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Publication date:
2012

University of Groningen

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Groningen Growth and Development Centre

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Research Memorandum GD-124

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RESEARCH MEMORANDUM

The relative price of services

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Groningen Growth and Development Centre

February 2012

Abstract

Relative GDP prices increase with rising income per capita, which is generally attributed to services being cheaper in poorer countries. In this paper we re-examine this based on a new set of PPPs for industry output. These are estimated in an augmented Geary-Khamis approach using prices for final goods, exports and imports. The resulting multilateral PPPs cover 35 industries in 42 countries for the year 2005. We find that the rising relative GDP prices are entirely due to the rapid rise in the output prices of non-market services. This seems related to that sector's high labour intensity.

Acknowledgements

The research on which this paper is based is part of the World Input-output Database (WIOD) project. This project is funded by the European Commission, Research Directorate General as part of the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities (grant Agreement no: 225 281). In addition, financial support from the NSF Project "Integrating Expenditure and Production Estimates in International Comparisons" is gratefully acknowledged. We thank the World Bank for providing the underlying basic heading data from the 2005 ICP round and Robert Feenstra for providing quality-adjusted export and import unit values. We also thank participants at various seminars, in particular Robert Hill for helpful comments on an earlier draft.

1. Introduction

A stylized fact that has proven very durable in the economic literature is that price levels of GDP rise with income per head, with empirical support going back as far as (at least) Balassa (1964).[1] This has been explained by arguing that rising income is related to technical change that leads to higher productivity in the tradable goods sector. This leads to higher overall wages, driving up prices in the non-tradable services sector that has much lower productivity growth. This mechanism is known as the Harrod-Balassa-Samuelson (HBS) effect.[2] Alternatively, Bhagwati (1984) has argued that services are labour-intensive and poor countries are labour-abundant, leading to relatively low prices for services. As capital accumulates, countries grow richer and less labour-abundant, and therefore the prices of services increase even when technical change is sector-neutral. These arguments are based on differences in output prices and factor usage across sectors, but the cross-country evidence for the HBS effect is solely based on expenditure prices for final goods.

There are other reasons to reconsider the conventional arguments underlying the HBS effect. Not all services industries can be considered as ‘stagnant’, as productivity growth in market services industries has been considerable in the United States and other countries since the mid-1990s.[3] Furthermore, not all services industries are labour-intensive as services are amongst the most intensive users of information and communications technologies (ICT).[4] This calls for a new analysis of the HBS effect based on data on relative prices of industry output for a wide range of countries.

The main contribution of this paper is to estimate such relative prices, for a set of 42 countries covering all income levels and 35 industries covering the total economy in 2005. We define a relative price as a purchasing power parity (PPP) divided by the exchange rate. In the literature, there are two main approaches to estimating relative industry output prices. The first is the so-called industry-of-origin approach that was pioneered by Paige and Bombach (1959) in a comparison of the United Kingdom and the United States.[5] This approach aims to directly observe industry output prices, mostly by calculating unit values for specific products. In the past two decades, this method was

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[1] For more recent discussion, see Bergin, Glick and Taylor (2006) and Feenstra, Inklaar and Timmer (2012).

[2] Harrod (1939) was the first to hypothesize this effect and Samuelson (1964) also made a theoretical argument. See also Kravis, Heston and Summers (1982).

[3] See e.g. Inklaar, Timmer and van Ark (2008) or Timmer and de Vries (2009).

[4] See e.g. Stiroh (2002) and Jorgenson and Timmer (2011).

[5] The earlier work was conveniently summarised by Kravis (1976).

further developed and used in the ICOP project (International Comparisons of Output and Productivity) at the University of Groningen, see Maddison and van Ark (2002) for an overview. However, the lack of readily available producer price surveys has limited price estimates based on the industry-of-origin approach to a modest number of industries and countries.

An alternative to the industry-of-origin approach is to use data from internationally coordinated surveys on expenditure prices such as in the International Comparisons Program (ICP) under the auspices of the United Nations and the World Bank.[6] These price comparisons are based on purchasers' prices of final goods and services with a detailed product specification. To apply these to output and productivity comparisons by industry, the relative prices need to be mapped from expenditure categories to industries, an approach that was pioneered by Jorgenson, Kuroda and Nishimizu (1987) and has been more recently applied by Nicoletti and Scarpetta (2003), Griffith et al. (2004), Biesebroeck (2009) and Sørensen and Schjerning (2008). In general, relative prices based on expenditure price surveys suffer less from quality problems than unit values as product comparisons are based on detailed specifications. However, the approach also has a number of drawbacks for comparisons of output and productivity at the industry level, as it requires detailed adjustments for margins, taxes and international trade. Furthermore, by definition these relative prices only cover prices for final expenditure and do not reflect relative prices of intermediate goods.

In this paper we outline a methodology that deals with the problems in using relative expenditure prices for the derivation of relative production prices by improving on the existing studies in two important ways. First, we expand the range of price information by also considering export and import prices. The export and import prices are quality-adjusted unit values from Feenstra and Romalis (2012) and these allow us to greatly expand the scope of products for which we have price data. Moreover, we integrate the expenditure and trade prices within a consistent framework of input-output data. Our second contribution is to develop estimates of industry prices that are consistent in methodology and outcomes with the cross-country GDP comparisons of the Penn World Tables (PWT). So we do not just estimate gross output, but also value added prices by accounting for price differences of imported and domestically sources intermediate inputs. While Jorgenson and Nishimizu (1978) were also able to achieve this in a bilateral comparison, we greatly improve the scope by comparing 35 industries in 42 countries. In

[6] See e.g. Kravis, Heston and Summers (1982), Summers and Heston (1991) and World Bank (2008). Since the early 1980s, the OECD has regularly published estimates of expenditure PPPs, derived from its joint programme with Eurostat.

our own previous work (Inklaar and Timmer, 2009) we covered 30 countries, but this is the first study to compare a significant number of emerging economies, including China and India. Moreover, the output prices are consistent with GDP price levels. In due time, these estimates will be part of the next generation of the PWT to complement the estimates from the expenditure side (Feenstra, Inklaar and Timmer, 2012).

Our third contribution is using the industry-level output prices to relate relative price and income levels. Consistent with many earlier studies, we find that aggregate price levels increase with income. We also find that the price of manufacturing industries relative to services decreases; a finding consistent with HBS. Within services though, there is a striking difference between market and non-market services. Only the relative price of non-market services (which we define to include public administration, health, education and real estate) increases, while prices of market services (such as distributive trade, business and transport services, etc.) decrease relative to the aggregate price level. Consistent with the theory of Bhagwati (1984), we find that with rising income, industries that are more labour-intensive show a greater increase in prices. Since non-market services are very labour-intensive, this finding can explain why prices of non-market services industries rise so rapidly with increasing income.

