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# Industry-of-Origin Prices and PPPs: A New Dataset for International Comparisons

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**Abstract**

This paper provides a conceptual basis for a system of purchasing power parities by industry of origin. On the basis of supply-use tables, the paper identifies how expenditure prices and output prices are related, and it develops criteria on the basis of which either adjusted expenditure PPPs or output PPPs should be used for individual industries. The paper then develops a PPP dataset for 45 industries (based on an underlying set of 221 3-digit industries) capturing the total economy of 25 countries (24 OECD countries and Taiwan). This dataset is the first comprehensive dataset of industry PPPs covering such a large number of industries and countries.

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## 1. Introduction

The theory of Purchasing Power Parity and the use of PPPs for a range of analytical purposes has recently received renewed attention in the literature. Except for the use of PPPs for international comparisons of income, output and productivity, some of the traditional PPP debates on, for example, the law of one price and the theory of the real exchange rate, have been revisited by several scholars (Rogoff, 1996; Taylor and Taylor, 2004; Neary, 2004). Even old workhorses like the Balassa-Samuelson hypothesis, the analysis of price convergence, and historical comparisons of relative income have been readdressed in various studies (Ito et al., 1997; Canzoneri et al., 1999; Goldberg and Verboven, 2004; Ward and Devereux, 2003; Broadberry, 2003).

Most studies, however, are based more or less exclusively on a purchasing power parity concept that is rooted in the expenditure approach. Exceptions are studies that focus on sectoral price and productivity issues, including some historical studies and Balassa-Samuelson type studies, which need PPPs by industry-of-origin mainly to identify dynamics of growth process from perspective of structural change. However, industry-of-origin PPPs have not been available on a large scale, whereas the comprehensive dataset on expenditure PPPs from the International Comparisons Project (ICP) has provided a useful alternative.

Many scholars have paid lip-service to the need that PPPs based on the expenditure approach should be complemented with PPPs by industry-of-origin, if only to check consistency of the estimates. But generally the claim is that industry PPPs are not feasible because:

1) Industry PPPs are only available for a small number of countries which hampers generalizations;
2) there are conceptual, measurement and data difficulties with industry PPPs, such as the lack of readily available price surveys, and problems with double deflation of output and intermediate inputs;
3) most industry PPP studies are based on bilateral/pairwise comparisons instead of multilateral comparisons of prices;
4) there is usually incomplete coverage of industries, with several studies for agriculture and manufacturing, but a lack of industry PPPs for services and no possibility to develop aggregate PPPs for the total economy based on industry aggregation
5) if mentioned at all, there are difficulties in making a precise reconciliation of industry and expenditure PPPs, in particular because of the handling of relative prices for the trade balance.

However, over the past two decades many of the concerns on industry-of-origin PPPs have been tackled. A range of studies on industry PPPs have been done during the 1980s and 1990s, in particular by the International Comparisons of Output and Productivity (ICOP) group at the University, but also by other research institutes such as NIESR and CEPII. More than 60 studies have appeared, togeter adding up to comparisons for more than 100 countries in agriculture, over 30 countries in manufacturing, and more than 10 countries in some service industries.[2]

The recent ICOP studies have dealt with a range of problems on the use of industry-of-origin PPPs as indicated above (see, OECD, 2005):

- Data sources for various industries have been more extensively exploited, including the use of farm price data from the FAO, the switch to a harmonized database on manufacturing production for European countries, and an increased use of expenditure PPPs from the ICP programme;
- Methodological problems have been documented and where possible tackled. These included issue concerning double deflation, adjustments for product mix and quality problems in specific industries, improvements to PPP for specific service industries.
- Multilateralisation procedures (mainly based on Geary-Khamis and augmented EKS PPPs) have been experimented with and increasingly applied on a consistent basis.

However, what has been missing so far is, firstly, a clear conceptual basis for the development of industry-of-origin PPPs. Much of the choices for expenditure and output PPPs at industry level have therefore remained rather ad-hoc. Secondly, except for some pioneering attempts for a few countries (Brazil, Mexico, Korea, Japan), there has so far not been a sufficiently comprehensive industry-PPP dataset, both in terms of country and industry coverage. This paper aims to fill these two gaps.

Section 2 of this paper sets out a framework to reconcile measures of prices based on expenditure and output. This will provide criteria on the basis of which expenditure PPPs (E-PPPs), adjusted for trade and transport margins and taxes, and output PPPs (O-PPPs) can be selected and allocated to individual industries. Section 3 introduces a new dataset of PPPs on an industry-by-industry basis for 25 countries, which have been aggregated from the level of 221 industries to a level of 45 major industries covering the total economy. Section 4 discusses some of the first results on relative price levels based on this new dataset.

## 2. Obtaining Industry-by-Origin PPPs within a Supply-Use Table (SUT) framework

### *2.1 Outline of the SUT framework*

To understand the various price concepts that can be used to obtain PPPs by industry-of-origin comparison of PPPs, it is useful to draw a parallel with the ways by which GDP is measured in framework of the System of National Accounts (SNA), i.e. the expenditure approach, the production approach and the income approach. In the expenditure approach, GDP is measured as the summation of final expenditure on goods and services, adjusted for imports. In the production approach, GDP is measured as the summation of

[2] See Van Ark and Timmer (2001) and Maddison and van Ark (2003).

gross value added over all industries. Finally, in the income approach, GDP is the summation of all compensation for the use of factor inputs (labour and capital). In the past, most national statistical offices prepared estimates of GDP according to one, two, or sometimes even all three methods. However, this was mostly not done in a unified framework so that estimates differed according to which methodology was used. The differences would show up as a statistical discrepancy, or smoothed out in an ad-hoc way (Beaulieu and Bartelsman, 2004).

Since the introduction of the SNA 1993 and the European System of Accounts (ESA) 1995, there has been a decisive shift towards measuring GDP in an integrated framework of Supply and Use Tables (SUT). The SUT provides a unified framework for checking the consistency of statistics on flows of goods and services obtained from quite different statistical sources, such as expenditure surveys, tax records, industrial surveys, foreign trade statistics etc. A particular advantage is that within a consistent SUT, GDP measured by either the expenditure, production or income approach will be equal. The SUT framework has been used by many European countries since the end of the 1990s, and other OECD countries including the U.S. are gradually shifting towards it (Moyer et al. 2004).

