Cross-country Conversion Factors for Sectoral Productivity Comparisons

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Abstract

International comparisons of productivity have used exchange rates or purchasing power parity (PPP) to make output comparable across countries. While aggregate PPP holds rather well in the long run, sectoral deviations are very persistent. Differences in the importance of nontradables by sector exacerbate the problem. It raises the need for a currency conversion factor at the same level of aggregation as the output that is compared. I map prices from household expenditure surveys into the industrial classification of sectors and adjust for taxes and international trade to obtain a sector-specific PPP. The few previous studies that accounted for sectoral price differences only constructed similar conversion factors for a single year. Using detailed price data for 1985, 1990, 1993, and 1996, I am the first to test whether such sectoral PPPs adequately capture differential changes in relative prices between countries. For some industries—notably Agriculture, Mining, and less sophisticated manufacturing sectors—the indices prove adequate. For most other industries, aggregate PPP is superior.

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For comparisons of economy-wide productivity or GDP per capita, researchers have the option to use PPP or exchange rates to convert domestic output into a common denominator. Similar calculations at the sectoral level will only capture the productivity difference if the two countries share the same relative prices. Moreover, performing such sectoral comparisons at multiple points in time—as is done to assess cross-country convergence—will lump price changes with productivity changes if relative prices evolve differently by country.

To construct PPP, prices on a basket of identical goods are collected in each country and aggregated using expenditure weights. This generates an appropriate conversion factor only for output that is well represented by the basket of goods. This is well known. For example, to compare TFP levels across countries, the value of capital also has to be converted into a common denominator. Because price changes for investment goods often differ from the general rate of inflation, a separate investment PPP is calculated, aggregating only prices of the relevant subset of goods.

To compare sectoral productivity between countries, one should exert similar caution. For example, if the price of textiles relative to machinery increases faster in Japan than in the United States, it will not be correct to use the same aggregate PPP to convert both Japanese textile and machinery output into U.S. dollar. Japanese relative productivity growth in textiles will be overestimated and vice versa for machinery. Without a sectoral equivalent to PPP, one inevitably gets the productivity comparison wrong. As recent as 2001, Bernard and Jones write in response to Sørensen (2001):

> The clear implication of the Comment is that future research is needed to construct conversion factors appropriate to each sector and that research relying on international comparisons of sectoral productivity should proceed with caution until these conversion factors are available. (Bernard and Jones (2001), p. 1169).

Some previous studies have recognized the problem and constructed disaggregate conversion factors.[1] Harrigan (1999) uses published PPPs, which are specific to different components

[1]Dollar and Wolff (1988) and Bernard and Jones (1996) use aggregate PPP to convert sectoral output.

of GDP. Only a few components are available and the correspondence to industrial sectors is only approximate. van Ark and Pilat (1993) rely on producer price surveys to construct sectoral PPPs from unit value ratios. In contrast, Jorgenson et al. (1987) and Pilat (1996) use consumer price surveys instead, which are less appropriate in theory, but cover more products and might be preferable in practice. The sectoral PPPs I construct also draw on consumer prices. The contribution of this paper is to calculate sectoral PPPs in four different years. This allows me to verify whether they accurately capture changes in relative prices, which is necessary to compare sectoral output at different times.

An important application for sectoral productivity comparisons is in the convergence debate. Within the group of OECD countries, GDP per capita or aggregate labor productivity was found to be converging over the last 40 years.[2] A natural question is to ask what drives convergence in this group of countries. Are all sectors converging to the same extent or is the decline of sectors with large productivity differentials, such as agriculture, important? Alternatively, are service sectors that account for an ever larger portion of GDP more comparable across countries? It is also possible that increased trade intensity, especially in manufacturing, drives the convergence results. In order to answer any of the above question, one needs to calculate sectoral productivity differences at several points in time.

In Section 1, the need for sector-specific currency conversion factors is illustrated in greater detail. Section 2 discusses previous approaches in the literature and describes the construction of the sectoral PPPs that will be used in this study. The validity of these measures is evaluated directly, in Section 3, by comparing relative price changes with changes in sectoral PPP. A number of reasons for the failure of sectoral PPP to track relative price changes are discussed in Section 4. In Section 5, sectoral convergence rates are calculated using the most appropriate currency conversion factor for each industry. Section 6 concludes.

Sørensen (2001) shows this to be appropriate for the total business or service sector, but not for manufacturing.

[2]An overview of the debate with recent evidence can be found in a symposium in the July 1996 issue of the *Economic Journal* or in Durlauf and Quah (1999).

1 International productivity comparisons

To compare output between countries one needs to convert local currency values into a common unit of measurement. Exchange rates are often deemed inappropriate because they fluctuate a lot and are only affected by tradable and financial assets. The proper conversion factor into U.S. dollar, for example, measures the price in each country, using that country's currency, for a basket of goods that is representative of the output that is compared. The basket is rescaled such that it would cost $1 in the U.S. For GDP, this is exactly what aggregate PPP is designed to accomplish. For example, the relative labor productivity level of the Japanese economy relative to the U.S. in 1970 is calculated as:

$$\text{level comparison:} \qquad \left(\frac{LP^J}{LP^{US}}\right)^{\$}_{70} = \frac{LP^{J,¥}_{70}/PPP^{¥/\$}_{70}}{LP^{US,\$}_{70}}, \tag{1}$$

with $PPP^{¥/\$} = \frac{P^{¥}}{P^{\$}}$, the number of yen needed to purchase the same basket of goods in Japan that costs $1 in the U.S. LP is simply value added divided by total employment or any other input measure that is deemed appropriate. To compare output for single sector, one should construct a sectoral PPP based only on the prices of the goods in that industry.

To compare the evolution of relative productivity levels over time, e.g. from 1970 to 2000, two approaches are possible. The most straightforward one would be to compare the productivity levels using current prices in both years and measure the change in this ratio. The yen denominated Japanese production is converted into dollars at both times using time-specific conversion factors ($PPP^{¥/\$}_t$). The following calculation measures the change in relative productivity level between Japan and the U.S. from 1970 to 2000:

$$\text{growth comparison 1:} \qquad \frac{\text{relative LP}^{J/US}_{00}}{\text{relative LP}^{J/US}_{70}} \equiv \frac{\left(\frac{LP^J}{LP^{US}}\right)^{\$}_{00}}{\left(\frac{LP^J}{LP^{US}}\right)^{\$}_{70}} = \frac{\frac{LP^{J,¥}_{00}/PPP^{¥/\$}_{00}}{LP^{US,\$}_{00}}}{\frac{LP^{J,¥}_{70}/PPP^{¥/\$}_{70}}{LP^{US,\$}_{70}}}. \tag{2}$$

Alternatively, if we do not observe PPP in both periods or if we have more faith in price deflators, we can calculate real output or productivity growth separately for each country and compare the growth rates. Using country-specific deflation rates (P_{00}/P_{70}), the nominal values for 2000 are converted into real, 1970 values, which is indicated by $LP_{00,70}$. The change in productivity for Japan and the U.S., in real 1970 prices, is compared directly to measure the evolution of their relative performance.

$$\text{growth comparison 2:} \qquad \frac{1+LPG^{J}_{70/00}}{1+LPG^{US}_{70/00}} \equiv \frac{\left(\frac{LP_{00,70}}{LP_{70}}\right)^{J,¥}}{\left(\frac{LP_{00,70}}{LP_{70}}\right)^{US,\$}} = \frac{\frac{LP^{J,¥}_{00}/(\frac{P_{00}}{P_{70}})^{¥}}{LP^{J,¥}_{70}}}{\frac{LP^{US,\$}_{00}/(\frac{P_{00}}{P_{70}})^{\$}}{LP^{US,\$}_{70}}} \tag{3}$$

Obviously, for (2) and (3) to give the same result, the price deflators and currency converters have to be related. Rearranging both equations reveals that they have to satisfy:

$$\frac{PPP^{¥/\$}_{00}}{PPP^{¥/\$}_{70}} = \frac{\left(\frac{P_{00}}{P_{70}}\right)^{¥}}{\left(\frac{P_{00}}{P_{70}}\right)^{\$}}. \tag{4}$$

The ratio of the currency conversions factors at both points in time has to equal the ratio of price deflation in both countries. If one country experiences more rapid inflation than the other, its currency should depreciate in PPP terms. In theory, $PPP^{¥/\$}$ is defined as $\frac{P^{¥}}{P^{\$}}$ and (4) should hold. In practice, both sides of the equation are calculated from different data and equality is not guaranteed. For a set of 14 OECD countries, results in Sørensen (2001) confirm that the equation holds for the deflation rates of the Total business sector and aggregate PPP. For sectoral comparisons, the change in PPP has to match the cross-country difference in sectoral deflation rates. If relative prices change differently by country, aggregate PPP cannot satisfy equation (4) for all industries.

