it puts heavy requirements on the data, in particular the need for prices of intermediate goods. The short-cut proposed is much less data-intensive and could be relatively easily extended to other countries with the availability of a larger set of international input-output tables.

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Table 1 Price levels and real GDP, 2005

	Relative prices (PPP/exchange rate)					Real GDP per capita		
	GDP (1)	Final domestic demand (2)	Terms of Trade (3)	Exports (4)	Imports (5)	Real GDP(e) (6)	Real GDP(o) (7)	Difference (%) (8)
Argentina	0.42	0.43	0.75	0.55	0.73	11,135	11,468	-2.9
Australia	1.12	1.06	1.18	0.92	0.78	32,751	31,109	5.3
Austria	1.10	1.04	1.11	0.94	0.85	35,748	33,717	6.0
Belgium	1.24	1.08	1.17	1.01	0.87	33,294	28,917	15.1
Brazil	0.53	0.54	0.90	0.69	0.76	8,845	8,975	-1.4
Bulgaria	0.31	0.35	0.67	0.52	0.78	9,995	11,530	-13.3
Canada	1.04	0.97	1.16	0.89	0.77	36,266	33,878	7.0
China	0.33	0.36	0.61	0.46	0.76	4,789	5,191	-7.8
Czech Republic	0.54	0.54	0.97	0.75	0.78	22,463	22,633	-0.8
Denmark	1.72	1.44	1.34	1.19	0.89	33,168	27,760	19.5
Estonia	0.55	0.60	0.90	0.70	0.78	17,260	18,710	-7.7
Finland	1.42	1.24	1.33	1.13	0.85	30,127	26,259	14.7
France	1.12	1.10	1.06	0.93	0.88	31,033	30,373	2.2
Germany	1.10	1.06	1.12	0.95	0.85	31,852	30,662	3.9
Greece	0.89	0.89	0.91	0.69	0.76	25,130	25,031	0.4
Hungary	0.60	0.60	1.01	0.82	0.81	18,195	18,302	-0.6
India	0.27	0.29	0.47	0.34	0.74	2,478	2,651	-6.5
Indonesia	0.31	0.34	0.51	0.41	0.80	3,812	4,247	-10.2
Ireland	1.74	1.32	1.32	1.19	0.90	36,543	27,852	31.2
Italy	1.07	1.05	1.06	0.90	0.85	28,779	28,255	1.9
Japan	1.24	1.14	1.55	1.09	0.70	31,167	28,720	8.5
Latvia	0.44	0.50	0.79	0.58	0.73	14,124	15,885	-11.1
Lithuania	0.45	0.49	0.86	0.60	0.69	15,296	16,747	-8.7
Luxembourg	1.30	1.13	1.14	1.08	0.95	70,169	61,091	14.9
Mexico	0.60	0.61	0.88	0.67	0.76	12,048	12,433	-3.1
Netherlands	1.15	1.08	1.11	0.95	0.85	36,043	33,797	6.6
New Zealand	1.20	1.05	1.40	1.02	0.73	25,266	22,098	14.3
Norway	1.86	1.38	2.00	1.50	0.75	47,289	35,138	34.6
Poland	0.50	0.52	0.87	0.71	0.81	15,246	15,808	-3.6
Portugal	0.88	0.88	0.99	0.85	0.86	19,986	19,971	0.1
Romania	0.44	0.49	0.76	0.57	0.75	9,343	10,344	-9.7
Russian Federation	0.41	0.47	0.55	0.42	0.77	11,473	13,011	-11.8
Slovak Republic	0.49	0.50	0.97	0.73	0.75	17,436	17,947	-2.8
Slovenia	0.73	0.75	0.97	0.83	0.85	23,446	23,903	-1.9
South Africa	0.65	0.64	1.07	0.72	0.68	8,057	7,918	1.8
South Korea	0.74	0.73	1.05	0.81	0.77	22,616	22,222	1.8
Spain	0.95	0.94	1.01	0.88	0.87	27,627	27,392	0.9
Sweden	1.27	1.23	1.12	1.01	0.91	32,247	31,118	3.6
Taiwan	0.51	0.58	0.75	0.53	0.71	27,230	30,695	-11.3
Turkey	0.60	0.62	0.92	0.68	0.74	8,100	8,287	-2.3
United Kingdom	1.22	1.15	1.15	1.00	0.87	32,340	30,507	6.0
United States	1.00	0.98	1.04	0.80	0.77	42,420	41,675	1.8

