Chapter VII Data Sources and Methodology

Robert Inklaar, Lucy Stokes, Edwin Stuivenwold
Marcel Timmer and Gerard Ypma

VII.1 General Introduction on Performance Measurement Issues

Over the past decades there have been increasing concerns about whether the macroeconomic statistics correctly trace output, employment and productivity changes in the knowledge economy. Most famous is of course the Solow quip that "you can see computers everywhere, except in the statistics" (Solow, 1987). Also Griliches (1994) shows a striking difference between the acceleration of labour productivity growth in 'measurable' sectors of the US economy (agriculture, mining, manufacturing, transport and communication, and public utilities) and the slowdown in 'unmeasurable' sectors (like construction, trade, the financial sector, 'other' market services and government). Apart from this rise in measurement error at the aggregate level due to a shift towards the unmeasurable sectors of the economy, one may also observe an increase in measurement problems in the 'unmeasurable' sector itself. This component of the rise in measurement problems may – at least in part – be related to the increased use of ICT.

For a comprehensive view of measurement problems concerning output, value added and productivity, one needs to make a distinction between the various sources of measurement problems. These can be divided into four categories, namely measurement problems with regard to output in manufacturing (which is the major industry of the 'measurable' sector of the economy) and output in services (which dominate the 'unmeasurable' sector) vis-à-vis measurement problems concerning the inputs (production factors and intermediate inputs) in manufacturing and services. The diagram below presents a summary of the major issues in each quadrant as well as the most desirable and feasible solutions (van Ark, 2002).

	Manufacturing	Services
Output	Primarily computers and other ICT, Solution primarily through use of Hedonic price indices Feasible provided data availability	Most services with "customised" production, and non-market services (education, health, etc.) Solutions through detailed surveys on multiple dimensions of output for each industry Difficult in methodological terms as well as in terms of data availability

Input	Primarily semiconductors and software	Primarily ICT input including software
	Solution primarily through use of Hedonic price indices	Solution through use of real input series adjusted with hedonic price deflators
	Feasible given availability of data and use of input-output matrices	Feasible provided availability of capital-flow matrices

For manufacturing output the problems are relatively straightforward. Nominal output and prices of industrial products are relatively easy to measure. The measurement problems in the northwest quadrant of the diagram are therefore largely confined to measuring ICT output in constant prices. It is well known that the capabilities of semiconductors and computers have improved tremendously over the past few decades.[1] Since consumers can buy computers with vastly more computing power at comparable prices, the price of computing power has declined continuously. However, traditional methods of sampling and calculating price indices for these goods will almost certainly underestimate the rate of price decline and, as a result, the rate of productivity growth. At present there are only a few countries, like the US and Canada, that have a comprehensive system in place for measuring prices of computers and semiconductors.

An adequate implementation of hedonic deflators, however, requires some further considerations. Apart from adjusting the deflator for computer output, it is also necessary to make an adjustment for the most important ICT inputs in industry (the southwest quadrant of the diagram above). For example, Triplett (1996) shows that between 1974 and 1994 the prices of semiconductors declined almost 3000 times compared to only 20 times for computers over the same period.[2]

To ensure international comparability of ICT deflators, a harmonised procedure has been applied in the industry databases for this report. Thus value added deflators for ICT-producing industries (derived with a double deflation procedure) and ICT investment in the US are applied to the same industries in all other countries, after adjusting for differences in general inflation (see section VII.2).

In contrast to manufacturing, measurement problems in the service sector (the southeast quadrant of the diagram) are perhaps easier to deal with for inputs than for output output (the

[1] See Nordhaus (2001) for a long-term perspective on the increase in computing power.
[2] See also Jorgenson (2001) for updated series and Triplett (1996) for the importance of double deflation in the computer and semiconductor industries.

northeast quadrant of the diagram). The most important technological inputs in the service sector are ICT products, which give rise to the same measurement issues as for ICT output. The share of computers and other high tech equipment in the inputs in market services has strongly increased in most OECD countries. A major problem here is the measurement of own-account software which makes up a substantial part of investment. They create the greatest problems in terms of international comparability (Lequiller et al. 2003).