The basic equation in the SUT is the balance between total supply and total use of a product. This balance holds for each product in the economy. The use of a product consists of its intermediate consumption, final expenditure (private and government), use for gross capital formation and exports. The supply of products is either trough domestic production or by imports, so:

intermediate consumption + final consumption + gross capital formation + exports =
domestic output + imports

This holds for quantities, but also for values provided that supply and use are valued at the same price concept. Products can be valued at three price concepts: basic price, producer price and purchasers' price. These are linked in the following way:

Producer price = basic price of the product received by the producer +
taxes on the product - subsidies on the product

Purchasers' price = producer price + trade and transport margins in
delivering the product to the purchaser

In the SUT framework, the preferred valuation of domestic output is at basic prices, and the use of products should be recorded at purchasers' prices. Exports are valued at free on board (f.o.b.) prices and the imports at cost, insurance and freight (c.i.f.) prices. The export fob price is essentially a purchasers' price including net taxes and trade and transport margins up to the border of the exporting country. The import cif price is essentially a basic price but excluding net taxes levied after crossing the border and trade and transport margins within the country. Finally, the implicit valuation of gross value added (GVA) depends on the valuation of the two flows, output and intermediate consumption, from which it is derived. The preferred valuation is at basic prices, so

GVA at basic prices =
output at basic prices –I ntermediate consumption at purchasers' prices

In the next section we will formalise these measures and lay out the full structure of the SUT framework. The following notation is used:

Commodities i, i=1,..,m and industries j, j=1,..,n

$S_i$ = the quantity of total supply of product $i$

$U_i$ = the quantity of total use of the product $i$

$M_i$ = the imported quantity of product $i$

$Y_j$ = output quantity of industry j

$C_i$ = quantity of product $i$ for final domestic demand

$E_i$ = quantity of product $i$ exported

$Y_{ij}$ = the quantity of commodity i produced by industry j

$X_{ij}$ = the quantity of commodity i used as intermediate input by industry j

$L_j$ = labour quantity used by industry j

$K_j$ = capital quantity used by industry j

$p_{ij}^{Y}$ = the basic price received by industry j for selling commodity i

$p_{ij}^{X}$ = the purchasers' price paid by industry j for intermediate consumption of commodity i

$p_i^M$ = the basic (c.i.f) price of imported commodity i.

$p_i^C$ = the purchasers' price for final domestic demand of commodity i

$p_i^E$ = the purchase (f.o.b) price of exported commodity i

$p_j^L$ = the price of labour used by industry j

$p_j^K$ = the price of capital used by industry j

$T^Y$ = total taxes net of subsidies on domestically produced products

$T^M$ = total taxes net of subsidies on imports.

$R$ = total trade and transport margins

$r_{ij}^{X}$ = trade and transport margin rate on product $i$ used by industry j.

$t_{ij}^{X}$ = net tax rate on domestically produced product $i$ used by industry j.

$r_{i}^{C}$ = trade and transport margin rate on product $i$ used for final domestic demand.

$t_{i}^{C}$ = net tax rate on product $i$ used for final domestic demand.

$r_{i}^{E}$ = trade and transport margin rate on exported product $i$

$t_{i}^{E}$ = net tax rate on exported product $i$.

$r_{i}^{S}$ = trade and transport margin rate on supplied product $i$

$t_{i}^{S}$ = net tax rate on supplied product $i$.

$T_{j}^{VA}$ = other taxes, net of similar subsidies, on production paid by industry $j$

$GVA_j = VL_j + VK_j + T_j^{VA}$ = value added of industry $j$ at basic prices

A capital *V* in front of a symbol is used to indicate value.

In Table 1 we provide a simplified outline of a Supply and Use Table. Both tables have commodities in the rows, and industries in the columns. The Use table indicates for each product *i* its usage: intermediate, final domestic demand or exports. The last column indicates total use. The entries are at purchasers' prices. In addition, the Use table contains a value added block. The components of value added at basic prices (operating surplus, labour compensation and net taxes on production) are given. For each industry *j*, total intermediate input at purchasers' prices plus value added at basic price adds up to gross output at basic prices. This is given in the last row.

The Supply table indicates for each product its origin: domestic production or import. The fifth column records total supply at basic prices. The other columns provide information on taxes and subsidies on products and trade and transport margins. These are needed to arrive at total supply at purchasers' prices which can be set against total use at purchasers' prices from the Use table. Output of all products produced in industry *j* valued at basic prices sums to gross output at basic prices in this industry. This total is given in last but one row in the supply table. The last row is added to indicate net taxes on domestically produced goods and imports by industry. They add up to the total net tax on products in column 6.

The Supply and Use tables are linked by two basic identities: the row identity which requires balance between use and supply for each product, and the column identity which requires identity for each industry between the sum of gross output over all products produced in an industry on the one hand, and value added plus intermediate consumption on the other. The first identity links the expenditure and production approach at the product level, and the latter links the income and production approach at the industry level.