Comparing sectoral deflation rates directly across countries, it is obvious that relative prices change differently even over the medium term (11 years). At the 2 digit ISIC level, the price increase for goods in the Machinery & equipment industry in Canada relative to the U.S. between 1985 and 1996 was 16% higher than the difference between the Canadian and U.S. manufacturing deflation rates, while prices of Transport equipment increased at a much slower (25% lower) pace in Canada. In Japan, the second largest trading partner for the U.S., price increases relative to the average price level were 15% than in the U.S for Machinery & equipment and 40% higher for Textiles, while the price index for Chemicals, Transport equipment, and Paper products rose relatively more slowly.[3] In Japan, seven of the ten 2 digit industries experienced faster price increases than the U.S., while in the Netherlands only two industries saw faster price increases than their U.S. counterparts.

The differential sectoral price evolutions are not confined to these three countries. While the price deflator for the Machinery & equipment industry increased more in each of 13 OECD countries than in the U.S., the difference varies from 4% in South Korea and 16% in Canada, to almost a full 100% in Belgium. As before, relative sectoral price changes are normalized by the relative change in manufacturing prices. The reverse is true for the Paper, pulp, printing, and publishing industry, where the U.S. saw the largest price increase of all 14 countries. Finally, Basic metals and fabricated metal products experienced very small changes in relative prices in most countries. The largest relative price increase was recorded in the United Kingdom, 9% higher than in the U.S., and the largest decline was in Portugal, with a 27% relative price decline.[4]

As relative prices evolve differently by country, productivity comparisons will have to use currency conversion factors that adequately reflect relative prices. To assess convergence, one can compare productivity levels at two times, requiring currency conversions in both years. Alternatively, one can only compare the initial productivity level and calculate subsequent real productivity growth relying on domestic deflation rates instead. This implies that the

[3]Results for all two-digit manufacturing industries are in Figure A.1 in the Appendix.
[4]Full results are in Figure A.2 in the Appendix.

currency conversion has to be performed at least once, but not necessarily more than once. However, in order to assess the validity of the currency conversion factors, i.e. whether they satisfy the equality in equation (4), several years of data are needed.[5]

2 Sectoral PPP

Even though few researchers have constructed sector-specific conversion factors, I am obviously not the first to compare sectoral output across countries. Dollar and Wolff (1988) and Bernard and Jones (1996) ignore changes in relative prices and use aggregate PPP to convert sectoral output, which will only be appropriate for some sectors. Harrigan (1999) uses disaggregate PPPs specific to some component of GDP. These are published by the OECD, but do not always correspond well to the industries that provide the output measures.

To construct sectoral PPP measures, one can use producer or consumer prices. The industry-of-origin approach aggregates unit value ratios, obtained directly from producer price surveys, to the level of aggregation of output and input statistics. This method was pioneered by van Ark and Pilat (1993) and is explained in detail, with recent advances, in van Ark and Timmer (2001).[6] Its appeal stems from the natural concordance between price and output measures and the possibility to control accurately for changes in product mix.

The expenditure approach provides an alternative by aggregating consumer prices using

[5] As an example of the potential pitfalls from using aggregate PPP, consider photographic cameras in Japan. In 1985, cameras were relatively expensive in Japan, costing 268 yen per dollar worth, while aggregate PPP was 218. By 1996, relative prices dropped and a camera costing $100 in the U.S. could be bought for only 8600 yen in Japan. Even if convergence in productivity was perfect, it would not be picked up using aggregate PPP. Assume, for example, that Japan was initially less productive, but that the entire difference was eliminated through faster productivity growth. If aggregate PPP is used to convert the high nominal output (in yen) in 1985 into dollars, we overestimate Japanese initial productivity. The low nominal amount in yen in 1996 produces an underestimate of the Japanese productivity level if the aggregate PPP of 166 is used to convert it into 1996 dollars. The puzzling conclusion would be that a country with relatively high initial productivity level in camera production enjoyed higher productivity growth than the U.S., but has fallen behind in relative productivity by 1996.

[6] Researchers at the Groningen Growth and Development Centre have been instrumental in developing this approach. Relative productivity comparisons are available online in their data set "International Comparisons of Output and Productivity by Industry" at http://www.eco.rug.nl/GGDC/icop.html.

expenditure shares, obtained from consumer and retail price surveys.[7] The same method is used to construct aggregate PPP. It has been the more popular approach in productivity comparisons, even though output and inputs are measured from the production side of the national accounts, while prices correspond to the expenditure side. In a comment on van Ark and Pilat (1993), Jorgenson argues:

> The unit value ratios are preferable, in principle, because they represent ratios of producers' prices for the two countries being compared. [...] The practical disadvantages of unit value ratios largely outweigh their conceptual advantages, so the purchasing power parities of Kravis and his associates [...] are far more satisfactory. ("Comment" on van Ark and Pilat (1993), p. 53)

The expenditure approach is described in detail in Jorgenson and Kuroda (1990) and was first used to compare sectoral productivity between Japan and the U.S. Using the same methodology, Conrad and Jorgenson (1985) extend the results and include Germany in the comparison. Lee and Tang (2001) perform similar comparisons between Canada and the U.S. for Industry Canada.[8]

Recently, Pilat (1996) compares sectoral productivity levels for nine OECD countries. He uses industry-of-origin data (producer prices) where available, but supplements them with expenditure PPP data for 1985. The latter are consumer price ratios for a number of detailed commodity groups, called basic headings.[9] The original data, compiled by Kravis, Heston, and Summers (1978) for 1970, contained 153 categories, but this was expanded to 210

[7] The International Comparison Program is regularly updating the data and methodology. The program was first established in 1968 as a joint venture of the UN and the International Comparisons Unit of the University of Pennsylvania. Currently, it entails a data collection and processing collaboration between many statistical agencies, foremost the World Bank, the OECD, and Eurostat. Information on the program is available online at http://www.worldbank.org/data/.

[8] Using sectoral PPPs in a productivity comparison using gross output, as in Jorgenson and Kuroda (1990), or adjusting unit value ratios for "double deflation", as in van Ark and Timmer (2001), requires detailed and internationally harmonized input-output tables. This is beyond the scope of this paper and I limit myself to comparing value added per worker, using sectoral PPPs to convert value added directly. I similarly ignore the issue of aggregation as the merits of different methods, most notably the Geary-Khamis and EKS methods— are still debated, see for example Dowrick and Quiggin (1997) or OECD (2002).

[9] These are the most detailed product categories for which expenditure weights can be estimated for all countries. Bradford (2003) describes the data and uses it to measure protection in OECD countries.

internationally comparable basic headings by 1985. These aggregate prices and expenditures on approximately 2500 goods and services, chosen to be representative of the entire economy, i.e. of total consumption by consumers, businesses, and government. The data collection is coordinated by the International Comparison Program. For the countries I study, all data is collected by the OECD and Eurostat.

I work with the same expenditure PPPs and add information for three more years—1990, 1993 and 1999—and five more countries (listed in Table 1). Even though a conversion factor is only needed in a single year to study sectoral convergence, I calculate sectoral PPP at different times to test whether they adequately capture relative price changes. The implicit assumption that differential evolutions of relative prices between countries are unimportant or that relative real growth rates are equally well measured by equations (2) or (3) is questioned in another comment on van Ark and Pilat (1993) by Frank Lichtenberg:

> Another, *less serious* limitation of the paper's approach is that the authors constructed "benchmark" estimates of relative productivity levels for only a single year—1987; ("Comment" on van Ark and Pilat (1993), p. 58).

All studies using sector-specific conversion rates to compare productivity levels between countries over time have similarly assumed that (4) holds. As far as I am aware, I am the first to test the adequacy of sectoral PPPs.