The remainder of the paper is as follows. In Section 2 we outline the methodology for estimating industry prices, which is a variant of an augmented Geary Khamis-system introduced in Feenstra et al. (2009). In Section 3 we describe our basic data sources and implementation. In Section 4 we analyse the relation between price and income levels, and Section 5 concludes.

2. Methodology

Suppose there are i=1,..,N final goods that may also be used as intermediate inputs. All goods are domestically produced and/or internationally traded. 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 domestic final 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 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

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

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. We allow the prices of exports and imports to differ from domestic output and consumption prices. Such price differences occur in practice, which is why we want to allow for them here without considering why the price differences arise.

Multiplying each element in (1) by its price we obtain the second equality between supply and use in nominal terms:[7]

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

Summing over all goods, and rearranging, we obtain:

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

The left-hand side of equation (3) equals nominal GDP from the expenditure side: domestic final demand plus exports minus imports. The right-hand side equals GDP from the production side defined as total output of all goods minus those goods used for intermediate inputs.

For this paper we are interested in deriving real measures of value added by industry. Assume that each industry produces one product only, but may use many products as intermediates. An industry will sell its product to domestic final consumers (*qd*), to other domestic producers for intermediate use (*zd*), or to foreign buyers, as exports. In turn, this industry uses intermediate inputs, partly from other domestic producers and partly from foreign producers. Let *zd* denotes intermediate demand of domestically produced goods then nominal value added of industry k can be expressed as:

(4) $$\begin{aligned} p_{kj}^{v}v_{kj} &\equiv p_{kj}^{y}y_{kj} - \sum_{i=1}^{N} p_{ij}^{z}z_{ij}^{k} \\ &= p_{kj}^{qd}qd_{kj} + p_{kj}^{zd}zd_{kj} + p_{kj}^{x}x_{kj} - \sum_{i=1}^{N} p_{ij}^{z}z_{ij}^{k} \\ &= p_{kj}^{qd}qd_{kj} + p_{kj}^{zd}zd_{kj} + p_{kj}^{x}x_{kj} - \sum_{i=1}^{N}\left[p_{ij}^{zd}zd_{ij}^{k} + p_{ij}^{m}m_{ij}^{k}\right] \end{aligned}$$

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

In equation (4), subscript *k* indicates the output of industry *k* and a superscript *k* denotes that a term represents demand from industry *k*.

Summing over all industries then gives GDP as given in equation (3)

(5)
$$\sum_{k=1}^{N} p_{kj}^{v} v_{kj} = \sum_{k=1}^{N} \left(p_{kj}^{qd} qd_{kj} + p_{kj}^{zd} zd_{kj} + p_{kj}^{x} x_{kj} - \sum_{i=1}^{N} \left[p_{ij}^{zd} zd_{ij}^{k} + p_{ij}^{m} m_{ij}^{k} \right] \right)$$
$$= \sum_{i=1}^{N} \left(p_{ij}^{q} q_{ij} + p_{ij}^{x} x_{ij} - p_{ij}^{m} m_{ij} \right)$$

imports are partly for intermediate use and partly for final use such that $p_{j}^{qd} qd_{j} - \sum_{k} p_{j}^{m} m_{j}^{k} = p_{j}^{q} q_{j} - p_{j}^{m} m_{j}$ and total intermediate demand for domestic production cancels out the total domestic production for intermediate demand: $\sum_{k=1}^{N} p_{kj}^{zd} zd_{kj} = \sum_{k=1}^{N} \sum_{i=1}^{N} p_{ij}^{zd} zd_{ij}^{k}$. This relationship was used by Feenstra et al. (2009) to estimate real GDP from the production side without consideration of prices of intermediate inputs. However, the key contribution of this paper is to show how production-side GDP can be estimated while at the same time providing estimates of industry value added. Therefore we also need to estimate prices of intermediates.

For this estimation, we set up an augmented Geary-Khamis (Geary, 1958; Khamis, 1970; henceforth GK) system.[8] In the GK-system average "reference prices" for goods and purchasing power parities (PPPs) are obtained by solving a set of simultaneous equations. In PWT this system is normally only applied to goods for final domestic demand. Instead, we expand the augmented GK-system proposed by Feenstra et al. (2009) and also include reference prices for imports, exports and intermediate goods. We estimate the following GK-system, with reference prices given by:

(6)
$$\pi_{i}^{qd} = \sum_{j=1}^{C} \left(p_{ij}^{qd} / PPP_{j}^{o} \right) qd_{ij} \Big/ \sum_{j=1}^{C} qd_{ij} , \forall i$$

(7)
$$\pi_{i}^{zd} = \sum_{j=1}^{C} \left(p_{ij}^{zd} / PPP_{j}^{o} \right) zd_{ij} \Big/ \sum_{j=1}^{C} zd_{ij} , \forall i$$

(8)
$$\pi_{i}^{x} = \sum_{j=1}^{C} \left(p_{ij}^{x} / PPP_{j}^{o} \right) x_{ij} \Big/ \sum_{j=1}^{C} x_{ij} , \forall i$$

[8] See Balk (2008) for a more in-depth discussion of the GK system, as compared with other index numbers.

(9) $$\tilde{\pi}_i^{zd} = \sum_{j=1}^{C}\sum_{k}\left(p_{ij}^{zd} / PPP_j^o\right)zd_{ij}^k \Bigg/ \sum_{j=1}^{C}\sum_{k} zd_{ij}^k ,\forall i$$

(10) $$\pi_i^m = \sum_{j=1}^{C}\left(p_{ij}^m / PPP_j^o\right)m_{ij} \Bigg/ \sum_{j=1}^{C} m_{ij} ,\forall i$$

And the purchasing power parity for GDP from the production side (PPP^o) as nominal GDP divided by real GDP at reference prices:

(11) $$PPP_j^o = \frac{\sum_{k=1}^{N}\left(p_{kj}^{qd} qd_{kj} + p_{kj}^{zd} zd_{kj} + p_{kj}^{x} x_{kj} - \sum_{i=1}^{N}\left[p_{ij}^{zd} zd_{ij}^k + p_{ij}^m m_{ij}^k\right]\right)}{\sum_{k=1}^{N}\left(\pi_j^{qd} qd_{kj} + \pi_j^{zd} zd_{kj} + \pi_j^{x} x_{kj} - \sum_{i=1}^{N}\left[\pi_i^{zd} zd_{ij}^k + \pi_i^m m_{ij}^k\right]\right)},\forall j$$

The number of reference prices in this system is equal to 5N. The system given by equation (6) through (11) can be estimated by choosing starting values for either reference prices or PPPs, say setting them equal to 1, and then iterating between equations (6) through (10) on the one hand and equation (11) on the other, until reference prices and PPPs converge. This convergence is not guaranteed in theory but occurred in practice after a limited set of iterations. Also, a normalization is required and commonly, one of the PPPs is set equal to 1, e.g. the United States.