**Table 1 - Outline of Supply and Use Table**

**USE table at purchase prices**

| | Industries 1 …. j …. n | Total intermediate use | Final domestic demand | Exports fob | Total use at purchase price |
|---|---|---|---|---|---|
| Commodities 1 : i : m | : …. $P_{Xij}X_{ij}$ …. : | : $VX_i$ : | : $P_{Ci}C_i$ : | : $P_{Ei}E_i$ : | : $VX_i+VC_i+VE_i$ : |
| Total at purchase price | …. $VX_j$ …. | VX | VC | VE | VX+VC+VE |
| Operating surplus | …. $P_{Kj}K_j$ …. | VK | | | |
| Compensation | …. $P_{Lj}L_j$ …. | VL | | | |
| Taxes minus subsidies on production | …. $T_{VAj}$ …. | $T_{VA}$ | | | |
| Gross value added at basic price | …. $GVA_j$ …. | GVA | | | |
| Gross output at basic prices | …. $VY_j$ …. | VY | | | |

**SUPPLY table at basic prices**

| | Industries 1 …. j …. n | Total domestic supply | Import cif | Total supply at basic prices | Taxes minus subsidies | Trade and transport margins | Total supply at purchase prices |
|---|---|---|---|---|---|---|---|
| Commodities 1 : i : m | : …. $P_{Yij}Y_{ij}$ …. : | : $VY_i$ : | : $P_{Mi}M_i$ : | : $VS_i= VY_i + VM_i$ : | : $t_iVS_i$ : | : $r_iVS_i$ : | : $(1+t_{Si}+r_{Si})VS_i$ : |
| Total at basic price | …. $VY_j$ …. | VY | VM | VS= VY + VM | $T_Y+T_M$ | R | $VS+R+T_Y+T_M$ |
| Taxes minus subsidies on products | …. $T_{Yj}$ …. | $T_Y$ | $T_M$ | $T_Y+T_M$ | | | |

*Row identity:*

$$VX_i + VC_i + VE_i = (1 + t_i^S + r_i^S)VS_i \quad \forall i \qquad \Leftrightarrow$$

$$\sum_j P_{ij}^X X_{ij} + P_i^C C_i + P_i^E E_i = \left( \sum_j P_{ij}^Y Y_{ij} + P_i^M M_i \right) + T_i^Y + T_i^M + R_i \; \forall i \tag{1}$$

*Column identity:*

$$VY_j = VX_j + GVA_j \quad \forall j \qquad \Leftrightarrow$$

$$\sum_i P_{ij}^Y Y_{ij} = P_j^L L_j + P_j^K K_j + T_j^{VA} + \sum_i P_{ij}^X X_{ij} \quad \forall j \tag{2}$$

With these identities, we can now derive Gross Domestic Product (GDP). GDP represents the final result of the production activity of resident producer units. Using the SUT conventions, GDP at purchasers' prices (or market prices as it is still often denoted) can be measured by the expenditure, production or income approach. Let *GDP* denote GDP at market prices then:

Expenditure approach: $$GDP = \sum_i \left( P_i^C C_i + P_i^E E_i - P_i^M M_i \right) \tag{3}$$

Production approach: $$GDP = \sum_j \left[ \sum_i \left( P_{ij}^Y Y_{ij} - P_{ij}^X X_{ij} \right) \right] + T^Y + T^M \tag{4}$$

Income approach: $$GDP = \sum_j \left( P_j^L L_j + P_j^K K_j + T_j^{VA} \right) + T^Y + T^M \tag{5}$$

### *2.2 Derivation of PPPs for Industry-of-Origin Comparisons*

For international comparisons of real GDP quantities can be valued at a common set of prices. These can be prices of a particular country or a set of international prices. Equation (3) shows that for using the expenditure approach one needs not only a set of final expenditure purchasers' prices, but also sets of fob export and cif import prices. The production approach needs basic prices of domestic output and purchasers' price of intermediate goods (equation (4)). In addition, net taxes on domestic output and imports need to be deflated.[3] For the income approach comparable prices of both labour and capital are needed (equation (5)).

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[3] Taxes and subsidies on products affect only the price of het a product and not the volume. This means that for deflation it is required that the volume index of the tax (subsidy) must equal the volume index of the product on which the tax (subsidy) is applied (Eurostat 2002, Chapter 9).

Using the SUT framework all these prices can be obtained, in theory:

a. Expenditure prices, $p_i^C$. These are purchasers' prices for goods for final domestic demand, thus including net taxes and trade and transport margins.
b. International trade prices, $p_i^M$ and $p_i^E$. The export f.o.b. prices are purchasers' prices, and the import c.i.f. prices are basic prices.
c. Industry input and output prices, $p_{ij}^X$ and $p_{ij}^Y$. The first is the purchasers' price of intermediate inputs by industry j, and the second the basic price of outputs from industry j.
d. Factor income prices, $p_j^L$ and $p_j^K$. These are the prices paid for labour and capital services respectively, by industry j.

These price sets are not independent from each other. The Row identity (1) gives the relationship between expenditure, international trade and industry prices. The Column identity (2) gives a relationship between industry and factor prices. Especially the first identity is important from the perspective of this paper.

As mentioned above, there are basically three sets of comparable prices which can be used for international comparisons: expenditure prices from the ICP (Kravis et al. 1982, OECD, 1999, 2002), industry output prices from ICOP (Maddison and van Ark 2003; van Ark and Timmer 2001; OECD, 2005) and, more recently, trade prices (Feenstra et al. 2004, Timmer and Richter 2005). [4]

For aggregate comparisons, expenditure prices are the common basis for measures of GDP PPP (hereafter, named, E-PPPs). For industry comparisons, however, the conceptually correct prices to make the comparisons are basic output prices by industry (hereafter named, O-PPPs). Until recently, basic output prices have not been not available on a large scale for the purpose of PPP comparisons, and certainly not for all industries. As an alternative proxy PPPs have often been used (Jorgenson et al. 1995; Hooper and Vrankovich, 1995). These proxy PPPs were based on expenditure prices (E-PPP) which were re-allocated from expenditure categories to industry groups (which we will call *component* E-PPPs), and in some cases adjusted to a basic price concept by 'peeling off' trade and transport margins and net taxes. We call these PPPs *'adjusted component'* E-PPPs.[5]

The SUT provides a clear conceptual framework which can be used to investigate for which industries, or in which circumstances, adjusted expenditure prices are a reasonable proxy for basic output prices. By rewriting equation (1), the relationship between

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[4] Prices of production factors, in particular capital, are not easily obtained for the purpose of international comparisons. The main problem is the price of capital services which cannot be easily derived. Factor price PPP are not discussed in the remainder of this paper.