The construction of sectoral PPPs has three components to it. First, the basic headings are mapped into the industrial classification of sectors. Second, prices are aggregated to the level of output and input. Third, adjustments are made for trade, indirect taxes, and differences in retail or wholesale margins to better approximate producer prices.[10]

I use internationally comparable input and output statistics at the 2 digit ISIC Revision 3 industry classification. Obviously a number of judgement calls have to be made to perform the mapping from basic headings to the ISIC classification. I experimented with different

[10] Lack of data forces me to drop the last adjustment.

criteria yielding largely similar results.[11]

To calculate a single price index for each industry, basic heading categories had to be aggregated. By necessity, this was done using expenditure shares as weights. Table 1 contains results for country-specific weights, producing a Paasche index, for U.S. weights, producing a Laspeyres index, and a geometric average of these two indices, a bilateral Fisher index. The latter will be used in the productivity calculations.[12] Note that the Fisher indices are not transitive and most suitable for bilateral comparisons. As a result, all comparisons are explicitly relative to the U.S. While it is possible to construct a conversion factor more suitable for multilateral comparisons, see Rao and Timmer (2003), choosing weights for each country is nontrivial. Moreover, I only observe basic headings relative to the U.S.

At the aggregate level, the expenditure PPPs are adjusted for differences in indirect taxes or subsidies, as these are excluded from the output statistics. This is an important adjustment as the Value Added Tax in most countries is higher than the sales tax in the U.S. The adjustment for country i follows Pilat (1996):

$$PPP^i_{\text{net}} \quad = \quad PPP^i_{\text{expenditure}} \Big/ \Big(\frac{1 + \left(\frac{\text{Tax–Subsidy}}{\text{Production}}\right)_i}{1 + \left(\frac{\text{Tax–Subsidy}}{\text{Production}}\right)_{USA}} \Big). \tag{5}$$

Gross expenditure prices are divided by the relative net tax difference with the U.S. The observed indirect tax ratios are taken from the ISDB data set, produced by the OECD, and

[11] A complete list of the mapping is available upon request. Three basic headings were omitted as they could not be matched to any specific industry: 1182022 "Other personal goods and effect", 1431011 "other products" (the very last, catch-all category), 1500000 "change in stocks". Two other basic headings had to be omitted as they capture purchases abroad: 1191011 and 1600000. One potentially problematic assumption is to include consumption of fixed capital by hospitals, nonprofit institutions, and educational institutions, in the sector where they sell their services. Implicitly this assumes that the cost of these expenditures will be passed on to consumers in the price of their services. As I don't know the breakdown between buildings, types of equipment, furniture, etc., the only other option is to omit those expenditures.

[12] One can also use a geometric average of the U.S. and country-specific weights, as in Hooper and Larin (1989). Results are virtually indistinguishable. This is consistent with recent results in Rao and Timmer (2003). They investigate the sensitivity to different weighting schemes in aggregating unit value ratios and find that the main impact is at the product level, not the "branch level" (comparable to basic headings).

vary by country, industry, and year.[13]

Because not all output is sold domestically, one should also adjust for exports. The adjustment assumes that exports are exchanged with the rest of the world using the exchange rate and that firms will only export if there is an incentive to.[14] Firms in a country with a domestic price level that exceeds the exchange rate are assumed to export only the trade balance (exports minus imports) or nothing if the country is a net importer. For countries with a domestic price level below the exchange rate, all exports are counted in the export share. If the product is less expensive domestically than abroad, the relevant PPP to convert domestic production into U.S. dollar will be higher than the domestic expenditure PPP, and vice versa:

$$PPP_{\text{production}} = PPP_{\text{net}} * \left(\frac{e}{PPP_{\text{net}}}\right)^{\text{export share}} \tag{6}$$

The first four columns in Table 1 list the exchange rate, published (aggregate) PPP, and unadjusted and adjusted (sectoral) PPPs for the Total economy in 1996. My results are very close to the OECD estimates; both often differ substantially from the exchange rate.[15] The next six columns show the impact of different weights and the tax and trade adjustments on the PPP for Total manufacturing. Clearly, the price of manufacturers relative to the total price level differs substantially by country, underscoring the need for sectoral PPPs.

[Table 1]

Because I construct sectoral PPPs for several years, I am able to test their validity. In the

[13]The ISDB data set was discontinued after 1998. When sectoral tax data was missing, the average tax rate over all non-missing years is used. If data was missing in all years, the tax ratio of the industry one level up in the aggregation is used.

[14]Firms are assumed to export if foreign price levels exceed the domestic price level or if domestic production exceeds domestic consumption. Using exchange rates implicitly assumes that exports are to the U.S. or that, on average, PPP holds across countries. Alternative calculations, replacing the exchange rate in (6) with a weighted average price level for all export destinations, yielded very similar results.

[15]The unadjusted PPP differs slightly from the OECD results because they use the unweighted EKS method to produce a multilateral index and use 3 more basic headings, see before.

next Section, I verify whether the change in sectoral PPP equals the price change relative to the U.S. for that industry, as described by equation (4). Appropriate conversion factors will produce measures of $\beta-$ or $\sigma-$convergence that are independent of the year in which the currency convergence is carried out. Sørensen (2001) argues that aggregate PPP is not appropriate for Manufacturing. In Section 5, I verify whether sectoral PPP passes this test.

3 Direct comparison of relative price evolutions

It is difficult to verify whether the sectoral PPPs adequately capture relative price differences across countries. The ICP regularly evaluates its estimates, most recently in UN (1999), mainly by investigating the accuracy of the collected data. One possibility is to compare the results with those from alternative approaches. The last column in Table 1 lists the unit value ratios for the manufacturing sector in the E.U. countries, taken from O'Mahoney and van Ark (2003). Their estimates are invariably lower, which they explain by the likely inclusion of some ancillary services in the expenditure PPPs, while services in most countries are more expensive than in the U.S. Such differences will affect comparisons of productivity at each point in time, but as long as they remain constant, they will not affect convergence results.

An alternative way to verify the accuracy of the sectoral PPPs is to look at relative price changes directly. If $PPP_i^{¥/\$}$ captures the relative prices of sector i in Japan relative to the U.S., changes in PPP should correspond to the difference in deflation rates for sector i in Japan relative to the U.S. If sectoral PPPs satisfy this equality in equation (4), they will produce productivity comparisons that are invariant to the base year for the currency conversion.

Changes in sectoral PPP are readily obtained from the PPPs calculated in Section 2. Japanese PPP for sector i at time t is calculated as $PPP_{it}^{¥/\$} = \frac{P_{it}^{¥}}{P_{it}^{\$}}$ and the change over time is given by

$$\log \frac{PPP_{it}^{¥/\$}}{PPP_{it-1}^{¥/\$}} = \log \frac{P_{it}^{¥}\big/P_{it}^{\$}}{P_{it-1}^{¥}\big/P_{it-1}^{\$}} = \log \left(\frac{P_{it}}{P_{it-1}}\right)^{¥} - \log \left(\frac{P_{it}}{P_{it-1}}\right)^{\$}. \tag{7}$$

Sector-specific deflation rates are constructed by differencing the nominal and real output growth rates from the STAN database. Real value added for sector i in Japan at time t is calculated as $\frac{\text{nominal VA}_{it}^{J,¥}}{P_{it}^{¥}}$ and the growth rate is

$$\underbrace{\log \frac{\text{real VA}_{it}^{J,¥}}{\text{real VA}_{it-1}^{J,¥}}}_{\dot{var}_{it}^{J,¥}} = \underbrace{\log \frac{\text{nominal VA}_{it}^{J,¥}}{\text{nominal VA}_{it-1}^{J,¥}}}_{\dot{va}_{it}^{J,¥}} - \log \frac{P_{it}^{¥}}{P_{it-1}^{¥}}.$$

Subtracting the deflation rate for the U.S. and rearranging gives an alternative estimate of the relative price change.:

$$(\dot{va}_{it}^{J,¥} - \dot{var}_{it}^{J,¥}) - (\dot{va}_{it}^{US,\$} - \dot{var}_{it}^{US,\$}) = \log \left(\frac{P_{it}}{P_{it-1}}\right)^{¥} - \log \left(\frac{P_{it}}{P_{it-1}}\right)^{\$}. \tag{8}$$

The price changes in (7) and (8) are calculated from entirely different data sources, but they are supposed to measure the same relative price evolution. The first column in Table 2 lists the correlation across countries between relative deflation rates and the change in sectoral PPP, separately for all industries over the 1985-1996 period. Except for Manufacturing, not elsewhere classified & recycling—an industry that differs a lot by country—, all correlation statistics are positive and often very high. Nevertheless, there is substantial variation. A second check, in the second column, lists the number of countries (out of a maximum of 13) for which the sign of the price difference predicted by both equations is the same.

Most researchers comparing productivity across countries, even at the sectoral level, have done so using aggregate rather than sectoral PPP. A switch to sectoral PPP is only warranted if they approximate relative price changes across countries better than the aggregate measures.