Notes: Column 1 is normalised so that the real and nominal values of GDP are equal in the US; columns 2, 4 and 5 are computed according to equation (12); column 3 equals column 4 over 5; columns 6 and 7 by deflating nominal GDP by the PPP in column 2 and 1 respectively; and column 8 equals column 6 over 7 minus 1.

Table 2 Comparison of PPPs for real GDP^{O} in 1997, various approaches

	Alternative approaches			Deviation from industry-of-origin approach	
	Unit value	International IO	Industry-of-origin	Unit value	International IO
AUS	1.22	1.33	1.24	-1.3%	7.7%
AUT	1.11	0.90	1.01	9.8%	-10.2%
BEL	1.07	0.93	0.89	20.0%	3.6%
CAN	1.28	1.23	1.13	13.7%	8.7%
CZE	11.01	10.80	9.49	16.0%	13.9%
DNK	8.68	9.67	7.54	15.2%	28.4%
EST	5.25	4.51	4.83	8.7%	-6.6%
FIN	0.99	1.10	0.91	8.8%	20.6%
FRA	1.04	0.91	1.02	2.3%	-10.5%
DEU	1.08	0.98	0.98	10.2%	-0.5%
GRC	0.70	0.60	0.64	9.2%	-6.3%
HUN	91.39	76.21	61.70	48.1%	23.5%
IRL	1.14	1.07	0.86	32.8%	24.5%
ITA	0.84	0.83	0.80	5.0%	4.7%
JPN	162.85	169.17	189.71	-14.2%	-10.8%
LVA	0.19	0.19	0.17	12.6%	13.6%
LTU	1.36	1.23	1.20	13.6%	2.8%
NLD	1.01	0.82	0.80	26.2%	2.4%
POL	1.39	1.26	1.15	21.0%	10.2%
PRT	0.66	0.63	0.54	23.4%	17.6%
SVK	10.94	10.23	9.88	10.7%	3.5%
SVN	0.44	0.43	0.43	1.9%	-0.7%
KOR	557.45	696.05	716.03	-22.1%	-2.8%
ESP	0.77	0.67	0.71	8.8%	-6.2%
SWE	10.49	9.82	9.23	13.7%	6.4%
GBR	0.67	0.63	0.63	7.4%	0.1%
USA	1.00	1.00	1.00	0.0%	0.0%
Average of absolutes				14.0%	9.1%

Notes and sources: Unit value approach results from Feenstra et al. (2009) Table 2, updated from 1996, international IO results as in this paper backdated from 2005. Industry of origing results from Inklaar and Timmer (2009).