[5] Hereafter we simply use the term 'adjusted E-PPP' because in the discussion we only refer to expenditure prices and E-PPPs for single items, which makes the term 'component' redundant here.

expenditure prices on the one hand and industry and international trade prices on the other can be derived at the product level. For sake of exposition and simplification we assume that for each country there is only one basic price in the system for an individual product i, that is, the basic price of a product is independent from its origin (either an individual domestic industry j, or a particular country from which it is imported):

**Assumption 1** $P_{ij}^{Y} = P_{i}^{Y} = P_{i}^{M} \quad \forall i$

In that case the export price, final expenditure price and intermediate consumption prices can be written as:

$$P_{ij}^{X} = (1 + t_{ij}^{X} + r_{ij}^{X}) P_{i}^{Y} \quad \forall i$$
$$P_{i}^{E} = (1 + t_{i}^{E} + r_{i}^{E}) P_{i}^{Y} \quad \forall i$$
$$P_{i}^{C} = (1 + t_{i}^{C} + r_{i}^{C}) P_{i}^{Y} \quad \forall i$$

Typically, margin and net tax rates differ considerable across export, final expenditure and intermediate use, but for the moment, let’s assume that trade and transport margins and tax rates on product i do not depend on its use:

**Assumption 2** $P_{ij}^{X} = P_{i}^{C} = P_{i}^{E} \quad \forall i$

We will relax this implausible assumption later on. But for now it is easy to derive the following result, using equation (1):

**Result 1**
Under the assumptions 1 and 2, the final expenditure price is equal to the basic output price, when corrected for average net taxes and margins on supplied product *i*:

$$P_{i}^{Y} = \frac{1}{(1 + t_{i}^{S} + r_{i}^{S})} P_{i}^{C} \qquad (6)$$

This results shows that expenditure prices need to be adjusted for the net tax rate and the trade and transportation margins on final expenditure, to provide an appropriate proxy of the basic domestic output price. The information for these adjustment rates can be found in the Supply table.

However, as mentioned above, the assumption of identical margins and taxes in all uses is implausible (see below). In that case, result 1 does not hold and the final expenditure price cannot be easily adjusted to estimate the domestic output price. Rearranging the row identity (equation 1), the following result can be derived (omitting index *i* for clearity)

**Result 2**

Under assumption 1, the general relationship between domestic output prices and expenditure prices can be written as

$$P^Y = \frac{1}{(1+t^S+r^S)}P^C + \frac{1}{(1+t^S+r^S)}\sum_j \left(P_j^X - P^C\right)\frac{X_j}{Y} + \frac{1}{(1+t^S+r^S)}\left[\left(P^E - P^C\right)\frac{E}{Y} - \left((1+t^S+r^S)P^M - P^C\right)\frac{M}{Y}\right] \tag{7}$$

Result 2 shows that using an adjusted final expenditure price, $\frac{1}{(1+t^S+r^S)}P^C$, might in some cases not be a good proxy for the domestic output price $P^Y$. This depends on the size of the differences between the final expenditure prices and the other purchasers' prices (export, import and intermediate consumption), and on the ratio of export, import and intermediate consumption to total domestic output. The bigger these differences are, the weaker the proxy approach using adjusted component PPPs.

The differences in final expenditure prices and the other purchasers' prices can be pinned down more precisely by making the following assumption

**Assumption 3**

$$(t_i^X + r_i^X) < (t_i^C + r_i^C) \quad \forall i$$
$$(t_i^E + r_i^E) < (t_i^C + r_i^C) \quad \forall i$$

The plausibility of these assumptions is motivated as follows. Trade margins for final expenditure are generally higher than for other uses. While wholesale margins may be identical across the board, final consumers typically purchase through retailers and hence pay an additional retailing margin on top of what intermediate users or exporters pay. Also, product tax rates for final consumers frequently differ from tax rates paid by producers for the same good. This is especially true for countries which have a VAT-system. Typically, VAT (value added tex) is being paid by final consumers, not by producers. In addition, one can deduce that net taxes and margins for total supply will be lower than the net taxes and margins for final expenditure.

**Result 3**
Under assumptions 1 and 3, the following inequalities hold.

$$P_{ij}^{X} < P_{i}^{C} \quad \forall i$$

$$P_{i}^{E} < P_{i}^{C} \quad \forall i$$

$$(1+t_{i}^{S}+r_{i}^{S})P_{i}^{M} < P_{i}^{C} \quad \forall i$$

Because of assumption 1 (basic prices are equal in all uses), it follows from assumption 3 that the intermediate consumption and export purchasers' prices, and the import price adjusted with total supply net taxes and margins, are all lower than the final expenditure price.

Results 2 and 3 can now be used to assess the difference between the adjusted expenditure price and the domestic output price. In Table 2 we provide an overview of various possibilities for a particular good *i*. We distinguish the following two-dimensional categories: the use of the product and the international tradeability of the product. The use-dimension subdivides into the following exclusive categories: final expenditure only, intermediate consumption only and the trade-dimension into: no trade, only exports, only imports, and both. For each case we indicate whether a adjusted expenditure price is a good proxy for the domestic output price. It can either be a good estimator (√), have a bias which direction is known, either an overestimation (overest) or underestimation (underest), have a bias whose direction is unknown (?), or not available (n.a.).

**Table 2 Evalution of fitness of adjusted final expenditure price as a proxy for for domestic output price**

| | *No int. trade* | *Only Export* | *Only Import* | *Both* |
|---|---|---|---|---|
| *Only Final use* | (1) √ | (4) overest | (7) underest | (10) ? |
| *Only Intermediate use* | (2) n.a. | (5) n.a. | (8) n.a. | (11) n.a. |
| *Both uses* | (3) overest | (6) overest | (9) ? | (12) ? |

Below the 12 possible cases in Table 2 are discussed.

*Case 1*: when the product is not internationally traded and all domestically produced goods are for final expenditure, the adjusted expenditure price is equal to the basic output price (see equation 6). This is the only situation where this holds true. In all other cases the expenditure price is biased or not available.

*Cases 2, 5, 8 and 11:* when the product is only used for intermediate consumption, no final expenditure price exists. Obviously, the domestic output price cannot be proxied by expenditure prices in these cases, and seeking an independent basic output price (or unit value) is the only alternative. For a large number of agricultural, mining and basic manufacturing products this holds true.