To decide which measure is preferable, the same summary statistics for aggregate PPP are included in the third and fourth columns.

The evidence is mixed. For the first nine industries, Agriculture to Non-metallic minerals and for Community, social, and personal services, the correlation is higher for sectoral than aggregate PPP and the sign equality holds for at least as many industries using sectoral PPP. For this group of industries—exactly half of the industries included—it clearly makes sense to use the disaggregate conversion factors. In the remaining ten industries, including the Total economy entry, the correlation statistics are higher for aggregate PPP, even though only six industries have more correct sign predictions using aggregate PPP. For some industries, the use of sectoral PPP will be relatively inconsequential, but for others, most notably Transport equipment, Manufacturing, not elsewhere classified & recycling, Transportation & communication, and Financial & business services, using sectoral PPP would introduce noise.

[Table 2]

The results in Table A.1 in the Appendix, combining shorter term price changes over each pair of consecutive surveys, 1985-1990, 1990-1993, 1993-1996, are less supportive for sectoral PPP. In only four industries, Total manufacturing, Pulp, paper, printing & publishing, Chemicals & plastic products, and Construction are the sectoral PPP results superior for both measures, correlation and sign predictions. Aggregate PPP is preferable for exactly half of the industries. For short run changes, sectoral PPP seems to contain more noise than information, e.g. due to the imperfect mapping or adjustments for trade and taxes, and its use is doubtful at best.

The corresponding results for unit value ratios, in the last two columns of Table 2, are only available for a subset of four countries plus the U.S., but they confirm that changes in sectoral conversion factors can capture relative price changes.[16] In most industries, the correlation

[16]These measures are taken from van Ark (1993) for 1987 and Groningen Growth and Development Centre (1997) for 1997.

is higher than for changes in aggregate PPP. Similarly as the results for the sectoral PPP, they tend to perform better for industries listed higher up in the table. Generally, these are industries that produce less sophisticated manufacturing products.

Another check on the accuracy of the sectoral PPP is whether within each country the two measures for relative price changes are correlated. Aggregate PPP, by construction, ignores changes in relative prices within a country. Using these to compare sectoral productivity implicitly assumes that each industry experiences the same inflation as the total economy or that the relative price changes for each industry follow the same pattern as in the U.S. No differential changes in relative prices are allowed.

The correlations and sign predictions in Table 3 are for relative price changes across industries, separately by country. For ten of the thirteen countries, the change in sectoral PPP is positively correlated with the relative deflation rate. The average correlation statistic is 0.07, positive but low. Only three countries, Australia, France, and Japan, have a negative correlation. Including only Agriculture, Mining, and Manufacturing industries in the comparison, as aggregate PPP was clearly preferred in the other industries, some correlations are substantially increased, even though more countries have negative correlation statistics, see results in the third column. Except for Denmark and Norway, the sectoral PPPs predict the relative price change correctly for the majority of industries.

[Table 3]

The results for price changes over shorter time periods, in Table A.2 in the Appendix, and the results using unit value ratios, in the last two columns of Table 3 confirm that the sectoral conversion factors manage to capture some of the cross-industry variation in relative prices. For most countries, the correlation are firmly positive, only the results for the U.K. are consistently of the wrong sign.

4 Why sectoral PPP is inadequate for some industries

Before turning to convergence results, I explore why sectoral PPP might be an inadequate measure of relative price in some industries or why the calculations in the previous section might be a misleading test of their adequacy. Four likely reasons are international trade, imperfections in the mapping, the absence of relative price changes, and quality adjustments.

Trade

The statistics used to calculate sectoral PPP are collected using domestic price and expenditure surveys, while firms export some of their production and consumers also buy imports. The expenditure weights used to aggregate prices will be imperfect if import penetration varies by product, as is likely. For the trade adjustment to PPP, one needs to make an assumption on the price fetched abroad by exports. Using the average domestic price in the other countries is an alternative to the exchange rate, but results are similar. If exports differ in a systematic way from other goods in the same industry, neither alternative is satisfactory, but without further information nothing can be done. Note that aggregate PPP suffers from the same defects.

Many industries with high trade intensity did have a low correlation between changes in sectoral PPP and relative prices in Table 2. Agriculture is the industry least exposed to trade of all industries for which trade data is available and sectoral PPP did perform very well.[17] Transport equipment, on the other hand, has the greatest trade exposure and aggregate PPP was found to be superior. The effect of trade is investigated in a more systematic way by regressing the ratio of the correlations for sectoral and aggregate PPP, the ratio of the entries in the first and third columns in Table 2, on the average trade intensity. The negative coefficient in the first column of Table 4 suggests a negative relationship between trade and

[17] Only Electricity, gas & water is less exposed to trade, but these goods are often subject to large subsidies and it is unlikely that relative price measures from the consumer and producer side would match up.

the performance of sectoral PPP.[18]

[Table 4]

Mapping

A second reason for the poor results with sectoral PPP in some industries might be errors in the mapping from expenditure categories to industrial sectors. While the sectoral PPPs are fairly robust to the criteria used to make the mapping, the price data might not contain enough information to be representative for each industry. Many service industries had especially few products allocated to them.

The second column in Table 4 contains results for a similar regression as before, but with the number of products allocated to the industry and the within-industry standard deviation of prices as explanatory variables. The positive coefficient on the number of products and the negative coefficient for single product industries suggest that PPP measures improve if they are based on more data. Perhaps surprisingly, a large standard deviation of relative prices within an industry is also associated with better PPP measures. One interpretation is that observing prices over a wide range allows for a more precise estimate of average prices. At the same time, if prices vary a lot, more observations are needed for accurate estimates.

Price changes

A third situation where the use of sectoral PPP might make matters worse is for industries with low relative price changes. In such case, aggregate PPP will do nicely because aggregate price changes resemble the changes in the U.S. for almost all countries included. If relative deflation rates are very low or hardly vary across countries, correlations in Table 2 are bound to be low. The construction of sectoral PPP inevitably introduces some noise, while there was no real problem to start with.

[18] A number of more disaggregate industries were added to the sample, but with only 31 observations the coefficient is not significantly different from zero. Full results are available in Van Biesebroeck (2004).

Using the average absolute size and the standard deviation of the difference between the sectoral and economy-wide deflation rates as explanatory variables in the same regression as before, both coefficients are positive, see the third column of Table 4. If sectoral prices change in line with the aggregate price level, i.e. relative prices do not change, sectoral PPP does not bring much benefit. Similarly, if changes in relative prices are relatively homogeneous across countries, there is again no need for sector-specific conversion factors.[19]

Including the measures for all three reasons at the same time, in the fourth column of Table 4, strengthens the previous findings. Sectoral PPP performs well if trade is low, if a lot of products are used to estimate PPP, and if sectoral prices change a lot and differently across countries.

Quality adjustments

Finally, differences across countries in the extent to which improvements in product quality are controlled for is a fourth reason why changes in sectoral PPP might be imperfectly correlated with sectoral deflation rates. Statistical agencies in each country decompose nominal output changes into price and quantity changes, counting improved quality as higher quantity. Some countries account more widely for quality improvement, which are subtracted from price increases. As a result, the interpretation of sectoral deflation rates might differ by countries. The sectoral PPPs do not face the same problem, because prices of exactly the same goods are compared simultaneously in each country. The relative price at any point in time is well defined and easy to measure, as long as the same products are sold in both countries.

Industries with most scope for quality change are sophisticated manufacturing and service industries. Exactly those where sectoral PPP performed worst in Table 2. The computer industry, in Machinery & equipment, provides the best example. The average price per

[19] In most service sectors the standard deviations are much lower than in manufacturing. Even though the average relative price change is high for many service sectors, it is uniform across countries. For manufacturing sectors, the standard deviations are much larger, on average twice as large, and in percentage of the total price change almost four times as large.

computer changed little over time, while quality improved substantially. The per unit price for all characteristics that consumers value—processor speed, hard drive capacity, quality of the video output—declines constantly. To account for this quality improvement, the U.S. Bureau of Labor Statistics estimates a decrease in the real price and use this to deflate—in this case inflate—industry output. If the adjustment procedure varies by country, the sectoral deflation rates loose comparability. For example, the U.S. recently switched from a matched model approach to an adjustment based on hedonic regressions, see Pakes (2003). This impacts the relative price change obtained from sectoral deflation rates, but leaves sectoral PPP unchanged.