Note that this system has two sets of reference prices for intermediate inputs: π_i^{zd} and $\tilde{\pi}_i^{zd}$, where the first indicates the output price of a good *i* sold by an industry to another industry in the same country, whereas the latter indicates the price of good *i* when used by a domestic industry as an intermediate input. There is no a priori reason why these prices would differ (when both are at the basic price concept), a point we return to below when discussing our specific implementation.

If the main goal is to come up with estimates of PPP_j^o, then a simpler procedure would suffice since all domestic intermediate deliveries, *zd*, cancel out for the economy as a whole. This was the insight used by Feenstra et al. (2009) to estimate real GDP from the production side without estimation of intermediate input prices. However, the main benefit of the procedure from equations (6)-(11) is that it allows for the calculation of real value added by industry. We define the value added PPP for industry *k* in country *j* (PPP_{kj}^v) as:

(12) $$PPP_{kj}^{v} = \frac{p_{kj}^{q} q_{kj} + p_{kj}^{zd} zd_{kj} + p_{kj}^{x} x_{kj} - \sum_{i=1}^{N} \left[p_{ij}^{zd} zd_{ij}^{k} + p_{ij}^{m} m_{ij}^{k} \right]}{\pi_{j}^{q} q_{kj} + \pi_{j}^{zd} zd_{kj} + \pi_{j}^{x} x_{kj} - \sum_{i=1}^{N} \left[\pi_{i}^{zd} zd_{ij}^{k} + \pi_{i}^{m} m_{ij}^{k} \right]}, \forall k, j$$

Such that real value added of this industry is given by nominal value added divided by the PPP

(13) $$GDP_{kj}^{v} = p_{kj}^{v} v_{kj} / PPP_{kj}^{v}$$

Summing across all industries *k* then gives real GDP from the production side.

3. Data sources and empirical implementation

To estimate the reference prices and PPPs, we combine a number of international sources to create a dataset of prices and nominal values of final 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 GDP. In this section we discuss the various data sources and the practical implementation of the GK-system defined above.

Data sources

Our analysis requires two sets of data, one on nominal values and one on relative prices. Information by industry is required on the different purchasers of industry output and suppliers of intermediate inputs. Our main data on nominal values is drawn from (a draft version of) the World Input-Output Table (WIOT), which is available for 2005. This table is constructed out of national supply- and use tables in combination with bilateral trade statistics as described in Timmer et al. (2012) and can be found at www.wiod.org. This data allows us to distinguish domestic and foreign buyers of industry output and distinguish domestic and foreign suppliers of intermediate inputs. The table is in basic prices and margin values are included in the trade and transport industries. The 39 countries covered in the WIOT together cover more than 80 percent of world GDP in 2005. To broaden our coverage, we also include Argentina, Chile and South Africa using national input-output tables from these countries. Appendix Table 1 gives a full list of countries and Appendix Table 2 lists the 35 industries.

Our data set on prices is eclectic and drawn from a number of sources to use the broadest set of information. The backbone of our price data set is formed by the basic heading parities and expenditure data from the 2005 ICP benchmark described in World Bank

(2008). These parities refer to 126 items of final expenditure and cover household consumption, investment and government consumption. The transformation of these expenditure prices to a basic price concept is described below.

We also include output prices and quantities for up to 168 agricultural products from the FAO.[9] These cover both livestock and crops and are useful to estimate the output prices of the agricultural sector which cannot be derived from expenditure prices as output in this sector consists predominantly of intermediate, rather than final goods. Finally, we rely on quality-adjusted unit values and values of exports and imports for up to 766 products, provided by Feenstra and based on Feenstra and Romalis (2012). These products cover all of merchandise trade and export prices are given as free-on-board (fob) prices, while import prices are at cif (cost-insurance-freight).[10] The quality-adjustment is based on a model for the demand and supply of the quality of a product. The demand side is similar to Hallak and Schott (2011) and infers that quality is high if prices are high and demand is not low. On the supply side, firms will ship their highest-quality products to destinations for which the trade costs are largest, the so-called 'Washington apples' effect. The importance of quality for a specific product is then estimated using a regression relating cif and fob prices for the same product and trade route. Based on this estimation, all import and export unit values are adjusted for quality differences.

These sources provide us with detailed value and price data (up to 1060 individual products for each country), but we aim to estimate value added PPPs for 35 industries only, see Appendix Table A2 for the industry list. We therefore normalize our detailed output, final expenditure, exports and imports values to the control totals from the WIOT for each of the 35 industries. We allocate goods to specific industries for each of the data sets in the following fashion:

1. Expenditure categories are allocated to industries based on their name. For example, 'Fresh or frozen fish and seafood' is allocated to the 'Food, beverages, and tobacco' industry. In addition, we assume that all consumption goods are bought through the retail trade industry, while all investment goods are purchased through the wholesale trade industry, more on this below. Finally, there are a number of industries that only produce intermediate products. In those cases, we apply the prices of downstream industries to their upstream counterparts. So, for example, the prices for mining include the prices for petroleum, non-metallic mineral products and metal products.

[9] Downloaded from http://faostat.fao.org on October 27, 2010.
[10] We are grateful to Robert Feenstra for providing us with these data.

For business services, the overall consumption price is used, following the practice in ICP for financial intermediation services indirectly measured (FISIM).

2. All crops and livestock products are allocated to the agriculture, forestry and fishing industry.
3. The export and import data are classified by SITC rev. 2, 4-digit level. We use a concordance table to ISIC rev. 2 and from there to ISIC rev. 3, the classification used in the WIOT.

The link between expenditure and output prices

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. They are linked in the following way (System of National Accounts, 1993, section VI.J):

> Purchasers' price = basic price of the product received by the producer + taxes on the product[11] - subsidies on the product + trade and transport margins in delivering the product to the purchaser

We use this relationship to derive industry output PPPs based on the expenditure PPPs for 126 detailed basic headings that are underlying the calculation of real GDP by the World Bank (2008).

We derive the basic price of final goods, p_{ij}^{q}, by "peeling off" the domestic margin from the purchasers' prices for final domestic demand. We define

(14) $$p_{ij}^{q} = \frac{\left(1 + r_{i,US} + t_{i,US}\right)}{\left(1 + r_{ij} + t_{ij}\right)} \tilde{p}_{ij}^{q}, \forall i$$

r_i = trade and transport margin rate on supplied product i and t_i = net tax rate on supplied product i. That is, we adjust the expenditure PPP for each country, by the ratio of the margin rates in the country itself and the US, our benchmark country. The margins for each product group and country are derived from the input-output data. In fact, this adjusted expenditure PPP has been used as a proxy for output prices by, for example, Jorgenson, Nishimizu and Kuroda (1987), Lee and Tang (2000) and most recently by Biesebroeck (2009) and Sørenson and Schjerning (2008).[12]

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[11] Taxes include any taxes on products at the sales point such as a sales or a value-added tax.