*Case 3:* when the product is not internationally traded, but is partly used for intermediate consumption and partly for final use, the final expenditure price overestimates the basic output price. This can be seen by combining results 2 and 3. In this case, E and M are zero and result 3 shows that the intermediate consumption price will be lower than the final expenditure price, so the final expenditure price must be too high.

*Case 4:* when the product is only exported and a final good, the peeled final expenditure price overestimates the basic output price. This can be seen by combining results 2 and 3. In this case, X and M are zero and result 3 shows that the export price will be lower than the final expenditure price, so the adjusted final expenditure price will be too high.

*Case 6:* when the product is only exported and both a final and intermediate good, the peeled final expenditure price overestimates the basic output price. In this case X and E are positive, and given case 3 and 4, this leads to an overestimation.

*Case 7:* when the product is only imported and a final good (X=E=0), the adjusted final expenditure price underestimates the basic output price. This is opposite to case 4, as the difference between the adjusted import price and final expenditure side enters with a minus sign in equation (7).

*Case 9 and 12:* when the product is only imported or both imported and exported, and both a final and intermediate good, the bias is unknown. On the one hand, it underestimates due to imports (see case 7), but it overestimates due to exports and intermediate use (see case 6). The combined effect is unknown.

*Case 10:* when the product is both imported and exported, and a final good, the bias is also unknown. On the one hand, it underestimates due to imports (case 7), but it overestimates due to exports (case 4). The combined effect is unknown.

Table 2 can be summarised in the following result:

**Result 4**
Under assumption 3, result 2 leads to the following:

A. Only for final goods, which are not internationally traded, the adjusted final expenditure price are equal to the basic output prices (see equation (6)).
B. When the product is only used for intermediate consumption, the domestic output price cannot be estimated on the basis of a final expenditure price.
C. In all other cases, the 'adjusted component' final expenditure price provides a biased estimator of the basic output price which size depends on the differences in purchasers' prices and the ratio of import, export and intermediate consumption to total output

Hence, in order to assess whether an adjusted expenditure price can be used to proxy the basic output price, one should pay attention to (quantity) ratio of exports, imports and intermediate consumption to domestic produce. The differences between purchasers' prices could be derived in case valuation tables are available which provide margins and net taxes by use category. This has not yet been done in the framework in this paper.

When price comparisons are made between countries, the important question in this context is whether the countries will differ in these respects. When the bias can be assumed to be in the same direction and of a similar size in both countries, final expenditure price ratios might be a reasonable proxy of output price ratios. But if these assumptions do not hold, the adjusted final expenditure price provides a biased estimator of the basic output price ratios between the countries

### *2.3 Assessment of PPP Alternatives for Industry-of-Origin Comparisons*

When applying PPPs at the aggregate level of the total economy, neither the expenditure approach nor the industry-of-origin approach is conceptually superior to the other in obtaining PPPs. As indicated in the SUT framework, these are just two different approaches to get at a decomposition of PPPs into either expenditure categories or into industries. In practice, the E-PPP approach (as developed in the framework of the ICP project) has been mostly applied, mainly because it can be based on a separate survey of expenditure prices for specified items, and because it avoids the problem of double deflation. However, even when using E-PPPs at the level of total economy GDP only, one should be cautious about the adjustment for the terms of trade effect (see equation 3). In practice, the market exchange rate is often used to proxy this effect, which clearly is not correct in the light of the previous discussion.

At industry level, the O-PPP approach (as traditionally developed in the ICOP programme) is the most preferable one at industry level, at least in theory. E-PPPs may be acceptable as an alternative to O-PPPs if they are properly adjusted for relative margins and taxes. Below we look at the implications from the insights from the SUT framework discussed in sections 2.1 and 2.2 that affect the choice between E-PPPs and O-PPPs on an industry-by-industry basis. However, practical considerations also play an important role in this choice. For example, a practical disadvantage of E-PPPs is that they require detailed adjustments for margins, taxes and terms of trade effects, which are often not available. This is especially true for the adjustments for import and export prices, which at the detailed level has not been done by anyone so far.[6] In other cases E-PPPs are not an option because no price data are available for intermediate product items. Finally, in some industries (e.g., public administration, education and health) the emphasis is typically on the use of relative input prices.

The main practical objection against using O-PPPs is that these are mostly based on ratios of unit values. Basic prices for specified items at producer level are often not available. Unit values often suffer from ‘product mix’ problems in international comparisons. Unit value ratios may also be biased towards samples of products which are relatively homogeneous, less sophisticated goods. The O-PPPs are then not representative of the more upgraded, high-quality varieties in the same industry. Finally, there are also a

[6] See Hooper and Vrankovich (1995) for a first attempt.

number of service industries for which ICOP O-PPPs do not exist due to a lack of appropriate value data and the difficulty of defining quantities.

In sum, the choice on whether to use an E-PPP (with imperfect adjustments) or an O-PPP (which is often based on a unit value) is an empirical one, and will differ between industries. It may also change over time. For example, the availability of a harmonized industry survey with quantity and value data at basic prices in for European Union member states (PRODCOM), and the use of secondary sources on prices either derived from private data sources or from industry specific surveys, are important improvements that have helped to reduce the biases in O-PPPs.

In Table 3 an assessment is made of the usefulness of E-PPPs and O-PPPs for 19 major sectors of the economy.[7] PPPs are ranked from 0 (not useful) to 5 (very useful) depending on the appropriate use of the PPP alternatives as discussed above. On the basis of Result 3 and Table 2, we can assess for each industry which approach is the most appropriate. Result 4 shows that for an industry in which the share of final expenditure in total use is low, adjusted E-PPPs might serve as a bad proxy for domestic output prices (e.g. agriculture, mining, basic manufacturing, transport).[8] A high share of imports in total supply of goods also indicates the possiblity of mismeasurement (e.g. durable and non-durable manufacturing). E-PPPs are acceptable proxies for domestic output prices when expenditure shares are high and import ratios low as, for example, is the case in sectors such as construction, hotels and catering and real estate. In Section 3 we will discuss and present the new industry-of-origin PPP dataset on an industry-by-industry basis.