The impact of such adjustments can be gauged from the average price changes in Table A.3 in the Appendix. For most industries, the average deflation rates for the 13 countries is in the same direction and similar in magnitude as in the U.S., and it often corresponds to the average change in sectoral PPP. The only exception is Machinery & equipment, where U.S. prices are estimated to have declined by 28% from 1985 to 1996, while other countries record an average price increase of 19%. Figure A.2 in the Appendix illustrates how different the price evolution is for this industry. For example, between 1985 and 1996 the relative price of machinery relative to all goods for the Netherlands relative to the U.S. increased by 57%. The relative price of machinery declined by 2% in the Netherlands, while the U.S. records an astonishing 59% decline, quality adjusted.

Evidence for this relative increase in Dutch machinery prices is hard to detect in the price surveys that underlie the construction of PPP. Only a few products experienced an increase in price relative to the U.S.: *heaters and air conditioners, vacuum cleaners,* and *record players*. Some more products, e.g. *products of boilermaking, machinery for working wood, refrigerators,* and *television sets*, became relatively cheaper, but the price decline was smaller than for the Dutch aggregate PPP, contributing to the increase in relative price for machinery. Still, examples of products that saw prices relative to the U.S. decline faster than aggregate PPP abound, which works in the opposite direction of the price change suggested by industry deflators. A distinct possibility is that the U.S. goes further in making adjustment for quality improvements than other countries. The price surveys look for standardized products and do not have such a problem.

5 Sectoral convergence

Bernard and Jones (1996) use aggregate PPP to study convergence among 14 OECD countries for six broadly defined sectors. Sørensen (2001) proposes three tests to verify whether their convergence results are invariant to the choice of base year for the currency conversion. He finds that in the manufacturing sector the initial productivity levels for each country relative to the U.S., and hence the convergence conclusions, are not invariant to the base year. No convergence takes place if base years earlier than 1985 are used, while some convergence appears using more recent PPP measures. The price of manufactured goods relative to the aggregate price level must have evolved differently by country, or in other words, equation (4) does not hold with aggregate PPP in manufacturing. For the service sector, which accounts for more than 50% of GDP in the included OECD economies, the use of aggregate PPP did not pose the same problem.

The top row of Figure 1 contains the same three graphs as in Sørensen (2001), reproduced with my data set using aggregate PPP.[20] The bottom row shows the corresponding graphs when sectoral PPP is used for currency conversions. The results are slightly more robust to the year in which the currency conversion is carried out using sectoral PPP than using aggregate PPP. For each of the four base years, there is evidence for $\beta-$convergence, at a 5% significance level. $\sigma-$convergence is taking place in the first half of the sample, but the trend is reversed in the second half. While the results are not completely base year invariant—

[20]For comparability with the corresponding graphs for sectoral PPP, I limit the calculations in the top graphs to the same four base years, even though aggregate PPP is available in each year.

conversion is stronger if more recent PPPs are used—the variation is not large enough to alter the conclusions.

Each line in the graphs on the left represents the initial relative productivity (in 1970) for one country. The years on the X-axes indicate the year in which the currencies are converted to U.S. dollar. Real growth rates are used to bring nominal amounts back to 1970. The statistics for each country are normalized by the average over the four base years (1985, 1990, 1993, and 1996). If the currency conversion was independent of the base year, all lines would be horizontal at one. This is clearly not the case for aggregate PPP, but only marginally more so for sectoral PPP. The average standard deviation by country is 0.12 using aggregate PPP and 0.11 using sectoral PPP.

The graphs in the center plot the coefficient estimate and 95% confidence bound for β-convergence, again using the different base years to convert initial productivity levels. The relevant coefficient is obtained from an OLS regression of average real productivity growth over the 1970-2000 period on log initial productivity pooling all countries. If the currency conversion were base year invariant, we would find a horizontal line. A line above zero would be evidence of divergence, below zero of convergence. The results using aggregate PPP are insignificant for early base years, which led Bernard and Jones (1996)—who used 1985—to conclude no convergence was taking place in manufacturing. The point-estimates for the last two base years are significantly below zero and hint at convergence. Using sectoral PPP, in the center-bottom graph, convergence is always significant, for any of the four base years.

Finally, the graphs on the right provide an estimate of σ-convergence. The standard deviation of productivity levels across countries, normalized by the standard deviation in the first year, is plotted for each year. Every base year for the currency conversion generates a different curve. The line using aggregate PPP for 1996 (blue with x-marks) is trending down until 1995, indicative of convergence early on, and bends sharply upward afterwards, suggesting divergence in recent years. Using aggregate PPP from any of the earlier years, the curves bend upward much earlier; divergence starts already in 1980 and it is much more pronounced. If the conversion factors were time invariant, all four lines would lie on top of one another. This is largely the case in the bottom graph for sectoral PPP. Convergence is taking place throughout the seventies and eighties, but ends in the early nineties, after which the countries diverge rather strongly. Note that the curves for 1996 and 1985 are particularly close and that only the intermediate curves for 1990 and 1993 fluctuate. The sectoral PPPs capture longer term changes in relative prices rather well, but they are not able to pick up short term changes. We reached the same conclusion comparing the results in Tables 2 and A.1 and Tables 3 and A.2 in the previous Section.

[Figure 1]

Finally, I plot the sectoral convergence results for all industries in Figures 2 and 3. I only look at labor productivity, as Bernard and Jones (1996) indicate that the results for TFP are largely similar.[21] For each industry, I use the convergence factor that was found to be most appropriate in Section 3, i.e. sectoral PPP for the first nine and the second last industries in Table 2 and aggregate PPP for the other industries.

The graphs in Figure 2 show the $\beta-$convergence results in the same format as the center graphs in Figure 1 using each of the four base years to convert currencies . This measures the extent to which productivity growth across countries is explained by the initial productivity level. The reported statistic (the red line) is the regression coefficient on the initial productivity level when average productivity growth over the full sample period is the dependent variable. The least squares regression is run separately by industry and for each of the four base years. The green lines indicate a 95% confidence bound. Virtually all sectors have negative coefficient estimates, indicating convergence, and most are significantly different from zero. Convergence is strongest in Electricity, gas & water, Trade, and Financial

[21] The data used here extend the time period studied by Bernard and Jones (1996) by five years.

services. Moreover, most lines are nearly horizontal, indicating that the base year for the currency conversion is immaterial. The only industry with a distinct trend in the estimates is Machinery & equipment. Using 1985 (aggregate) PPP gives in an insignificant coefficient estimate, which turns negative if more recent PPP estimates are used.[22]

[Figure 2]

The graphs in Figure 3 show the results for $\sigma-$convergence in the same format as the graphs on the right in Figure 1. This measures the change over time in standard deviation of productivity levels across countries. Each line plots the annual standard deviation, normalized by the standard deviation in 1970, for a different base year. If convergence is taking place, the lines should trend downward. While this is the case for some industries, most notably Total economy, Electricity, gas & water, and Trade, the pattern is by no means universal.

Moreover, while the lines for most industries follow a very similar pattern over time, they sometimes diverge for at least one base year. For example, Financial services and Trade displayed strong $\beta-$convergence in Figure 2 for any base year, but $\sigma-$convergence is much stronger using recent PPP estimates than using 1985 PPP. While one would expect more variability in these annual statistics relative to the regression results in the previous graphs, some conclusions are not independent of the base year anymore. In four industries, Agriculture, Construction, Machinery & Equipment, and Manufacturing NEC, using 1985 PPP would lead one to conclude no convergence is taking place, while 1996 PPP would lead to strong $\sigma-$convergence conclusions. Using the alternative PPP estimates (aggregate PPP for Agriculture and sectoral PPP for the latter three) would not change this troubling result.

One finding for Total manufacturing that holds up at a number of more disaggregate manufacturing sectors is the trend towards convergence in the first part of the sample and divergence towards the end. Finally, there is no obvious pattern in the industries that display

[22] Results are no more robust to the base year if sectoral PPP is used instead for this industry.

the strongest $\sigma-$convergence. It includes industries that produce highly tradable products—e.g. Textiles and Metals—but also industries that produce nontradables—e.g. Electricity, gas & water or Wholesale and retail trade.

[Figure 3]

6 Conclusions

Relative prices evolve differently by country and one should account for this when studying sectoral convergence. The sectoral PPP indices do the job relatively well for several "industrial" sectors, but only longer term price changes are captured well. We can draw two conclusions from Figures 1, 2 and 3 .