Figure 1 Data set up

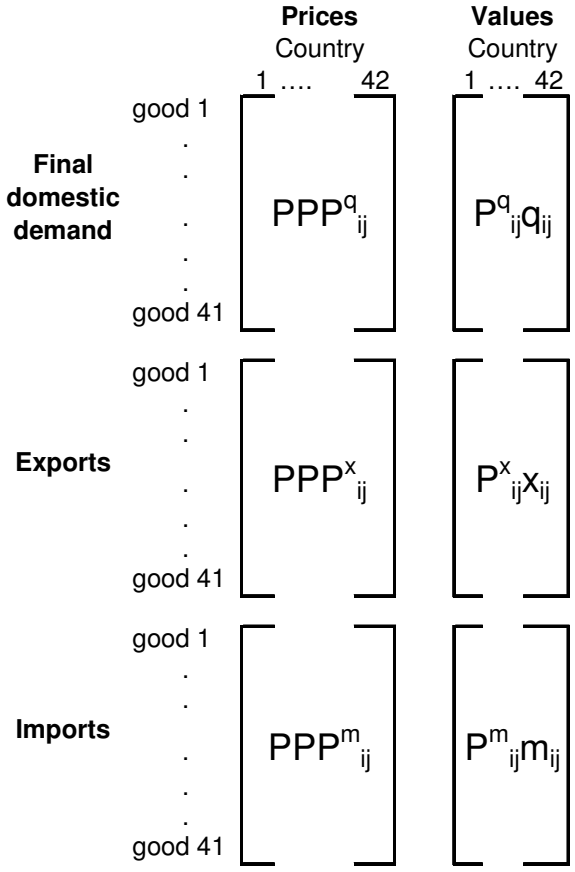


Figure 2 Terms of trade and real GDP per capita, 41 countries, 2005

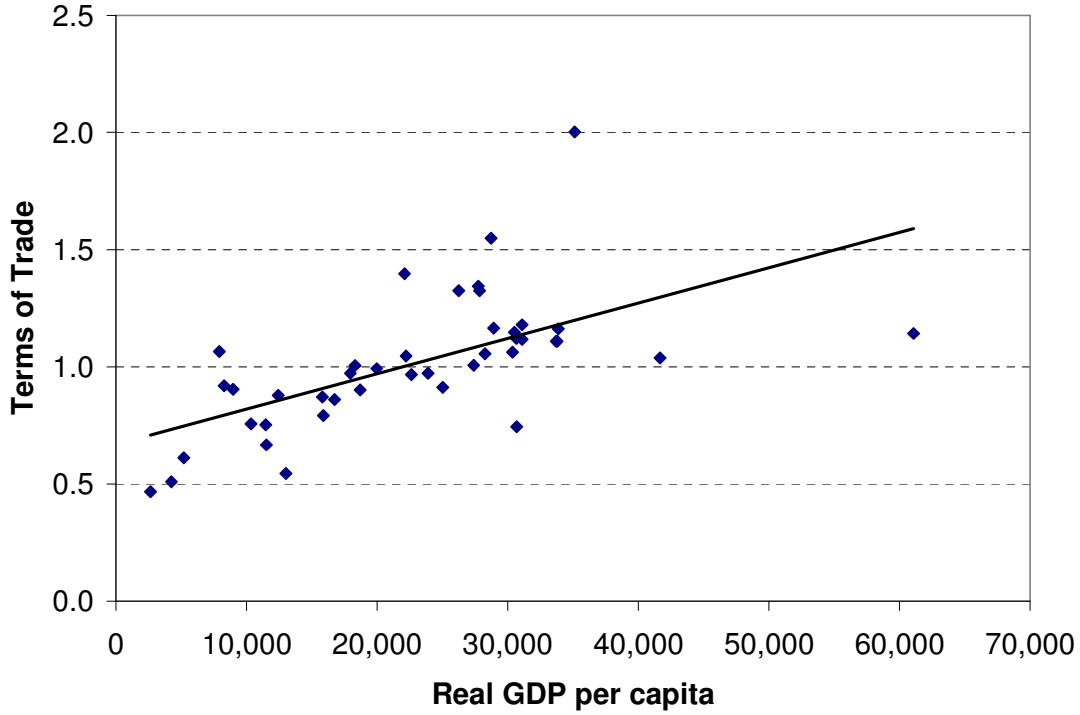
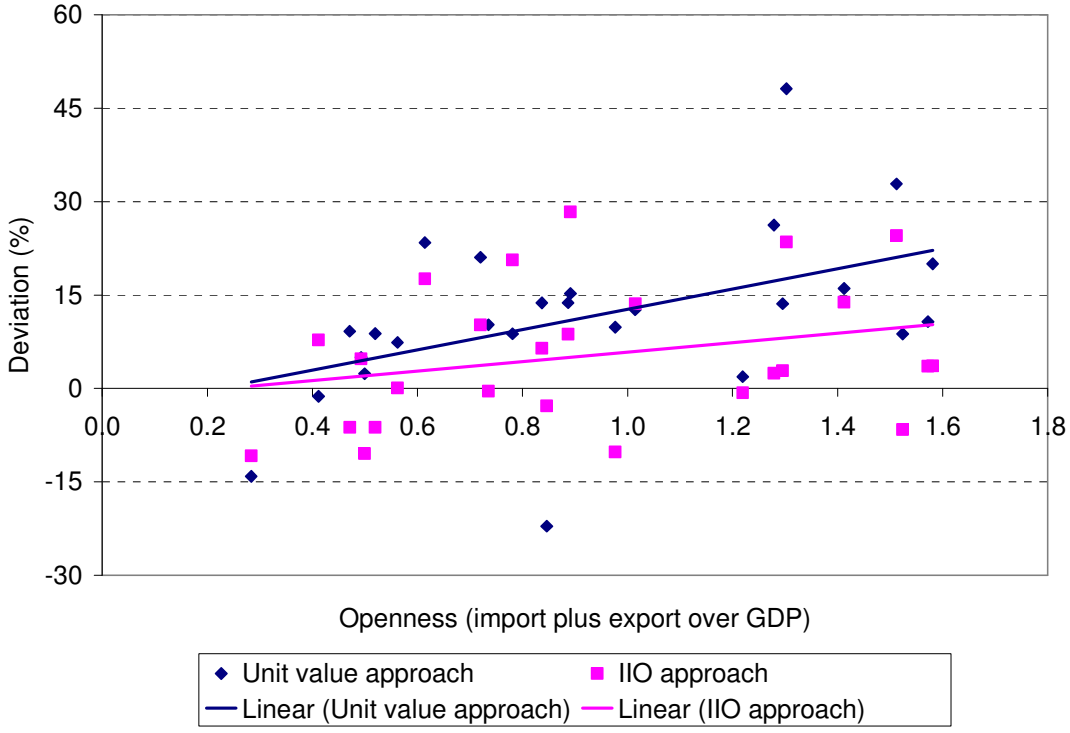