[7] In Appendix Table 1 we show for two countries (a large economy, the U.S., and a small open economy, the Netherlands) the shares of expenditure, intermediate and export demand in total use, and the shares of domestic production and imports in total supply for each major sector.
[8] Still this might not be a problem when the bundle of products and the corresponding prices do not differ much between final expenditure and other uses, but in many cases these differences are large.

**Table 3: Assessment of usefulness of adjusted E-PPPs and O-PPPs for industry output comparisons in the OECD**

| | | Grade | | Remark | |
|---|---|---|---|---|---|
| *Industry* | ISIC rev. 3 code | Expendi-ture PPPs | Output PPPs | Expenditure PPP | Output PPP |
| Agriculture | 01-05 | 0 | 5 | Small expenditure share | Homogeneous goods, producer prices |
| Mining and quarrying | 10-14 | 0 | 4 | Small expenditure share | Homogeneous goods |
| Manufacturing | 15-37 | 2 | 4 | See 4-7 | See 4-7 |
| *Food, drink & tobacco* | 15,16 | 3 | 4 | High exp.share but also trade intensive | Homogeneous goods |
| *Basic goods* | 17,20,21,23-28 | 1 | 4 | Small expenditure share | Homogeneous goods |
| *Non-durable* | 18,19,22,36,37 | 2 | 4 | Large import share | Homogeneous goods |
| *Durable* | 29-35 | 2 | 2 | Large import share | Quality and coverage problem |
| Electricity, gas and water supply | 40,41 | 3 | 4 | Homogeneous goods | Homogeneous goods |
| Construction | 45 | 4 | 1 | High expenditure share | Quality problem |
| Trade | 50-52 | 0 | 2 | Small expenditure share | Quality problem |
| Hotels & catering | 55 | 4 | 0 | High expenditure share | Not available |
| Transport | 60-63 | 1 | 3 | Dif. product mix | Quality problem |
| Communications | 64 | 3 | 3 | Homogeneous goods | Quality problem |
| Finance | 65-67 | 0 | 1 | Not available (reference PPP) | Quality and coverage problem |
| Real estate activities | 70 | 4 | 1 | High expenditure share | Quality and coverage problem |
| Business services | 71-74 | 1 | 0 | Small expenditure share | Not available |
| Public administration and defence | 75 | 0 | 0 | Based on input PPPs | Not available |
| Education and health | 80,85 | 0 | 0 | Mainly based on input PPPs | Not available |
| Other services | 90-95 | 2 | 0 | Dif. product mix | Not available |

Note: ranking indicates 0 (not useful), 1 (very poor), 2 ( poor), 3 (acceptable), 4 (useful) and 5 (very useful).

Source: assessment based on E-PPPs for OECD from 1999 round and O-PPPs for 1997 from Groningen Growth and Development Centre.

## 3. A new ICOP-dataset for Industry of Origin PPPs[9]

Using the criteria laid out in Section 2, we have developed a new dataset of industry PPPs at the output level for 45 industries and 25 countries for the year 1997. The 25 countries include 24 major OECD countries and Taiwan (See Table 4). This new dataset builds upon earlier work by the ICOP group at the Groningen Growth and Development Centre, which included studies for agriculture, manufacturing, wholesale and retail trade and transport and communication. Earlier attempts to cover the total economy were carried out for Korea and Japan (Pilat, 1994), Brazil and Mexico (Mulder, 1999), and for EU countries (van Ark and Inklaar, 2002; van Ark, Stuivenwold and Inklaar, 2003).[10]

The main differences between these previous studies and the present one are the following:

- the present dataset uses consistent criteria for the selection of the PPP method
- it uses a single set of weights (based on gross output or weighted output) to obtain estimates by industry.
- it applies a multilateral (EKS) weighting system for all industries;
- the present country and industry coverage is much bigger than in earlier datasets.

Hence this is the first time that there is a genuine alternative to multinational ICP expenditure comparisons by using an industry-of-origin approach.

Below we first describe the basic set up of our database. We subsequently discuss our approach towards individual major sectors, including agriculture, mining, manufacturing, public utilities, wholesale and retail trade, transport and communication, and other services. For each major sector, we will illustrate our approach with results of the France/U.S. comparison. The full set of country results will be made available on the GGDC and EUKLEMS websites in due time.

### *3.1 Basic set-up above the industry level*

In compiling this new ICOP dataset, we have made a clear and consistent distinction between the methodologies used above and below industry level. In the new dataset, there are 221 3-digit ISIC (rev 3) industries. This is comparable to the number of basic headings in the ICP expenditure approach. Below the industry level, PPPs are compiled on the basis of a variety of sources as will be described below. For aggregation of industries the EKS method, proposed by Elteto and Koves (1964) and Szulc (1964), is applied. This method is designed to construct transitive multilateral comparisons from a matrix of original binary/pairwise comparisons which does not satisfy the transitivity property. The EKS method in its original format uses the binary Fisher PPPs ($F_{jk}$: j,k=1,..M) as the starting point. The computational form for the EKS index is given by:

$$EKS_{jk} = \prod_{l=1}^{M} \left[ F_{jl} \cdot F_{lk} \right]^{1/M} \qquad (10)$$

[9] A complete underlying document on sources and methods will be provided in the summer of 2005, as part of the EUKLEMS project (Ypma, Timmer and van Ark, 2005).