First, using sectoral PPP to convert Total manufacturing output leads to convergence conclusions which are base year invariant. $\beta-$convergence results are notably more robust than $\sigma-$convergence results. For most industries investigated, using the most appropriate conversion factor will achieve that same feat. Results still vary somewhat by base year, but with few exceptions not enough to affect the conclusions and certainly less than using aggregate PPP throughout.

Second, the Total manufacturing sectors in 14 OECD countries have been converging in productivity in the first two decades of the 1970-2000 period, but this trend has been reversed noticeably in the last ten years. $\beta-$convergence conclusions are the same in every sector: initial productivity laggards have enjoyed higher average productivity growth. $\sigma-$convergence results are less uniform. The strong downward trend in standard deviation for the total economy is not replicated in most industries.

References

Bernard, A. B. and C. I. Jones (1996, December). Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries. *American Economic Review 86*(5), 1216–38.

Bernard, A. B. and C. I. Jones (2001, September). Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries: Reply. *American Economic Review 91*(4), 1168–69.

Bradford, S. (2003, February). Paying the Price: Final Goods Protection in OECD Countries. *Review of Economics and Statistics 85*(1), 24–37.

Conrad, K. and D. W. Jorgenson (1985). Sectoral Productivity Gaps between the United States, Japan and Germany, 1960-1979. In H. Giersch (Ed.), *Probleme und Perspectiven der Weltwirschaftlichen Etwicklung*, pp. 335–47. Berlin: Duncker and Humblot.

Dollar, D. and E. N. Wolff (1988, November). Convergence of Industry Labor Productivity among Advanced Economies, 1963-1982. *Review of Economics and Statistics 70*, 549–558.

Dowrick, S. and J. Quiggin (1997, March). True Measures of GDP and Convergence. *American Economic Review 87*(1), 41–64.

Durlauf, S. N. and D. T. Quah (1999). The New Empirics of Economic Growth. In J. B. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics, Volume 1A*, Chapter 4. New York: North-Holland.

Groningen Growth and Development Centre (1997). ICOP Database 1997 Benchmark. Technical report, http://www.ggdc.net.

Harrigan, J. (1999). Estimation of Cross-country Differences in Industry Production Functions. *Journal of International Economics 47*, 267–93.

Hooper, P. and K. A. Larin (1989, December). International Comparisons of Labor Costs in Manufacturing. *Review of Income and Wealth 35*(4), 335–355.

Jorgenson, D. W. and M. Kuroda (1990). Productivity and International Competitiveness in Japan and the United States, 1960-1985. In C. R. Hulten (Ed.), *Productivity Growth in Japan and the United States*, Volume 53 of *NBER Studies in Income and Wealth*, Chapter 2, pp. 29–57. Chicago, IL: University of Chicago Press.

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

Kravis, I. B., A. W. Heston, and R. Summers (1978). *World Product and Income: International Comparisons of Real Growth Product*. Baltimore: Johns Hopkins University Press.

Lee, F. C. and J. Tang (2001). Productivity Levels and International Competitiveness Between Canada and the United States. In D. W. Jorgenson and F. C. Lee (Eds.), *Industry-Level Productivity and International Competitiveness Between Canada and the United States*, Chapter 5, pp. 155–180. Ottawa: Industry Canada Research Monograph.

OECD (2002). *Purchasing Power Parities and Real Expenditures - 1999 Benchmark year.* Paris: OECD.

O'Mahoney, M. and B. van Ark (2003). EU Productivity and Competitiveness: An Industry Perspective. Can Europe Resume the Catching-up Process? Technical report, Office for Official Publications of the European Communities, Luxembourg.

Pakes, A. (2003, December). A Reconsideration of Hedonic Price Indexes with an Application to PC's. *American Economic Review 93*(5), 1578–97.

Pilat, D. (1996). Labour Productivity Levels in OECD Countries: Estimates for Manufacturing and Selected Service Sectors. Economics Department Working Papers 169, OECD, Paris.

Rao, D. S. P. and M. P. Timmer (2003, December). Purchasing Power Parities for Industry Comparisons Using Weighted Elteto-Koves-Szule (EKS) Methods. *The Review of Income and Wealth 49*(4), 491–512.

Sørensen, A. (2001, September). Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries: Comment. *American Economic Review 91*(4), 1160–67.

UN (1999). Evaluation of the International Comparison Programme. Technical report, United Nations, Secretary-General, Economic and Social Council.

van Ark, B. (1993). *International Comparisons of Output and Productivity. Manufacturing Productivity Performance of Ten Countries from 1950 to 1990.* Monograph Series No. 1. Groningen.

van Ark, B. and D. Pilat (1993). Productivity Levels in Germany, Japan, and the United States: Differences and Causes. *Brookings Papers on Economic Activity: Microeconomics 2*, 1–69.

van Ark, B. and M. Timmer (2001). PPPs and International Productivity Comparisons: Bottlenecks and New Directions. Working Paper for Joint World Bank-OECD Seminar on Purchasing Power Parities.

Van Biesebroeck, J. (2004, January). Cross-country Conversion Factors for Sectoral Productivity Comparisons. *NBER Working Paper,* No. 10279.