The largest measurement problems, however, relate to the measurement of output in the service sector. There are only few possible ways to resolve this without re-estimation by the national statistical offices. The current methodology of splitting the change in output value into a quantity component and a price component is difficult to apply to many service activities, as often no clear quantity component can be distinguished. Moreover, possible changes in the quality of services are also difficult to measure. These problems are not new, and improvement in the measurement of service output has been a topic on the agenda of statisticians and academics for a long time.[3] In many service industries information on inputs (such as labour income) was and still is used as a proxy for output.

The increased importance of ICT may have accelerated quality changes in services. For example, improved inventory management in the distribution sector makes it possible to differentiate the supply of goods in terms of time, place and type of product. The application of ICT has supported the customization of financial products or combinations of products (like an insurance, an investment fund and a mortgage). Services in the public sector, such as health care, are also increasingly characterised by diversity and differentiation in time, place and type of treatment. Even though such changes have not exclusively led to upward adjustments of real output, on balance the bias is probably towards an understatement of the growth in real service output (Triplett and Bosworth, 2000).

It should be emphasised that statistical offices are doing much to improve measurement methods. In the United States, the US Bureau of Labor Statistics (which is responsible for the development of price indices) and the Bureau of Economic Analysis (which produces the National Income and Product Accounts) have introduced various improvements in measurement methods (Dean, 1999; Gullickson and Harper, 1999; Landefeld and Fraumeni, 2001). In a series of reports, Eurostat recently evaluated measurement practices in various service activities, such as financial services and public services, and 'difficult to measure' goods industries, such as computers and large equipment (Eurostat, 2001).

[3] See, for example, Griliches (1992) and the statistical work of the Voorburg Group on Service Statistics (http://www4.statcan.ca/english/voorburg/).

In conclusion, measurement error at macroeconomic level has partly increased because of the greater share of 'difficult to measure' industries in the economy. In addition, there are indications that within these industries, in particular in services, measurement errors get bigger because of the increased use of ICT. It is not clear, however, whether these problems have systematically led to biases which differ across countries or over time. As discussed above in Chapters I and III it appears that non-market services add more to overall productivity growth in the European Union than is the case for the US. In several countries important adjustments to national accounts measurement are being implemented or considered, for example, for the measure of output in the finance sector in several countries. It also appears that the use of hedonic price indices, which is applied or experimented with by many statistical offices, is a promising avenue to improve the measurement of real output of and inputs for computers. The biggest problem area, however, remains the measurement of real output in many service industries.

VII.2 Databases for this project

Specifically for the purpose of this report, three new databases have been created. Most importantly, an industry database on labour productivity has been constructed including series on value added and labour input covering 56 industries for all 15 EU member states and the US allowing output and labour productivity growth comparisons.[4] Secondly, an industry growth accounting database was constructed for four European countries (France, Germany, Netherlands and UK) and the US allowing calculation of the contribution to growth from ICT-capital and total factor productivity. Finally a database was developed on relative measures of levels of productivity and unit labour cost in manufacturing, with relative levels being derived on the basis of unit value ratios (UVRs). The latter database is part of the International Comparisons of Output and Productivity (ICOP) programme at the University of Groningen.[5]

The databases are described in more detail below, and are available in electronic format in a CD-ROM with this report. Updates and extensions can be downloaded from the websites of the Groningen Growth and Development Centre and the National Institute of Economic and Social Research.[6]. The Industry Labour Productivity Database are time series in spreadsheets for each variable in individual country files. For each variable there is also an underlying

[4] At present the database covers 56 industries.
[5] See http://www.eco.rug.nl/dseries/icop.html
[6] See http://www.ggdc.net/dseries/ and http://www.niesr.ac.uk/

spreadsheet describing sources and methods. The industry growth accounting database has a similar format, with sources and methods described in more detail below (sub-section B). The database on labour productivity and unit labour costs is available in separate files for each of the two variables, with spreadsheets for individual countries. Sources and methods are described in sub-section C.

A. Industy labour productivity database for the European Union and the US

Introduction

The Industry Labour Productivity Database provides a comprehensive internationally comparable dataset on industrial performance at a detailed industry level for the 15 EU countries and the US. It enables the user to design indicators such as shares of output and employment by industry and to analyse trends in value added and labour productivity. Variables covered include current value added, value added deflators, persons engaged, number of employees, hours worked and labour compensation for 56 industries for the period 1979-2001.