[12] Ideally further adjustments are needed for international trade and intermediate use but these have not been implemented successfully so far, see Hooper (1996) and Inklaar and Timmer (2012).

The relative prices of exports and imports are 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 omit this for simplicity.

Agricultural output consists almost exclusively on products used for intermediate input by other firms, not for final consumption. Therefore, expenditure PPPs cannot be used as a proxy for agricultural output PPPs. Instead, the agricultural PPPs for this study are developed along the same lines as earlier ICOP work on agriculture (Rao, 1993). We rely exclusively on production PPPs based on producer prices from the FAOSTAT Database of the FAO. This database contains a very extensive set of quantities and farm-gate prices for up to 168 agricultural products.

For the distribution sector, we use expenditure basic headings to reflect the relative sales prices of wholesale and retail trade. As argued by Timmer and Ypma (2006), the relative sales prices should also be adjusted for the difference in the margin-to-sales ratio to better approximate the output concept in the National Accounts. Since we lack such data for our set of countries, we omit this adjustment.

Implementing the GK system

A major issue in the implementation of the GK-system defined in the previous section is the availability of prices for domestically produced intermediate inputs. We will assume that the basic price of a product is independent of its use: $p_{ij}^{q} = p_{ij}^{zd}$. Given our assumptions, the GK-system described in equations (6)-(10) is simplified as follows:

(15) $$\pi_i^{qd} = \sum_{j=1}^{C} \left(p_{ij}^{q} / PPP_j^{o} \right)(qd_{ij} + zd_{ij}) \Big/ \sum_{j=1}^{C} (qd_{ij} + zd_{ij}), \forall i$$

(16) $$\pi_i^{x} = \sum_{j=1}^{C} \left(p_{ij}^{x} / PPP_j^{o} \right) x_{ij} \Big/ \sum_{j=1}^{C} x_{ij}, \forall i$$

(17) $$\tilde{\pi}_i^{zd} = \sum_{j=1}^{C} \sum_{k} \left(p_{ij}^{q} \big/ PPP_j^{o} \right) zd_{ij}^{k} \Big/ \sum_{j=1}^{C} \sum_{k} zd_{ij}^{k}, \forall i$$

(18) $$\pi_i^{m} = \sum_{j=1}^{C} \left(p_{ij}^{m} / PPP_j^{o} \right) m_{ij} \Big/ \sum_{j=1}^{C} m_{ij}, \forall i$$

And the purchasing power parity for GDP from the production side, PPP^{o}, as nominal GDP divided by real GDP at reference prices:

(19) $$PPP_j^o = \frac{\sum_{k=1}^{N}\left(p_{kj}^q\left(qd_{kj} + zd_{kj}\right) + p_{kj}^x x_{kj} - \sum_{i=1}^{N}\left[p_{ij}^q zd_{ij}^k + p_{ij}^m m_{ij}^k \right]\right)}{\sum_{k=1}^{N}\left(\pi_k^{qd}\left(qd_{kj} + zd_{kj}\right) + \pi_k^x x_{kj} - \sum_{i=1}^{N}\left[\tilde{\pi}_i^{zd} zd_{ij}^k + \pi_i^m m_{ij}^k \right]\right)}, \forall j$$

The difference with the original system is that equations (6) and (7) are combined into one, given the same domestic price. Note that in this system there are independent estimates of the references prices for the use of domestically-produced intermediate inputs, $\tilde{\pi}^{zd}$, and outputs for domestic purchasers, π^{qd}, even though these reference prices are based on the same prices p^q. An alternative would be to impose $\tilde{\pi}^{zd} = \pi^{qd}$. We find our current, unconstrained approach preferable given that the output for domestic purchasers also includes output of final goods. Even in this approach the reference prices $\tilde{\pi}^{zd}$ and π^{qd} are already quite similar; the median absolute difference across products is 2.3 percent. We have experimented with imposing $\tilde{\pi}^{zd} = \pi^{qd}$ and we found that this leads to qualitatively the same results for the PPP^{o}s and the figures and tables that we discuss in the next section.[13]

In our implementation with prices for 1046 products across 35 industries in 42 countries, we estimate 42 PPP^{o}s and 2630 reference prices. To solve the GK system, we first set all PPPs equal to the exchange rate to calculate the reference prices from equations (14)-(17). We use these reference prices in equation (18) to update our PPP estimates. A normalization has to be chosen, so we set the US PPP^o equal to one. Results do not depend on this normalization. We then iterate between a new estimate of PPPs and new estimates of references prices based on these PPPs until the system converges. Despite the large number of reference prices, convergence takes less than 20 iterations.

4. Results

Starting with Kravis, Heston and Summers (1982), the stylized fact that services are cheaper in poorer countries has taken firm root. For instance, consider the title of Bhagwati's (1984) article "Why are services cheaper in the poor countries?" This could be driven by the Harrod-Balassa-Samuelson effect, whereby productivity gains in the traded sector drive up the overall wage level and hence the prices of non-traded services that have much lower productivity growth. Bhagwati's (1984) alternative explanation focused on different endowments of rich and poor countries, arguing that with increasing

[13] We imposed this condition by setting $\tilde{\pi}^{zd}$ and π^{qd} equal to the average of the two reference prices for each product in each iteration.

income, capital accumulates and thus wages increase relative to rental prices. As a result, labour-intensive services industries would become more expensive as income increases. For example, Nordhaus (2008) found these patterns for prices of US industries based on long-term series analysis.

We are now in a position to evaluate whether the value added prices of services are indeed cheaper in poorer countries and how this relates to income levels. We start with some simple graphs indicating correlations, before applying regression techniques. To begin with, Figure 1 shows the overall economy price level in a country in relation to its GDP per capita relative to the USA. We label each country using the 3-letter ISO code; see Appendix Table 1 for the full list of countries and codes. We find a clear positive relationship between the GDP price levels and income. We omit Luxembourg from this figure as its high GDP per capita makes it an outlier. However, even including Luxembourg, the positive relationship still holds. In some studies, the price level and GDP per capita are expressed in logs, but that also does not affect the main pattern.