[10] These studies are summarized by van Ark and Timmer (2001) and Maddison and van Ark (2003).

with $EKS_{jk}$ the EKS PPP between country j and k. The formula defines the EKS index as an unweighted geometric average of the linked (or chained) comparisons between countries j and k using each of the countries in the comparisons as a link. The EKS method does not only produce comparisons that are transitive, but indices also satisfy the important property that the index deviates the least from the pairwise Fisher binary comparisons.[11] The weights used in the ICOP aggregation are gross output weights. However, where possible these weights take into account the reliability of the industry PPP. Gross output weights were used in case the PPPs are considered to be reliable, but otherwise matched gross output is used (see below for criteria).[12]

### *3.2 ICOP PPPs on industry-by-industry basis*

Agriculture, forestry and fisheries

Manufacturing

Mining

Public Utilities

Wholesale and Retail Trade

Transport and Communication

Other Services

## 4. New Applications for the Use of Industry-by-Origin PPPs

[to be developed]

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[11] This property is in line with the property of characteristicity discussed by Drechsler (1973). Since the Fisher index is considered to be ideal and possesses a number of desirable properties, the EKS method has a certain appeal since it preserves the Fisher indices to the extent possible, while constructing multilateral index numbers.

[12] As there is no readily available data source on gross output covering all 221 industries, gross output by industry was specifically constructed for the purpose of this study. The dataset is based on gross output figures from the OECD STAN database, but this has only limited numbers at 3 digit level. The gaps were filled with output shares obtained from Use tables (form Eurostat or from individual countries) and industry statistics, such as the OECD Industrial Structure Database (I&S), the Eurostat Structural Business Statistics Database, national censuses and industry surveys, etc.. In all cases, however, the consistency with OECD STAN at a higher level was maintained. In due time this gross output dataset will be linked to the EU KLEMS dataset and similar KLEMS estimates for non-EU countries.

**Table 4: Country and Industry Coverage in ICOP Industry-by-Origin PPP dataset**

| Countries | Industries |
|---|---|
| European Union (a) | Agriculture, forestry and fishing |
| Austria | Mining and quarrying |
| Belgium | Manufacturing |
| Czech Republic | Food, beverages and tobacco |
| Denmark | Textiles |
| Finland | Wearing apparel |
| France | Leather |
| Germany | Wood products |
| Greece | Pulp, paper and paper products |
| Hungary | Printing and publishing |
| Ireland | Coke, refined petroleum products and nuclear fuel |
| Italy | Chemicals and allied products |
| Luxembourg | Rubber and plastics products |
| Netherlands | Non-metallic mineral products |
| Poland | Basic metals |
| Portugal | Fabricated metal products |
| Slovakia | Machinery, nec |
| Spain | Office, accounting and computing machinery |
| Sweden | Other electrical machinery and apparatus nec |
| U.K. | Radio, television and communication equipment |
| Norway | Instruments |
| U.S. | Motor vehicles, trailers and semi-trailers |
| Australia | Other transport equipment |
| Canada | Manufacturing nec, recycling |
| Japan | Electricity, gas and water supply |
| South Korea | Construction |
| Taiwan | Wholesale and Retail Trade |
| | Motor vehicle trade and repairs |
| | Wholesale trade and commission trade |
| | Retail trade and repair of household goods |
| | Hotels and restaurants |
| | Transport and Communication |
| | Inland transport |
| | Water transport |
| | Air transport |
| | Supporting and auxiliary transport activities; activities of travel agencies |
| | Post and telecommunications |
| | Financial intermediation |
| | Real estate activities |
| | Renting of machinery and equipment |
| | Computer and related activities |
| | Research and development |
| | Other business activities, nec |
| *(a) the three Baltic States, Cyprus, Malta and Slovenia are missing due to lack of data* | Government |
| | Education |
| | Health and social work |
| | Other community, social and personal services |
| | Private households |

**Appendix Table 1: Composition of Supply and Demand in the Netherlands and the United States, 1999.**

| | | | The Netherlands, 1999 | | | | | United States, 1999 (d) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | as % of total use (b) | | | as % of total supply (c) | | as % of total use (b) | | | as % of total supply (c) | |
| | *Industry (a)* | ISIC rev. 3 code | Final expen-diture | Inter-mediate use | Ex-ports | Dom-estic | Im-ports | Final expen-diture | Inter-media te use | Ex-ports | Dom-estic | Im-ports |
| 1 | Agriculture | 01-05 | 13% | 50% | 37% | 69% | 31% | 13% | 81% | 6% | 92% | 8% |
| 2 | Mining and quarrying | 10-14 | 1% | 80% | 19% | 46% | 54% | 1% | 96% | 3% | 71% | 29% |
| 3 | Manufacturing | 15-37 | 27% | 32% | 41% | 52% | 48% | 41% | 48% | 11% | 82% | 18% |
| 4 | *Food, drink & tobacco* | 15,16 | 34% | 26% | 40% | 76% | 24% | 62% | 33% | 5% | 94% | 6% |
| 5 | *Basic goods* | 17,20,21,23-28 | 15% | 45% | 40% | 58% | 42% | 19% | 73% | 7% | 87% | 13% |
| 6 | *Non-durable* | 18,19,22,36,37 | 52% | 27% | 20% | 58% | 42% | 66% | 29% | 5% | 73% | 27% |
| 7 | *Durable* | 29-35 | 29% | 22% | 49% | 34% | 66% | 50% | 33% | 17% | 75% | 25% |
| 8 | Electricity, gas and water sup | 40,41 | 34% | 66% | 0% | 98% | 2% | 48% | 52% | 0% | 100% | 0% |
| 9 | Construction | 45 | 58% | 40% | 2% | 100% | 0% | 79% | 21% | 0% | 100% | 0% |
| 10 | Trade | 50-52 | 50% | 50% | 0% | 100% | 0% | 66% | 30% | 4% | 101% | -1% |
| 11 | Hotels & catering | 55 | 72% | 28% | 0% | 100% | 0% | 81% | 19% | 0% | 100% | 0% |
| 12 | Transport | 60-63 | 21% | 29% | 50% | 91% | 9% | 37% | 53% | 10% | 92% | 8% |
| 13 | Communications | 64 | 33% | 59% | 9% | 91% | 9% | 49% | 50% | 1% | 100% | 0% |
| 14 | Finance | 65-67 | 64% | 33% | 3% | 97% | 3% | 53% | 44% | 3% | 100% | 0% |
| 15 | Real estate activities | 70 | 73% | 27% | 0% | 100% | 0% | 63% | 35% | 2% | 100% | 0% |
| 16 | Business services | 71-74 | 17% | 68% | 15% | 86% | 14% | 26% | 73% | 2% | 100% | 0% |
| 17 | Public administration and def | 75 | 95% | 5% | 0% | 100% | 0% | not available | | | | |
| 18 | Education and health | 80,85 | 94% | 6% | 0% | 100% | 0% | 96% | 4% | 0% | 100% | 0% |
| 19 | Other community, social and | 90-95 | 28% | 52% | 19% | 83% | 17% | 61% | 33% | 5% | 100% | 0% |