The Industry Labour Productivity Database updates and extends previous work at the Groningen Growth and Development Centre (GGDC) and the National Institute on Economic and Social Research (NIESR) recently described in, for example, van Ark, Inklaar and McGuckin (2002) and O'Mahony and de Boer (2002). For most variables and countries, the OECD STructural ANalysis (STAN) database is taken as the point of departure, which in turn is largely based on recent national accounts of individual OECD member states.[7] The STAN data is complemented, updated and backdated and further disaggregated by the use of information from industry surveys and additional information from (historical) national accounts of individual countries to provide a complete and up-to-date data set for the period 1979-2001. In general the method employed was to use STAN aggregates as control totals and the other data to divide these totals into sub-industries.[8] In a limited number of cases STAN also includes working hours per person employed (or per job), but for many countries alternative sources had to be employed to obtain these estimates.

Country Coverage

Table VII.1 provides a list of countries covered in the database. All 15 EU countries are covered as well as the United States. Aggregate estimates for the EU as a whole are also provided.

[7] See http://www.oecd.org/document/15/0,2340,en_2649_33703_1895503_119656_1_1_1,00.html

[8] Appromixately 50 per cent of individual cells in the Industry Labour Productivity Database is directly derived from OECD STAN, whereas the other 50 per cent represents extensions.

Table VII.1 List of countries in databases

Belgium	BE	Luxembourg	LU
Denmark	DK	Netherlands	NL
Germany*	DE	Austria	AT
Greece	GR	Portugal	PT
Spain	ES	Finland	FI
France	FR	Sweden	SW
Ireland	IR	United Kingdom	UK
Italy	IT	United States	US

* separate series are provided for West Germany for 1979-1991 and for unified Germany from 1991-2001

Industry coverage

Data are provided for 56 industries in total. The industries are classified according to the International Standard Industrial Classification (ISIC) revision 3. This classification is very close to the European NACE rev 1 classification system). Table VII.2 provides a listing of the industries. The industry division is more detailed than in STAN which allows a focus on industries which are characterised by high ICT-investment shares and/or ICT-goods production. For example, additional entries were included for five of the six ICT producing industries (semiconductors, ISIC 321; communication equipment, 322, fiber optics, 313; radio and TV equipment, 323; and instruments, 331). Separate entries are also included for motor vehicle trade and repairs, wholesale and retail trade (ISIC 50, 51 and 52) and professional and "other" business services (ISIC 741-743 and 749).

Variables

The following variables are covered:

Value added is current gross value added measured at producer prices or at basic prices, depending on the valuation used in the national accounts. It represents the contribution of each industry to total GDP.

Deflator is the change in the value added deflator. It can be combined with current value added to derive quantity indices of real value added at industry level.

Persons engaged comprises number of workers engaged in production, including employees as well as self-employed, working proprietors and unpaid family workers.

Employees is the number of employees.

Hours refers to average annual hours worked per employee or per person engaged.

Labour compensation is current price labour costs borne by the employer. It includes wages as well as the costs of supplements such as employer's compulsory pension or medical payments. It refers to compensation of employees only.[9] Labour costs can exceed value added in cases where an industry incurs losses, or when an industry receives significant net subsidies.