Figure 1, GDP price level and GDP per capita, 2005

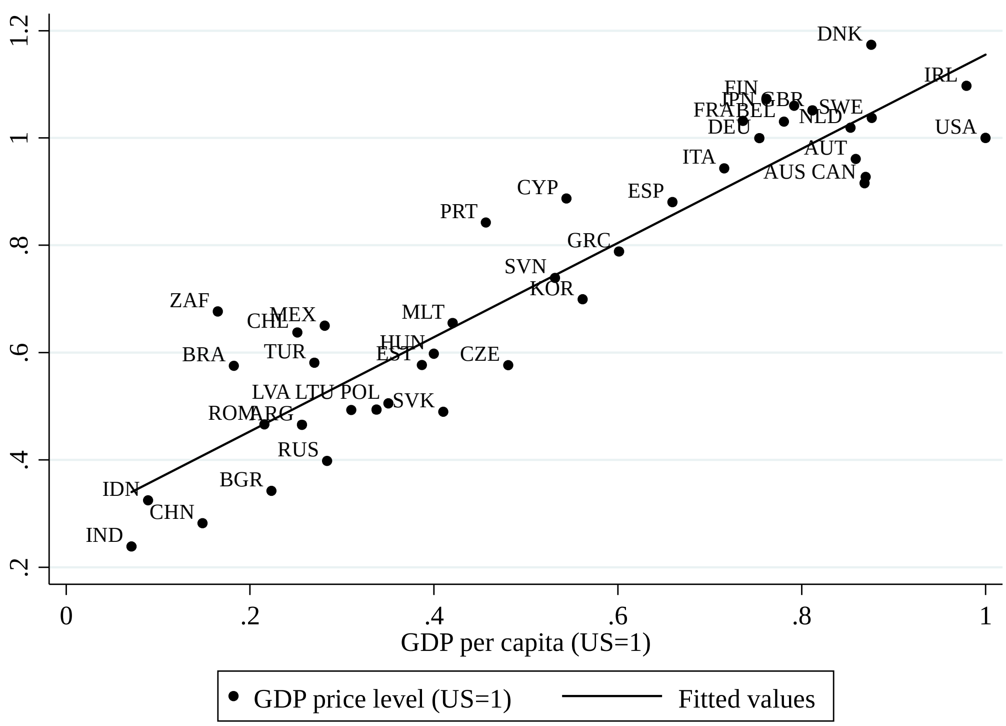


Figure 2, Price of goods-producing and services industries relative to the GDP price level, 2005

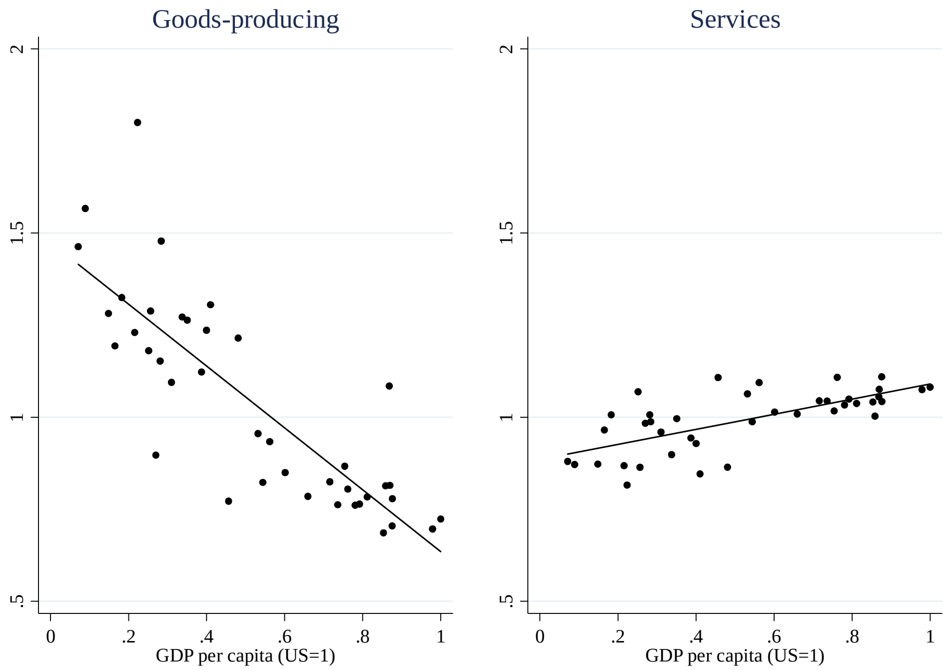
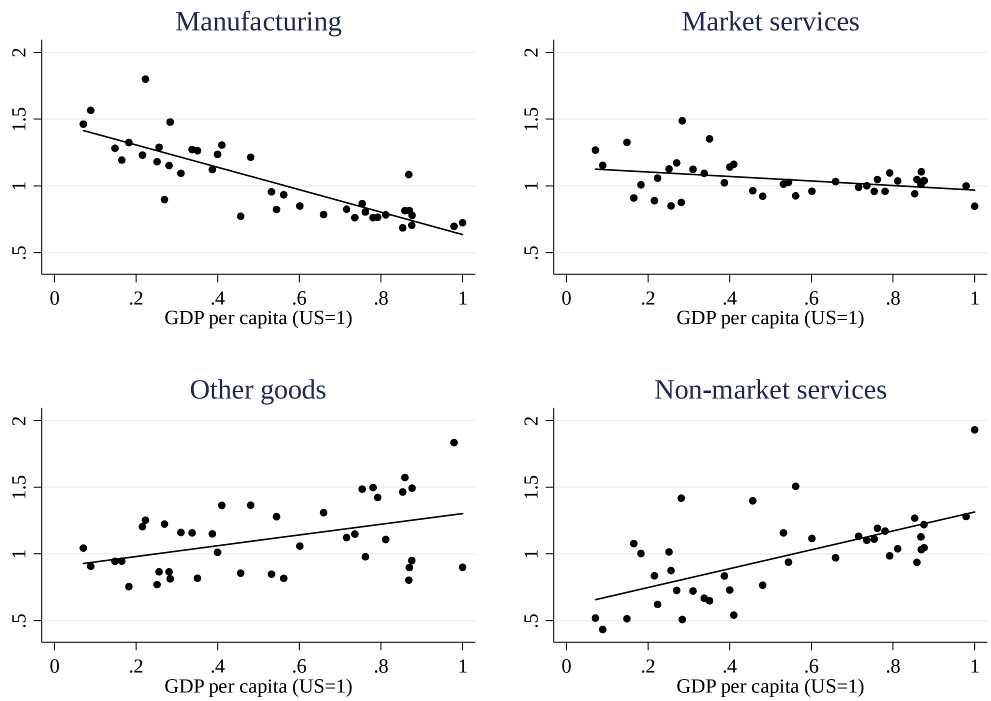


Figure 2 confirms the stylized fact that services overall become relatively more expensive as income rises.[14] The 35 industries are split into goods-producing industries (agriculture, mining, manufacturing, utilities and construction) and services industries and the value added price for each sector is divided by the GDP price level. The relative price of goods-producing industries declines strongly, while that of services increases. Figure 3 makes a further split. The group of goods-producing industries is split into manufacturing and other goods; the group of services is split into market services and non-market services. Non-market services includes government, health, education and real estate and market services includes all other services industries, such as wholesale trade, transport services and finance; see Appendix Table 2 for the full list.