Figure 3 Deviation in real GDP from industry-of-origin approach and openness



Appendix Table 1 GDP, export and import by country (at national prices), 2005

	Values at national prices				As % of GDP	
	GDP	Final domestic demand	Exports	Imports	Export	Import
Argentina	531,939	543,444	57,385	-68,890	10.8	-13.0
Australia	932,296	959,078	178,670	-205,453	19.2	-22.0
Austria	245,330	241,624	121,670	-117,964	49.6	-48.1
Belgium	301,966	285,835	246,763	-230,632	81.7	-76.4
Brazil	2,147,944	2,197,733	226,955	-276,744	10.6	-12.9
Bulgaria	42,797	48,862	14,437	-20,502	33.7	-47.9
Canada	1,375,080	1,276,520	658,930	-560,371	47.9	-40.8
China	18,386,790	17,495,043	6,714,487	-5,822,740	36.5	-31.7
Czech Republic	2,987,722	2,892,888	2,157,432	-2,062,599	72.2	-69.0
Denmark	1,551,967	1,470,355	732,399	-650,788	47.2	-41.9
Estonia	175,392	193,949	124,343	-142,900	70.9	-81.5
Finland	157,162	150,954	64,478	-58,269	41.0	-37.1
France	1,717,921	1,741,599	417,313	-440,991	24.3	-25.7
Germany	2,244,600	2,093,075	900,602	-749,077	40.1	-33.4
Greece	198,609	225,406	33,407	-60,204	16.8	-30.3
Hungary	22,055,093	22,788,950	13,996,107	-14,729,964	63.5	-66.8
India	34,339,015	35,286,023	4,130,886	-5,077,894	12.0	-14.8
Indonesia	2,784,960,400	2,652,363,471	945,882,006	-813,285,077	34.0	-29.2
Ireland	161,498	142,030	131,821	-112,353	81.6	-69.6
Italy	1,423,048	1,438,648	342,718	-358,318	24.1	-25.2
Japan	501,402,600	496,616,759	73,514,699	-68,728,858	14.7	-13.7
Latvia	9,059	10,406	3,922	-5,269	43.3	-58.2
Lithuania	71,380	77,565	43,143	-49,327	60.4	-69.1
Luxembourg	30,032	21,263	37,506	-28,737	124.9	-95.7
Mexico	8,374,349	8,542,161	2,107,395	-2,275,208	25.2	-27.2
Netherlands	508,964	464,733	347,475	-303,244	68.3	-59.6
New Zealand	154,571	149,781	52,466	-47,676	33.9	-30.8
Norway	1,942,887	1,556,704	894,546	-508,362	46.0	-26.2
Poland	983,302	992,889	349,238	-358,825	35.5	-36.5
Portugal	149,293	166,268	37,364	-54,339	25.0	-36.4
Romania	288,048	318,058	97,399	-127,409	33.8	-44.2
Russian Federat	21,620,111	17,382,376	9,103,651	-4,865,915	42.1	-22.5
Slovak Republic	1,471,130	1,538,648	1,122,544	-1,190,062	76.3	-80.9
Slovenia	6,768,272	7,038,855	3,991,037	-4,261,620	59.0	-63.0
South Africa	1,538,969	1,528,395	442,981	-432,406	28.8	-28.1
South Korea	810,515,800	814,574,272	340,818,136	-344,876,607	42.0	-42.6
Spain	908,450	985,103	197,648	-274,301	21.8	-30.2
Sweden	2,670,547	2,438,671	1,233,185	-1,001,309	46.2	-37.5
Taiwan	11,421,258	10,696,206	5,724,855	-4,999,803	50.1	-43.8
Turkey	487,202	515,374	90,864	-119,035	18.7	-24.4
United Kingdom	1,233,976	1,278,173	324,653	-368,850	26.3	-29.9
United States	12,376,100	12,987,660	1,088,890	-1,700,450	8.8	-13.7