Table VII.2 Industries in the labour productivty database

	Industry Name	ISIC rev 3
	TOTAL ALL INDUSTRIES	**01-99**
1	Agriculture	01
2	Forestry	02
3	Fishing	05
4	Mining and quarrying	10-14
5	Food, drink & tobacco	15-16
6	Textiles	17
7	Clothing	18
8	Leather and footwear	19
9	Wood & products of wood and cork	20
10	Pulp, paper & paper products	21
11	Printing & publishing	22
12	Mineral oil refining, coke & nuclear fuel	23
13	Chemicals	24
14	Rubber & plastics	25
15	Non-metallic mineral products	26
16	Basic metals	27
17	Fabricated metal products	28
18	Mechanical engineering	29
19	Office machinery	30
20	*Insulated wire*	*313*
21	*Other electrical machinery and aparatus nec*	*31-313*
22	*Electronic valves and tubes*	*321*
23	*Telecommunication equipment*	*322*
24	*Radio and television receivers*	*323*
25	*Scientific instruments*	*331*
26	*Other instruments*	*33-331*
27	Motor vehicles	34
28	*Building and repairing of ships and boats*	*351*
29	*Aircraft and spacecraft*	*353*
30	*Railroad equipment and transport equipment nec*	*352+359*
31	Furniture, miscellaneous manufacturing; recycling	36-37
32	Electricity, gas and water supply	40-41
33	Construction	45
34	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50
35	Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
36	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52
37	Hotels & catering	55
38	Inland transport	60
39	Water transport	61
40	Air transport	62
41	Supporting and auxiliary transport activities; activities of travel agencies	63
42	Communications	64
43	Financial intermediation, except insurance and pension funding	65
44	Insurance and pension funding, except compulsory social security	66
45	Activities auxiliary to financial intermediation	67
46	Real estate activities	70
47	Renting of machinery and equipment	71
48	Computer and related activities	72
49	Research and development	73
50	*Legal, technical and advertising*	*741-3*
51	*Other business activities, nec*	*749*
52	Public administration and defence; compulsory social security	75
53	Education	80
54	Health and social work	85
55	Other community, social and personal services	90-93
56	Private households with employed persons	95

[9] In some cases the variable employees and labour compensation are replaced by one variable: compensation per employee, depending on data availability.

Sources

The construction of the Industry Labour Productivity Database was done in a two-step procedure to ensure national accounts compatibility. Basic point of departure is the STAN database. STAN provides data which is generally based on the latest official national accounts data of individual OECD member states. Due to changes in industrial classifications and the introduction of the new 1993 System of National Accounts (SNA) and the 1995 European System of Accounts (ESA), official series often lack industry detail, especially for the period before the 1990s. In some cases, STAN goes beyond the official published data and provides data at more detailed levels based on additional sources, but important gaps still remain.

As a second step STAN data were complemented with information from detailed industry and services statistics and additional (historical) national accounts data for individual countries. Use was made of international statistics such as the *OECD Structural Statistics for Industry and Services*, the *OECD Services Statistics on Value Added and Employment* and the *Eurostat Labour Force Survey.* Furthermore national sources have been used including national accounts and economic census and survey material. The spreadsheets associated with each of the country files provide a full account of the sources used for each country, each year and each variable.

Filling procedure

In case of missing data there are basically two procedures for estimating value added, employment and compensation data by industry: (1) applying shares from additional data to higher level aggregates or (2) applying higher-level growth rates to more detailed levels. The first is most useful when for a particular sub-sector there is no data available for any year. In that case, the share of the sub-sector in some higher level aggregate is derived from additional secondary data sources and applied to the aggregate in the basic source. In case data is available in the basic source for some years, secondary data shares are used for missing years provided they correspond closely to the basic source. If not, growth rates from secondary data are applied to the original basic data for missing years. To maintain national accounts compatibility a normalisation procedure is used so that subsectors add to the corresponding higher-level industry aggregates provided in the basic source. If there is a summation discrepancy, the subsectors absorb the residual. Each sub-sector does so in proportion to its weight in the parent industry. This procedure ensures that output and employment measures are national accounts compatible and, importantly, have the same economy-wide coverage.[10]

[10] Often additional data is taken from surveys. Sampling coverage and definitions in survey data can differ within and across countries.

For series on hours worked per person and deflators for value added, gaps in the basic source (STAN) are filled in a simpler way. If no additional data could be found, higher level aggregates have been used. For example, in case no separate figure on hours worked per person for sub-sector 351 could be found, the figure for 35 (when available) is used instead. The same was done for deflators where necessary.

The source descriptions in each of the country files provide a detailed account of the filling procedures used for each country, year and variable.