[14] Malta is omitted from Figures 2 and 3 due to an outlying price level for other goods; the general relationship is very similar.

Figure 3, Price of manufacturing, other goods, market services and non-market services relative to the GDP price level, 2005.



This figure reveals important heterogeneity in both goods-producing and services. As income increases, the decline in relative prices of goods-producing industries is due to declining relative prices of manufacturing, while relative prices of other goods increase. More striking is that within services, relative prices decline for market services while they strongly increase for non-market services.

Of course, this finding could be due to heterogeneity at an even lower level of aggregation. We therefore run the following regressions at the level of individual industries:

$$(20)\ \log\left(p_{ij}\right) = \beta_i + \beta_1 \log\left(Y_j\right) + \beta_2 \log\left(Y_j\right) \times Ser_i\left(Y_j\right) + \varepsilon_{ij}$$

$$(21)\ \log\left(p_{ij}\right) = \beta_i + \beta_1 \log\left(Y_j\right) + \beta_3 \log\left(Y_j\right) \times Mfg_i + \beta_4 \log\left(Y_j\right) \times MSer_i + \beta_5 \log\left(Y_j\right) \times NMser_i + \varepsilon_{ij}$$

Here p_{ij} is the relative price level of gross output in industry i in country j, Y_j is GDP per capita relative to the US, and the remaining variables are dummies equal to one for services industries (Ser_i), manufacturing industries (Mfg_i), market services industries ($Mser_i$) and non-market services industries ($NMser_i$). The omitted group in equation (20) consists of goods-producing industries and in equation (21) it is other goods-producing industries: agriculture, mining, utilities and construction. Industry dummies are included in both equations to focus on the interplay between industry prices and income levels for different industry groups. The spread of price levels at the detailed industry level is much greater than at the sectoral or aggregate level, so we take logs of price levels and relative GDP per capita. We also move from value added prices to gross output prices, partly because that is the level at which we expect to see a relationship but also because value added prices tend to be more sensitive to measurement error.[15] Results are qualitatively similar using value added prices, though.

Table 1, Industry prices and income levels for different industry groups

	(1)	(2)	(3)	(4)
GDP per capita (US=1)	0.370***	0.234***	0.398***	
	(0.0543)	(0.0744)	(0.0449)	
Services dummy x GDP per capita		0.288***		
		(0.0553)		
Manufacturing industries dummy x GDP per capita			-0.212**	-0.222**
			(0.0812)	(0.0845)
Market services dummy x GDP per capita			0.0482	0.0411
			(0.0467)	(0.0464)
Non-market services dummy x GDP per capita			0.353***	0.348***
			(0.0614)	(0.0637)
Observations	1,431	1,431	1,431	1,431
R-squared	0.274	0.302	0.319	0.401
Country dummies	no	no	no	yes
Industry dummies	yes	yes	yes	yes

Notes: Robust standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variable in all regressions is the log of industry gross output prices. Results in column (2) correspond to equation (20); results in column (3) correspond to equation (21). In column (4), GDP per capita is omitted because country dummies are included.

Table 1 shows the result of estimating equation (20) and (21). Column (1) shows that on average industry prices increase with GDP per capita and columns (2) through (4) show the industry heterogeneity apparent from Figures 2 and 3. Column (2) shows that prices in services industries increase with rising GDP per capita. Column (3) shows that this is entirely due to rising prices in non-market services: β_5 from equation (21) is 1½ times as large as β_2 from equation (20), while β_4 is insignificant and close to zero. At the same time, output prices of manufacturing industries rise by significantly less as income increases. Column (4) adds country dummies, but the results are almost identical.[16]

[15] See e.g. Hill (1971) for more discussion.

[16] These results hold through a range of robustness analyses: dropping wholesale and retail trade industries because their prices are based on the sales prices of goods; dropping finance and business services because

As a further analysis, we test whether an industry's labour share in value added is related to prices changes as income increases. In the original HBS argument, services are the stagnant sector, so they are not able to increase their labour productivity with rising productivity in the tradable sector. As a result, wage increases translate to services price increases. In Bhagwati's (1984) refinement, this inability to increase labour productivity is linked to a labour-intensive production process. In this line of argument, capital accumulation increases average income and drives up wages relative to rental prices, so labour-intensive industries show increasing relative prices.

We analyse this through the following regression:

$$\log\left(p_{ij}\right)=\beta_0+\beta_1\log\left(Y_j\right)+\beta_2\alpha_{ij}+\beta_3\log\left(Y_j\right)\times\alpha_{ij}+\varepsilon_{ij} \qquad (22)$$

Here, α_{ij} is the share of labour compensation in value added in industry *i* in country *j*. For countries in the WIOD database, there are estimates of the labour compensation of all workers, so including an estimate of the labour income of self-employed workers. For Argentina, Chile and South Africa we make our own estimates, assuming the same average wage for self-employed as for employees, with compensation of employees drawn from the input-output tables. If Bhagwati's (1984) argument holds, the output price of labour-intensive industries should increase more as income increases, so β_3 should be significantly positive.

Table 2, Industry prices, income levels and the labour share in value added

	(1)	(2)	(3)
GDP per capita (US=1)	0.402***	0.291***	
	(0.0389)	(0.0447)	
Labour share	-0.0194	0.156**	0.236**
	(0.0641)	(0.0698)	(0.101)
Labour share x GDP per capita		0.222*	0.315**
		(0.113)	(0.123)
Observations	1384	1384	1384
R-squared	0.397	0.404	0.606
Country dummies	no	no	yes
Industry dummies	no	no	yes

Notes: Robust standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variable in all regressions is the log of industry gross output prices. Results in column (2) correspond to equation (22).

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their prices are mostly based on aggregate prices; or moving other social and personal services (industry O) and private households with employed persons (industry P) to non-market services.

Table 2 shows the result of estimating equation (22).[17] In column (1), we show that the labour share by itself has no explanatory power but that the interaction term is clearly significant and positive in columns (2) and (3). Coefficient β_2 is now also significant, since with the interaction term included, it shows the effect when $\log\left(Y_j\right)=0$ so for the United States. In other words, in the United States, industries with a higher labour share have significantly higher prices. The marginal effect of labour shares on price levels can also be evaluated at other levels of GDP per capita. This analysis shows that countries with a GDP per capita level of at least 80 percent of the US level, of which there are ten, show a significantly positive effect. Regardless of the marginal effects though, the positive and significant interaction term gives clear support for the Bhagwati (1984) line of reasoning that more labour-intensive industries show faster-rising prices with increasing income. And given that market services show considerable variation in labour shares (see Appendix Table 2), one would expect that as income increases, the price changes of these industries would vary, as found in Table 1. Conversely, government, health and education all have high labour shares, which can explain the clear positive relationship from Table 1.