Source: data underlying ICP 2005 (World Bank, 2008)

Appendix Table 2 Matching between ICP basic heading and product group

ICP basic heading	Product group	ICP basic heading	Product group
1101111 Rice	3	110561 Non-durable household goods	8
1101112 Other cereals and flour	3	1105621 Domestic services	41
1101113 Bread	3	1105622 Household services	41
1101114 Other bakery products	3	110611 Pharmaceutical products	8
1101115 Pasta products	3	110612 Other medical products	17
1101121 Beef and veal	3	110613 Therapeutical appliances and eq	17
1101122 Pork	3	110621 Medical Services	39
1101123 Lamb, mutton and goat	3	110622 Dental services	39
1101124 Poultry	3	110623 Paramedical services	39
1101125 Other meats and preparations	3	110630 Hospital services	39
1101131 Fresh or frozen fish and seafood	3	110711 Motor cars	18
1101132 Preserved fish and seafood	3	110712 Motor cycles	18
1101141 Fresh milk	3	110713 Bicycles	19
1101142 Preserved milk and milk products	3	110722 Fuels and lubricants for persona	7
1101143 Cheese	3	110723 Maintenance and repair of perso	24
1101144 Eggs and egg-based products	3	110724 Other services in respect of pers	24
1101151 Butter and margarine	3	110731 Passenger transport by railway	26
1101153 Other edible oils and fats	3	110732 Passenger transport by road	26
1101161 Fresh or chilled fruit	3	110733 Passenger transport by air	28
1101162 Frozen, preserved or processed fruits	3	110734 Passenger transport by sea and	27
1101171 Fresh or chilled vegetables	3	110735 Combined passenger transport	29
1101172 Fresh or chilled potatoes	3	110736 Other purchased transport servic	29
1101173 Frozen or preserved vegetables	3	110810 Postal services	30
1101181 Sugar	3	110820 Telephone and telefax equipmer	16
1101182 Jams, marmalades and honey	3	110830 Telephone and telefax services	30
1101183 Confectionery, chocolate and ice cream	3	110911 Audio-visual, photographic and i	14
110119 Food products n.e.c.	3	110914 Recording media	6
110121 Coffee, tea and cocoa	3	110915 Repair of audio-visual, photograp	24
110122 Mineral waters, soft drinks, fruit and vegetable ju	3	110921 Major durables for outdoor and i	20
1102111 Spirits	3	110931 Other recreational items and equ	20
1102121 Wine	3	110933 Gardens and pets	20
1102131 Beer	3	110935 Veterinary and other services for	39
110220 Tobacco	3	110941 Recreational and sporting servic	40
1103111 Clothing materials and accessories	4	110942 Cultural services	40
1103121 Garments	4	110943 Games of chance	40
1103141 Cleaning and repair of clothing	4	110950 Newspapers, books and statione	6
1103211 Footwear	4	110960 Package holidays	29
1103221 Repair and hire of footwear	24	111000 Education	38
110410 Actual and imputed rentals for housing	32	111110 Catering services	25
110430 Maintenance and repair of the dwelling	23	111120 Accommodation services	25
110440 Water supply and miscellaneous services relatir	22	111211 Hairdressing salons and persona	40
110442 Miscellaneous services relating to the dwelling	32	111212 Appliances, articles and products	8
110451 Electricity	21	111220 Prostitution	40
110452 Gas	21	111231 Jewellery, clocks and watches	20
110453 Other fuels	7	111232 Other personal effects	20
110511 Furniture and furnishings	20	111240 Social protection	37
110512 Carpets and other floor coverings	20	111250 Insurance	31
110513 Repair of furniture, furnishings and floor coverin	24	111261 FISIM	31
110520 Household textiles	4	111262 Other financial services n.e.c	31
110531 Major household appliances whether electric or	13	111270 Other services n.e.c.	40
110532 Small electric household appliances	15	150110 Metal products and equipment	13
110533 Repair of household appliances	24	150120 Transport equipment	19
110540 Glassware, tableware and household utensils	10	150210 Residential buildings	23
110551 Major tools and equipment	13	150220 Non-residential buildings	23
110552 Small tools and miscellaneous accessories	12	150230 Civil engineering works	23