Alternative deflators for ICT production

At present there are only a few countries that have an adequate system in place for measuring prices of computers and semiconductors which take into account the fast increase in quality of these goods. To achieve international comparability, harmonised US deflators are applied for six ICT-producing manufacturing industries (ISIC 30, 313, 31ex313, 321, 322, 323, 331 and 33ex331) in all countries. US value added deflators are corrected for differences in overall inflation between each country and the US. Inflation is measured as the change in the deflator of all industries, excluding the ICT-producing manufacturing industries.[11] Since the ICT-producing industries are not separately distinguished in the US National Income and Product Accounts, these deflators were constructed using price changes in output and intermediate inputs of ICT goods as follows:

1) Value of shipments deflators for manufacturing industries and gross output deflators for non-manufacturing industries were obtained from the BEA data sets on "Gross Output by Detailed Industry" and "Shipments of Manufacturing Industries". A Törnqvist index was applied to obtain gross output (value of shipments) deflators for each of the industries.
2) The Input/Output (I/O) tables from the Bureau of Labor Statistics (BLS)[12] for 1983-2001 are then used to calculate an intermediate input deflator for each ISIC industry.[13] For each of the 190 I/O industries a gross output deflator series was calculated.[14] These deflators are used to calculate an intermediate input price index for each industry. For industry i this is done in the following way:

[11] This procedure is based on Schreyer (2000, 2002).
[12] Specifically from the Office of Occupational Statistics and Employment Projections (www.bls.gov/emp). These tables are used since they are available for each year in the sample and because the industry detail is much greater (190 versus 96 industries).
[13] For the period 1979-1983 intermediate input shares are estimated for some industries such as the computer industry based on the 1977 BEA benchmark I/O table. For others such as machinery the intermediate input deflator for the most closely corresponding industry from the BEA GDP by Industry dataset.
[14] If there is a many-to-one correspondence, a Törnqvist index is used to aggregate to the level of aggregation of the I/O table.

$$\Delta \ln P_i^M = \sum_j \bar{s}_{i,j}^M \Delta \ln P_{i,j}^M \quad (1)$$

In equation (1) $P_{i,j}^M$ is the price of the j^{th} intermediate input used in industry *i*. The price change for this input is weighted by the average share of input *j* in total intermediate inputs in current prices of the industry over the two periods:

$$\bar{s}_{i,j}^M = \frac{1}{2}\left(\frac{P_{i,j}^{M,t} M_{i,j}^t}{\sum_j P_{i,j}^{M,t} M_{i,j}^t} + \frac{P_{i,j}^{M,t-1} M_{i,j}^{t-1}}{\sum_j P_{i,j}^{M,t-1} M_{i,j}^{t-1}} \right). \quad (2)$$

3) Using the deflators for gross output and intermediate inputs, gross output and intermediate inputs at constant prices was calculated. These are combined to calculate real value added growth :

$$\Delta \ln V_i = \frac{1}{\bar{s}_i^V}\left(\Delta \ln Q_i - \bar{s}_i^M \Delta \ln M_i \right) \qquad (3)$$

Here, V_i, Q_i and M_i are the quantity indices of value added, gross output and intermediate inputs respectively. Furthermore:

$$s_i^V = 1 - s_i^M = \frac{P_i^t Q_i^t - P_i^{M,t} Q_i^{M,t}}{P_i^t Q_i^t} \quad (4)$$

s_i^V is the share of current value added in current gross output. The average over the two periods is taken and used in equation (3). Finally, the value added deflator is derived as the difference between the growth rate of current and real value added. While this procedure does not exactly replicate the BEA procedure, it serves as a good approximation since the aggregate deflators are close to the original value added deflator from the national accounts.[15]

Aggregation

Many countries at present still use fixed-weight (Laspeyres) indices to calculate aggregate value added at constant prices. This can lead to serious substitution bias if the structure of the economy is changing over time. For example, when fixed weights are used the price decline for computers will be overstated because of the relatively large weight in the base year compared to successive years (Landefeld and Grimm, 2000). To correct for this problem, chain-weighted indices like Fisher or Törnqvist indexes are needed.

[15] Differences occur for a number of reasons: the BEA uses the detailed source material of the I/O tables, which is more disaggregated than the 190-industry table used here. Furthermore a single deflator was used for all inputs from a certain commodity category, while the BEA distinguishes between domestically produced and imported goods. Also, the price deflators used here correspond to the value of shipments of an *industry* not of the *commodities* that are used as inputs. Finally, the BEA uses Fisher aggregation instead of Törnqvist.