Figure 1: Three convergence tests for the manufacturing sector

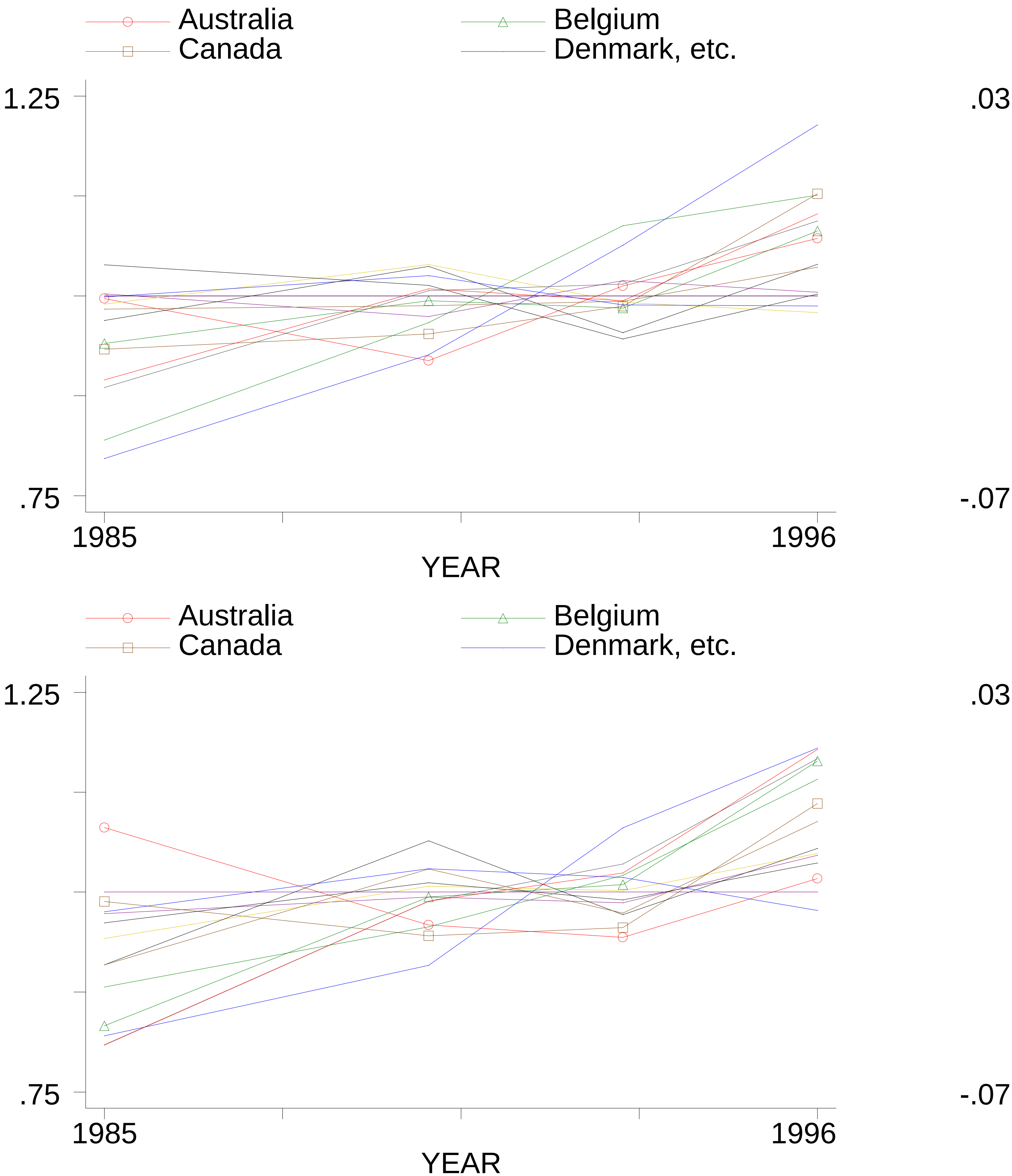

Figure 2: Three convergence tests for the manufacturing sector

Figure 3: Three convergence tests for the manufacturing sector

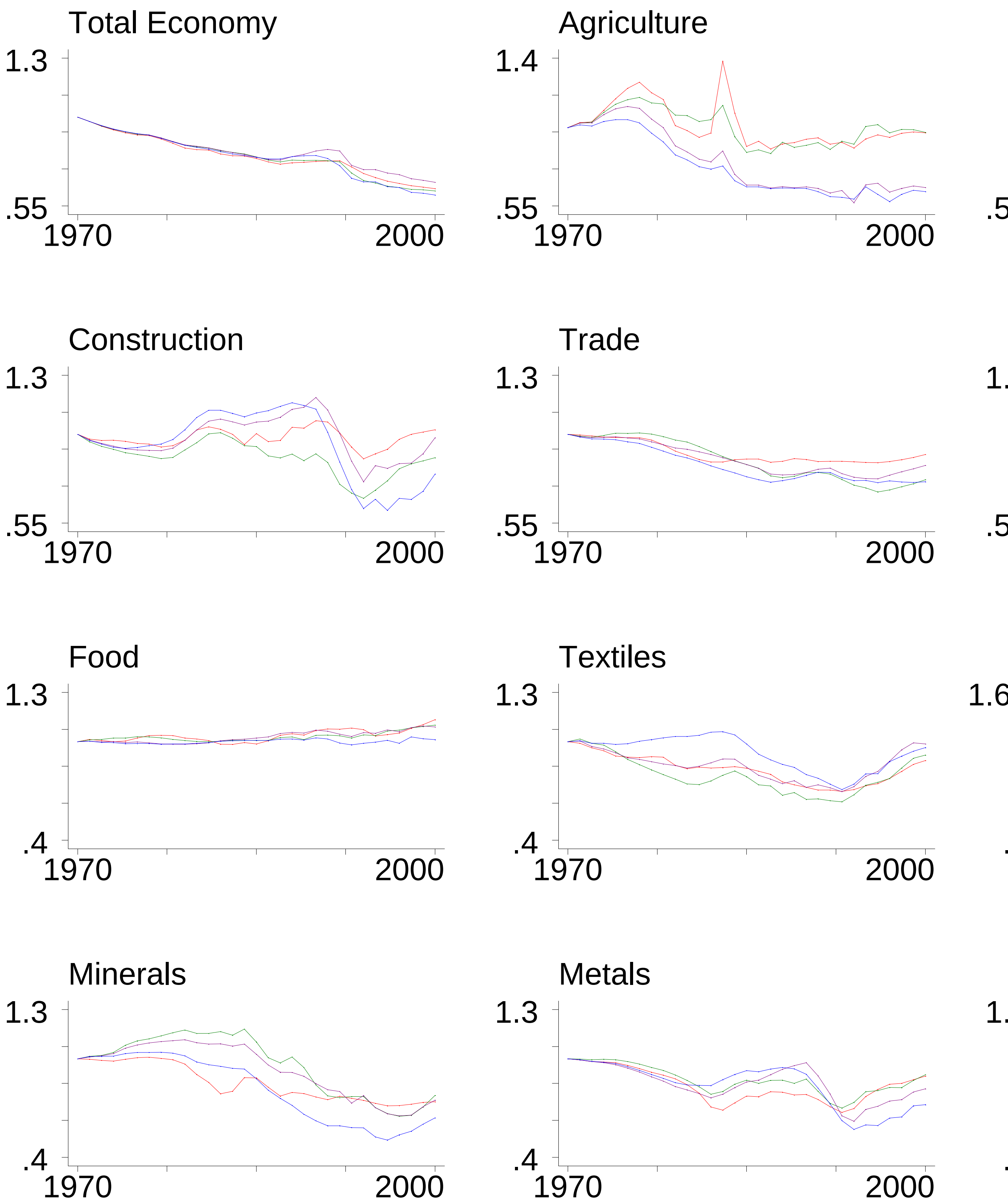

Table 1: Currency conversion factors in 1996

	Total economy				Manufacturing PPP						Manufact.
	Exchange Rate[1]	GDP-PPP (OECD)[1]	PPP (own)	PPP-adjusted	country weights	US weights	average	tax adjusted	trade adjusted	both adjusted	Unit value ratios (1997)[2]
Australia	1.28	1.30	1.28	1.26	1.57	1.60	1.59	1.51	1.59	1.51	
Belgium	0.77	0.91	0.91	0.96	1.08	1.10	1.09	1.11	1.07	1.09	0.88
Canada	1.36	1.19	1.15	1.11	1.39	1.37	1.38	1.40	1.38	1.40	
Denmark	5.80	8.33	8.34	7.82	9.61	9.74	9.68	8.80	9.54	8.71	7.21
Finland	0.77	0.99	0.99	1.07	1.29	1.32	1.30	1.36	1.24	1.28	0.92
France	0.78	1.00	0.99	1.02	1.13	1.15	1.14	1.10	1.13	1.09	0.95
Germany	0.77	1.04	1.01	1.05	1.08	1.13	1.11	1.06	1.09	1.05	0.98
Italy	0.80	0.82	0.84	0.88	1.04	1.07	1.05	1.07	1.04	1.06	0.76
Japan	108.8	166.0	159.4	162.0	196.8	200.8	198.8	188.0	194.8	184.7	
Netherlands	0.77	0.93	0.90	0.96	1.01	1.06	1.03	1.02	1.02	1.01	0.89
Norway	6.45	9.11	9.08	9.71	10.93	11.19	11.06	11.78	11.06	11.78	
Sweden	6.71	9.68	9.55	10.25	11.14	11.45	11.29	11.68	10.84	11.16	8.75
U. K.	0.64	0.64	0.65	0.62	0.81	0.81	0.81	0.74	0.81	0.74	0.70

Source: [1] OECD web site; [2] O'Mahoney and van Ark (2003); remainder: own calculations

For all countries currently in the euro zone, PPPs and exchange rate have been expressed in euros.

Table 2: Correlations across countries between changes in PPP and relative prices (1985-96)

Industry	Sectoral PPP		Aggregate PPP		Sectoral UVR[1]	
	corr.	= sign	corr.	= sign	corr.	= sign
Agriculture	0.76	12	0.66	11		
Mining	0.41	9	0.32	9		
Total manufacturing	0.73	12	0.66	9	0.74	3
Food, beverages, tobacco	0.68	12	0.60	10	0.91	4
Textiles, wearing apparel, leather	0.66	11	0.63	11	0.91*	3*
Wood & cork	0.45	8	0.14	7	0.74	4
Pulp, paper, printing, publishing	0.57	9	0.48	7	-0.46	4
Chemical & plastic products	0.65	11	0.53	9	0.69*	2*
Non-metallic minerals	0.81	9	0.64	8	0.37	2
Basic & fabricated metals	0.28	10	0.61	8	0.51	2
Machinery & equipment	0.39	8	0.42	8	-0.33	1
Transport equipment	0.36	7	0.57	9	0.96	1
Manufacturing NEC & recycling	-0.09	6	0.38	6	-0.79	2
Electricity, gas & water supply	0.56	10	0.65	7		
Construction	0.37	9	0.54	10		
Wholesale & retail; Rest. & Hotels	0.64	9	0.79	10		
Transport & communication	0.42	7	0.67	10		
Financial & business services	0.09	6	0.96	12		
Comm., soc. & pers. services	0.92	11	0.89	11		
Total economy	0.88	11	0.96	12		

[1] 1987-1997, based on only 4 countries plus the U.S. (listed in Table 3)

* aggregated from underlying two-digit industries

Table 3: Correlations across industries between changes in PPP and relative prices (1985-96)