Note: Product group indicates number of group to which basic heading is allocated.

Appendix Table 3 Product groups and number of basic headings

	Product group	Number of basic headings
1	Agriculture, hunting, forestry and fishing	a
2	Mining and quarrying	b
3	Food products, beverages and tobacco	33
4	Textiles, textile products, leather and footwear	5
5	Wood and products of wood and cork	b
6	Pulp, paper, paper products, printing and publishing	2
7	Coke, refined petroleum products and nuclear fuel	2
8	Chemicals, chemical products and man-made fibres	3
9	Rubber & plastics products	b
10	Other non-metallic mineral products	1
11	Basic metals	b
12	Fabricated metal products, except machinery and equip	1
13	Machinery and equipment n.e.c.	3
14	Office machinery and computers	1
15	Electrical machinery and apparatus n.e.c.	1
16	Radio, television and communication equipment and ap	1
17	Medical, precision and optical instruments, watches and	2
18	Motor vehicles, trailers and semi-trailers	2
19	Other transport equipment	2
20	Furniture; other manufactured goods n.e.c.	7
21	Electrical energy, gas, steam and hot water	2
22	Collected and purified water, distribution services of wat	1
23	Construction	4
24	Wholesale & retail trade; repairs	6
25	Hotel and restaurant services	2
26	Land transport; transport via pipeline services	2
27	Water transport services	1
28	Air transport services	1
29	Supporting and auxiliary transport services; travel agenc	3
30	Post and telecommunication services	2
31	Finance & insurance	3
32	Real estate activities	2
33	Renting services of machinery and equipment without op	c
34	Computer and related services	c
35	Research and development services	c
36	Other business services	c
37	Public administration and defence services; compulsory	1
38	Education services	1
39	Health and social work services	5
40	Other community, social & personal services	6
41	Private households with employed persons & extra-territ	2

Notes: this table indicates the 41 product groups and the number of ICP basic headings that have been used to derive the output PPP for each group

(a) based on unit values from FAO, following Prasada Rao (1993)

(b) based on nearest group: 2 uses 7, 5 uses 20, 9 uses 8 and 11 uses 12.

(c) based on overall services PPP