5. Concluding remarks

We re-examined the relative prices of services across countries using a new dataset of relative value added price levels for 35 industries across 42 countries in 2005. This dataset is derived in an augmented Geary-Khamis system drawing upon a number of large price data sets. Besides data on the relative price of final consumption and investment goods, we also incorporate agricultural unit values and quality-adjusted export and import unit values. We have shown how industry output prices can be estimated by combining these price data in a consistent input-output framework. This new PPP database is available at www.ggdc.net. Developing and implementing this new methodology is, in our opinion, the main contribution of this paper. Of course, there is still room for improvement in the basic price data, in particular for some services. But when such data would be available, they can be easily incorporated in the estimation framework.

We confirm that GDP prices are higher in richer countries using this data. Under the HBS line of reasoning, this is due to differences in productivity growth across industries. Manufacturing is seen as the ‘progressive’, tradable sector where relative prices decline as income rises. In contrast, services are the ‘stagnant’, non-tradable sector. In this paper

[17] We drop observations where the labour share is larger than one.

we have shown that this distinction is simplistic. An important new finding is that we show how the rise in the relative price of services that has been found earlier can be fully traced to non-market services (mostly government, health and education). Market services in contrast show price behaviour that is more similar to manufacturing, where relative prices decline with increasing income. This suggests that also in market services, prices rise by less than wages due to productivity increases. Non-market services look more like the prototypical ‘stagnant’ sector, where rising wage fully feed into prices. More in general, we find that the more labour-intensive industries show output prices that increase faster with rising income. Since non-market services are some of the most labour-intensive industries, this can explain our findings.

References

Balassa, B. (1964), “The purchasing-power parity doctrine: a reappraisal” *Journal of Political Economy* 72: 584–596.

Balk, B. M. (2008), *Price and Quantity Index Numbers: Models for Measuring Aggregate Change and Difference*, Cambridge: Cambridge University Press.

Bergin, P. R., R. Glick and A. M. Taylor (2006), “Productivity, tradability and the long-run price puzzle” *Journal of Monetary Economics,* 53: 2041-2066.

Bhagwati, J. N. (1984), “Why are Services Cheaper in the Poor Countries?” *Economic Journal* 94(374): 279-286.

Biesebroeck, J. van (2009), “Disaggregate productivity comparisons: sectoral convergence in OECD countries” *Journal of Productivity Analysis*, 32(2): 63-79.

Feenstra, R. C., A. Heston, M. P. Timmer and H. Deng (2009), “Estimating Real Production and Expenditures Across Nations: A Proposal for Improving the Penn World Tables” *Review of Economics and Statistics* 91(1): 201-212.

Feenstra, R. C., R. Inklaar and M. P. Timmer (2012), “PWT: The Next Generation”, University of California, Davis and University of Groningen, draft.

Feenstra, R C. and J. Romalis (2012), “International Prices and Endogenous Quality,” University of California, Davis and University of Chicago, draft.

Geary, R. C. (1958), “A Note on the Comparison of Exchange Rates and Purchasing Power between Countries” *Journal of the Royal statistical Society, Series A (General),* 121(1): 97-99.

Griffith, R., S. Redding and J. van Reenen (2004), “Mapping the Two Face of R&D: Productivity Growth in a Panel of OECD Countries” *Review of Economics and Statistics* 86(4): 883-95.

Hallak, J. C. and P. K. Schott (2011), “Estimating Cross-Country Differences in Product Quality” *Quarterly Journal of Economics* 126(1): 417-474.

Harrod, R. F. (1933), *International Economics*, Cambridge Economic Handbooks. Nisbet & Cambridge University Press: London.

Hill, T.P. (1971), *The Measurement of Real Product: a Theoretical and Empirical Analysis of Growth Rates, for Different Industries and Countries,* Paris: OECD.

Hooper, P. (1996), “Comparing Manufacturing Output Levels Among The Major Industrial Countries”, In OECD, *Productivity. International Comparison And Measurement Issues*, OECD Proceedings, Paris.

Inklaar, R., M. P. Timmer and B. van Ark (2008), “Market services productivity” *Economic Policy* 23(53): 139-194.

Inklaar, R. and M. P. Timmer (2012), “Using Expenditure PPPs for Sectoral Output and Productivity Comparisons”, Chapter 22 in World Bank (eds. forthcoming), *Measuring the Size of the World Economy The Framework, Methodology, and Results from the International Comparison Program (ICP)*, World Bank: Washington.

Inklaar, R. and M. P. Timmer (2009), “Productivity Convergence Across Industries and Countries: The Importance of Theory-based Measurement”, *Macroeconomic Dynamics* 13(Sup 2): 218–240.

Jorgenson, D. W. and M. Nishmizu (1978), "U.S. and Japanese economic growth, 1952-1974: an international comparison" *Economic Journal* 88: 707-726.

Jorgenson, D. W., M. Kuroda, and M. Nishimizu (1987), "Japan-U.S. industry-level productivity comparisons, 1960-1979" *Journal of the Japanese and International Economies*, 1: 1-30.

Jorgenson, D.W. and M.P. Timmer (2011), "Structural Change in Advanced Nations: A New Set of Stylised Facts" *Scandinavian Journal of Economics*, 113(1), pp. 1-29.

Khamis, S. H. 1970, "Properties and Conditions for the Existence of a New Type of Index Numbers", *Sankhya,* Series B, 32: 81-98.

Kravis, I. B. (1976), "A Survey Of International Comparisons Of Productivity", *The Economic Journal*, 86: 1-44.

Kravis, I. B., A. Heston and R. Summers (1982), *World Product And Income*, Johns Hopkins University Press, Baltimore.

Lee, F. and J. Tang (2000), "Productivity Levels and International Competitiveness between Canadian and U.S. Industries", *American Economic Review*, 90(2): 176-79.

Maddison, A. and B. Van Ark (2002), "The International Comparison Of Real Product And Productivity," In A. Maddison, D.S. Prasada Rao and W.F. Shepherd (Eds.), *The Asian Economies In The Twentieth Century*, Edwar Elgar, Cheltenham, 5-26.

Nicoletti, G. and S. Scarpetta (2003), "Regulation, Productivity and Growth: OECD Evidence" *Economic Policy* 18(36): 9-72.

Nordhaus, W.D. (2008), "Baumol's Diseases: A Macroeconomic Perspective," *The B.E. Journal of Macroeconomics*, Berkeley Electronic Press, vol. 8(1), pages 9-32.

Paige, D. and G. Bombach (1959), *A Comparison Of National Output And Productivity*, OEEC, Paris.

Prasada Rao, D.S. (1993) *Inter-Country Comparisons Of Agricultural Output And Productivity*, Food and Agricultural Organisation, FAO, Rome.