Notes: (a) based on use and make tables which list supply and demand of products rather than industries.
Products have been used as proxies for industries by allocating them to their primary sector of production.
(b) by definition total use is sum of intermediate use, exports and final expenditure
(c) by definition total supply is sum of domestic production and imports
(d) Due to differences in ISIC rev 3 and the classification used in the U.S. Input-output tables, the results for industries 20, 22, 24, 34 and 50 are proxies.
Sources: Statistics Netherlands, *Supply and use tables*, 1999 and Bureau of Economic Analysis, *Input-Output Accounts* for 1999.

## References


Ark, B. van and M.P. Timmer (2001), "PPPs and International Productivity Comparisons: Bottlenecks and New Directions", paper for Joint World Bank-OECD seminar on Purchasing Power Parties, 30 January – 2 February, Washington D.C. (downloadable from www.oecd.org/dataoecd/24/0/2424747.pdf)

Ark, B. van and R.C. Inklaar (2002), Purchasing Power Parities for Industry Comparisons, Final Report for the International Benchmark Club, BAK Basel Switzerland), Groningen Growth and Development Centre and The Conference Board, mimeographed.

Ark, B. van, E. Stuivenwold and R.C. Inklaar (2003), "ICOP Purchasing Power Parities for Industry Comparisons: Preliminary Estimates", Report for Ministry of Economic Affairs, The Netherlands, mimeographed.

Beaulieu, J.J. and E.J. Bartelsman (2004), "Integrating Expenditure and Income Data: What to do with the Statistical Discrepancy?", *Tinbergen Institute Discussion Papers 04-078/3*, Tinbergen Institute, Amsterdam.

Broadberry, S.N. (2003) "Relative per capita income levels in the United Kingdom and the United States since 1870: reconciling time-series projections and direct-benchmark estimates", *Journal of Economic History*, 63 (3), pp. 852-63.

Canzoneri, M.B., R.E. Cumby and B. Diba (1999), "Relative labor productivity and the real exchange rate in the long run: evidence for a panel of OECD countries", Journal of International Economics, no. 47 , pp. 245–266.

Drechsler, L. (1973), "Weighting of index numbers in multilateral international comparisons", *Review of Income and Wealth*, series 19, No. 1, March.

Elteto, O. and P. Koves (1964), "On an Index Computation Problem in International Comparisons" (in Hungarian), *Statistztikai Szemle*, Vol. 42, pp. 507-518.

Feenstra, R.C., A. Heston, M.P. Timmer, H. Deng (2004), "Estimating Real Production and Expenditures Across Nations: A Proposal for Improving the Penn World Tables", *NBER Working Paper No. W10866* , November.

Goldberg, P.K and F. Verboven (2004), "Cross-country price dispersion in the euro era: a case study of the European car market", *Economic Policy*, no. 40, October.

Hooper, P. and E. Vrankovich (1995), "International Comparisons of the Level of Unit Labor Costs in Manufacturing", in *International Finance Papers*, No. 527, Federal Reserve Board, Washington D.C.

Ito, T., P. Isard and S. Sysmansky (1997), “Economic Growth and Real Exchange Rate: An Overview of the Balassa-Samuelson Hypothesis in Asia”, *NBER Working Paper No. W5979* , March.

Jorgenson, D.W., M. Kuroda and M. Nishimizu (1987), “Japan-U.S. Industry-level Productivity Comparisons, 1960-1979”, *Journal of the Japanese and International Economics*, vol. 1, 1-30.

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

Maddison, A. and B. 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, pp. 5-26.

Moyer, B.C., M.B. Reinsdorf and R.E. Yuskavage (2004), “Aggregation Issues in Integrating and Accelerating BEA’s Accounts: Improved Methods for Calculating GDP by Industry”, Paper prepared for the Conference on Research in Income and Wealth (CRIW) Architecture for the National Accounts Conference, April 16-17, Washington D.C.

Mulder, N. (2002), *The Economic Performance of the Service Sector in Brazil, Mexico and the USA,A Comparative Historical Perspective*, Aldershot UK and Brookfield US: Edward Elgar.

Neary, P. (2004), “Rationalizing the Penn World Table: True Multilateral Indices for International Comparisons of Real Income”, *The American Economic Review*, December.

OECD (1999), *Purchasing Power Parities and Real Expenditures – EKS Results, 1996*, Paris.

OECD (2000), *Purchasing Power Parities and Real Expenditures, 1999 Benchmark Year*, OECD, Paris.

Pilat, D. (1994), *The Economics of Rapid Growth. The Experience of Japan and Korea*, Aldershot UK and Brookfield US: Edward Elgar.

Rogoff, K. (1996), “The Purchasing Power Parity Puzzle”, *Journal of Economic Literature*, vol. 34, pp. 647-668.

Szulc, B. (1964), “Index Numbers of Multilateral Regional Comparisons” (in Polish), *Przeglad Statysticzny*, Vol.3, 239-254.

Taylor, A.M. and M.P. Taylor (2004). “The Purchasing Power Parity Debate”, *Journal of Economic Perspectives*.

Timmer, M.P. and A. Richter (2005)

OECD (2005), *Measuring Productivity Levels – A Reader*, Paris (forthcoming).

Ypma, G., M.P. Timmer and B. van Ark (2005), "The 1997 ICOP Industry-of-Origin PPP Dataset", forthcoming.

Ward, M. and Devereux, J. (2003) 'Measuring British decline: direct versus long-span income measures', *Journal of Economic History*, 63 (3), pp. 826-51.