	All sectors (20)		Agriculture, mining, manufacturing (13)		UVR manufacturing (14)	
	corr	= sign	corr	= sign	corr	= sign
Australia	-0.07	13	0.56	11		
Belgium	0.12	15	0.27	10		
Canada	0.09	15	-0.08	9		
Denmark	0.08	10	-0.34	5		
Finland	0.09	12	0.58	11		
France	-0.11	15	-0.04	9	0.05	8
Germany	0.02	15	-0.45	10	0.11	10
Italy	0.33	15	0.59	9		
Japan	-0.13	19	-0.21	12		
Netherlands	0.26	19	0.12	13	0.38	10
Norway	0.08	10	-0.13	7		
Sweden	0.18	17	0.26	11		
U. K.	0.00	14	0.17	9	-0.02	6
average	0.07	14.5	0.10	9.5	0.13	8.5

Table 4: Explaining the correlation between changes in sectoral PPP and relative prices

	Trade	Mapping	Price change	All three
Average trade share	-0.633			-1.923
	(.61)			(.49)
Number of products		0.007		0.014
		(.01)		(.01)
Single product		-0.138		-0.089
		(.68)		(.48)
Standard deviation across products		1.087		0.800
		(.54)		(.43)
Absolute sectoral deflation			1.129	0.478
			(1.43)	(1.17)
Stand. dev. of rel. sectoral deflation			1.604	2.705
			(1.15)	(1.06)
Observations	31	31	31	31
R^2	0.04	0.16	0.32	0.63

Least squares regressions with as dependent variable the ratio of the correlation between changes in sectoral PPP and relative prices and the equivalent correlation for aggregate PPP (the ratio of entries in the first and third column of Table 2). 11 more disaggregate industries are included, see Van Biesebroeck (2004).

Appendix

Figure A.1: Relative deflation rates for three countries across industries (1985-1996)

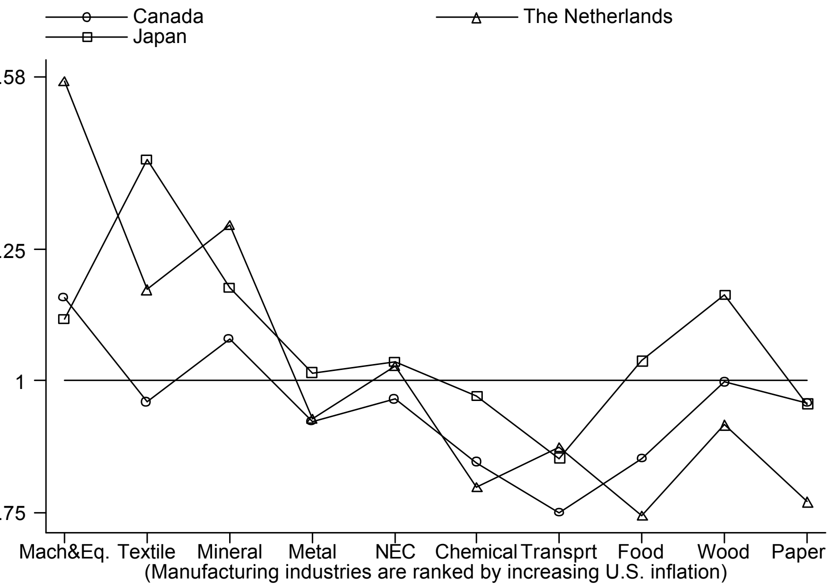

Figure A.2: Relative deflation rates for three industries across countries (1985-1996)

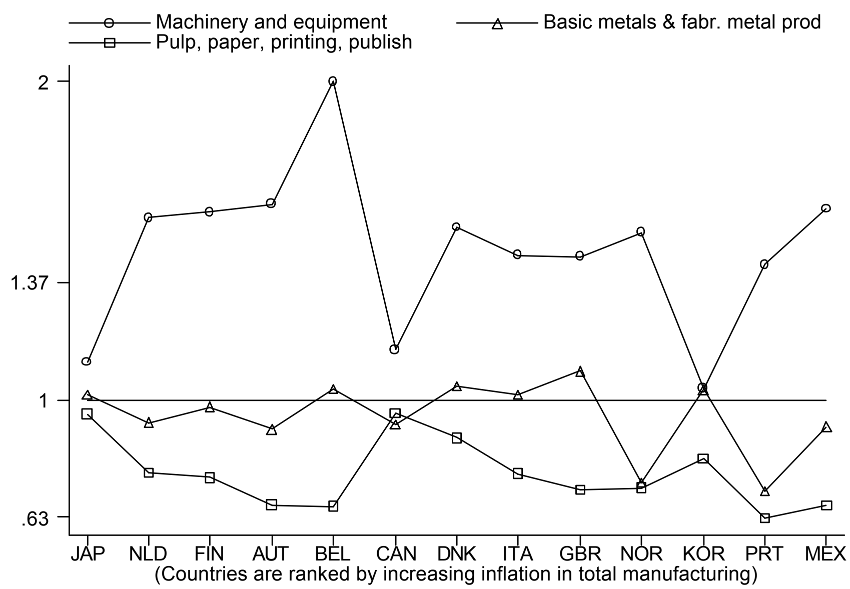

Table A.1: Correlations across countries between changes in PPP and relative prices (1985-90, 1990-93, 1993-96)

Industry	Sectoral PPP		Aggregate PPP	
	corr.	= sign	corr.	= sign
Agriculture	0.25	20	0.35	24
Mining	0.22	18	0.25	23
Total manufacturing	0.43	29	0.23	23
Food, beverages, tobacco	0.54	33	0.52	30
Textiles, wearing apparel, leather	0.29	27	0.25	27
Wood & cork	-0.07	18	0.16	22
Pulp, paper, printing, publishing	0.33	29	0.29	28
Chemical & plastic products	0.55	30	0.51	29
Non-metallic minerals	0.09	21	0.47	29
Basic & fabricated metals	0.08	20	0.36	24
Machinery & equipment	0.25	22	0.37	26
Transport equipment	0.16	17	0.29	25
Manufacturing NEC & recycling	0.01	24	0.25	27
Electricity, gas & water supply	0.25	31	0.64	29
Construction	0.56	27	0.47	25
Wholesale & retail; Rest. & Hotels	0.23	29	0.57	26
Transport & communication	0.24	26	0.46	25
Financial & business services	0.31	25	0.81	31
Comm., soc. & pers. services	0.65	31	0.76	33
Total economy	0.82	34	0.88	31

Table A.2: Correlations across industries between changes in PPP and relative prices (1985-90, 1990-93, 1993-96)

	All sectors (20)		Agriculture, mining, manufacturing (13)	
	corr	= sign	corr	= sign
Australia	0.05	39	0.10	25
Belgium	0.39	43	0.51	28
Canada	-0.08	33	-0.15	20
Denmark	0.01	35	-0.16	18
Finland	0.12	36	0.14	20
France	-0.04	41	-0.19	25
Germany	0.41	39	0.30	24
Italy	0.23	43	0.38	26
Japan	0.14	45	0.11	28
Netherlands	0.40	46	0.31	28
Norway	0.15	36	0.04	20
Sweden	0.01	39	-0.04	24
United Kingdom	-0.38	36	-0.40	22
average	0.11	39.3	0.07	23.7

Table A.3: Price and PPP changes for the U.S. and other countries (1985-96)

	Change in sectoral deflator			Change in
	U.S.	other countries	difference	in sectoral PPP
Agriculture	0.22	0.10	-0.12	-0.07
Mining	-0.33	-0.33	-0.03	-0.14
Total manufacturing	0.19	0.28	0.08	-0.02
Food, beverages, tobacco	0.45	0.31	-0.14	-0.02
Textiles, wearing apparel, leather	0.15	0.30	0.15	0.16
Wood & cork	0.53	0.34	-0.19	-0.46
Pulp, paper, printing, publishing	0.54	0.39	-0.15	-0.20
Chemical & plastic products	0.31	0.22	-0.09	-0.04
Non-metallic minerals	0.17	0.34	0.17	-0.13
Basic & fabricated metals	0.22	0.26	0.04	0.06
Machinery & equipment	-0.28	0.19	0.46	-0.14
Transport equipment	0.41	0.34	-0.07	-0.21
Manufacturing NEC & recycling	0.30	0.39	0.09	-0.23
Electricity, gas & water supply	0.19	0.25	0.07	0.24
Construction	0.36	0.38	0.02	-0.07
Wholesale & retail; Rest. & Hotels	0.23	0.33	0.10	-0.19
Transport & communication	0.12	0.20	0.08	-0.13
Financial & business services	0.44	0.47	0.03	-0.53
Comm., soc. & pers. services	0.49	0.41	-0.08	-0.19
Total economy	0.31	0.29	-0.01	-0.08