Samuelson, P. A. (1964), "Theoretical notes on trade problems" *Review of Economics and Statistics* 46(2): 145-54.

Sørensen, A. and B. Schjerning (2008), "Productivity Measurement in Manufacturing and the Expenditure Approach", *Review of International Economics*, 16(2): 327-340.

Stiroh, K. J. (2002), "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?" *American Economic Review* 92(5): 1559-1576.

Summers, R. and A. Heston (1991), 'The Penn World Table (Mark 5): An Expanded Set Of International Comparisons, 1950-1988', *Quarterly Journal Of Economics*, 106: 327-68.

Timmer, M.P. and G. Ypma (2006), "Productivity Levels in Distributive Trades: A New ICOP Dataset for OECD Countries" *GGDC Research Memorandum*, GD-83, Groningen Growth and Development Centre, University of Groningen.

Timmer, M.P. et al. (2012), Construction of WIODatabase, mimeo University of Groningen.

Timmer, M. P. and G. J. de Vries (2009), "Structural Change and Growth Accelerations in Asia and Latin America: A New Sectoral Data Set" *Cliometrica*, 3(2): 165-190.

World Bank (2008), *Global Purchasing Power Parities and Real Expenditures, 2005 International Comparison Program*, Washington DC.

Appendix Table A1, List of countries, GDP and sectoral price levels

Country	ISO-code	GDP	Manufacturing	Other goods	Market services	Non-market services
Argentina	ARG	0.47	0.60	0.40	0.40	0.41
Australia	AUS	0.93	0.76	0.83	1.03	0.96
Austria	AUT	0.96	0.78	1.51	1.01	0.90
Belgium	BEL	1.03	0.78	1.54	0.99	1.21
Brazil	BRA	0.58	0.76	0.43	0.58	0.58
Bulgaria	BGR	0.34	0.62	0.43	0.36	0.21
Canada	CAN	0.92	0.99	0.74	0.93	1.03
Chile	CHL	0.64	0.75	0.49	0.72	0.65
China	CHN	0.28	0.36	0.27	0.37	0.15
Cyprus	CYP	0.89	0.73	1.13	0.91	0.83
Czech Republic	CZE	0.58	0.70	0.79	0.53	0.44
Denmark	DNK	1.17	0.83	1.11	1.22	1.43
Estonia	EST	0.58	0.65	0.66	0.59	0.48
Finland	FIN	1.07	0.86	1.05	1.12	1.28
France	FRA	1.03	0.79	1.18	1.03	1.14
Germany	DEU	1.00	0.87	1.49	0.96	1.11
Greece	GRC	0.79	0.67	0.83	0.76	0.88
Hungary	HUN	0.60	0.74	0.60	0.68	0.44
India	IND	0.24	0.35	0.25	0.30	0.12
Indonesia	IDN	0.32	0.51	0.29	0.37	0.14
Ireland	IRL	1.10	0.76	2.01	1.10	1.40
Italy	ITA	0.94	0.78	1.06	0.93	1.07
Japan	JPN	1.06	0.81	1.51	1.16	1.04
Latvia	LVA	0.49	0.54	0.57	0.55	0.36
Lithuania	LTU	0.49	0.63	0.57	0.54	0.33
Luxembourg	LUX	1.08	0.71	1.44	1.02	1.48
Malta	MLT	0.66	1.51	0.53	0.76	0.52
Mexico	MEX	0.65	0.75	0.56	0.57	0.92
Netherlands	NLD	1.02	0.70	1.49	0.96	1.29
Poland	POL	0.51	0.64	0.41	0.68	0.33
Portugal	PRT	0.84	0.65	0.72	0.81	1.18
Romania	ROM	0.47	0.57	0.56	0.41	0.39
Russia	RUS	0.40	0.59	0.32	0.59	0.20
Slovakia	SVK	0.49	0.64	0.67	0.57	0.26
Slovenia	SVN	0.74	0.71	0.63	0.75	0.86
South Africa	ZAF	0.68	0.81	0.64	0.62	0.73
South Korea	KOR	0.70	0.65	0.57	0.65	1.05
Spain	ESP	0.88	0.69	1.15	0.91	0.85
Sweden	SWE	1.04	0.81	1.55	1.08	1.08
Turkey	TUR	0.58	0.52	0.71	0.68	0.42
United Kingdom	GBR	1.05	0.82	1.17	1.09	1.09
United States	USA	1.00	0.72	0.90	0.85	1.93

Notes: table entries are relative prices, so the PPP divided by the nominal exchange rate. See Table A2 for the industry composition of each sector.

Appendix Table A2, List of industries, sector classification and average labour share (%)

Industry	Industry code	Sector	Average labour share
Agriculture, Hunting, Forestry and Fishing	AtB	Other goods	58
Mining and Quarrying	C	Other goods	38
Food, Beverages and Tobacco	15t16	Manufacturing	52
Textiles and Textile Products	17t18	Manufacturing	70
Leather, Leather and Footwear	19	Manufacturing	70
Wood and Products of Wood and Cork	20	Manufacturing	64
Pulp, Paper, Paper , Printing and Publishing	21t22	Manufacturing	59
Coke, Refined Petroleum and Nuclear Fuel	23	Manufacturing	31
Chemicals and Chemical Products	24	Manufacturing	47
Rubber and Plastics	25	Manufacturing	58
Other Non-Metallic Mineral	26	Manufacturing	56
Basic Metals and Fabricated Metal	27t28	Manufacturing	59
Machinery, Nec	29	Manufacturing	68
Electrical and Optical Equipment	30t33	Manufacturing	61
Transport Equipment	34t35	Manufacturing	64
Manufacturing, Nec; Recycling	36t37	Manufacturing	65
Electricity, Gas and Water Supply	E	Other goods	32
Construction	F	Other goods	68
Motor vehicle trade and repair and fuel sales	50	Market services	60
Wholesale Trade, except motor vehicle	51	Market services	54
Retail Trade, except motor vehciles; repair of household goods	52	Market services	66
Hotels and Restaurants	H	Market services	65
Inland Transport	60	Market services	62
Water Transport	61	Market services	50
Air Transport	62	Market services	65
Other Supporting Transport Activities and Travel Agencies	63	Market services	52
Post and Telecommunications	64	Market services	39
Financial Intermediation	J	Market services	50
Real Estate Activities	70	Non-market services	10
Renting of M&Eq and Other Business Activities	71t74	Market services	62
Public Admin and Defence; Compulsory Social Security	L	Non-market services	81
Education	M	Non-market services	86
Health and Social Work	N	Non-market services	78
Other Community, Social and Personal Services	O	Market services	69
Private Households with Employed Persons	P	Market services	88

Note: industry code refers to ISIC rev. 3 division and industry codes. Average labour share is the share of labour compensation of all workers (including imputed earnings of self-employed) in industry value added, averaged across countries.