In (re)calculating real value added aggregates for industry groups and for the aggregate economy chain-weighted (Törnqvist) deflators for value added were used. For industry *i* this is done in the following way. Let P_i^V the deflator for value added in industry *i* and P^V the aggregate deflator, then the change of the deflator in period t is given by:

$$\Delta \ln P^{V,t} = \sum_i \bar{s}_i^{V,t} \Delta \ln P_i^{V,t} \qquad (5)$$

The price change in industry *i* is weighted by the average share of industry *i* in total value added over the two periods defined as:

$$\bar{s}_i^{V,t} = \frac{1}{2}\left(\frac{P_i^{V,t} V_i^t}{\sum_i P_i^{V,t} V_i^t} + \frac{P_i^{V,t-1} V_i^{t-1}}{\sum_i P_i^{V,t-1} V_i^{t-1}} \right). \qquad (6)$$

Finally, real aggregate value added growth is calculated as the growth rate of aggregate current value added[16] minus the growth rate of the deflator as follows:

$$\Delta \ln V^t = \Delta \ln V^t P^{V,t} - \Delta \ln P^{V,t} \qquad (7)$$

The use of chain-weighted deflators means that the estimates for the total economy here will generally not conform to the official real GDP series from national and international statistical agencies. However, with this procedure more consistency across countries is achieved.

It should also be stressed that the use of Törnqvist aggregation diverts from simply adding up value added estimates at constant prices from the lowest industry level to higher aggregates. In particular when underlying industries show strongly different growth rates (such as ICT-producing industries relative to non-ICT industries), a summed result may deviate from a Törnqvist weighted result. Hence intermediate aggregates, such as a series for say total manufacturing, can only be obtained by again applying the Törnqvist aggregation procedure.

European Union Aggregation

In order to arrive at totals for the European Union, current price measures in national currencies are converted into euro's using, as much as possible, sector specific purchasing

[16] Aggregate current value added is the sum of industry current value added .

power parities (PPPs).[17] For agriculture and manufacturing, these sector specific PPPs are obtained from industry-of-origin UVRs (see Rao, Ypma and van Ark (2003), forthcoming, on agriculture; and the description of the productivity level database for manufacturing below). For for mining and public utilities estimates were obtained on the basis of matching product quantity details of individual items in both industries with gross output values from industry surveys and national accounts. For a limited number of countries, industry-specific UVRs could be obtained for two service sectors (distribution and transport/communication). For most services industries, however, PPPs were obtained from specific expenditure PPPs from the Eurostat/OECD International Comparisons Project (ICP), which were adjusted for transport and distribution margins on the basis of I/O tables for individual countries (OECD, 2002b). In a small number of cases of large outlier PPPs for individual industries, aggregate GDP PPPs were used instead. The industry PPPs were all converted to a 1997 basis, and were then applied to obtain value added shares by industry and by country in the total EU aggregate for the whole period 1979-2001. These were then used to Törnqvist aggregate the deflators for individual industries to an EU aggregate.

German unification

In order to deal with German unification in 1990 two data sets have been constructed: one for Western Germany (covering the period 1979-1991) and one for unified Germany (covering the period 1991-2001). Growth rates for Western Germany are linked to 1991 data for unified Germany.

US reclassifications

As the US Standard Industrial Classification (SIC) differs considerably from the ISIC rev 3 (and NACE Rev.1) classification at more detailed industry levels, several major adjustments were made to the US National Income and Product Accounts. The main reclassifications were carried out for motor vehicle trade and repairs (ISIC 50), retail trade (ISIC 52), hotels and restaurants (ISIC 55), post and telecommunications (ISIC 64), all industries in business services (ISIC 71-74) and Other community, social and personal services (ISIC 90-93). See the sources and methods description in the US file for more details. Price deflators for these industries have been developed in a similar way as for ICT producing industries using a double deflation procedure (see above).

[17] See van Ark and Timmer (2003) for a discussion of approaches to obtain sector-specific PPPs. See also the discussion on the Productivity and Unit Labour Cost Database under C below.

B. Industry growth accounting database for the European Union and the US

Introduction

In addition to the Industry Labour Productivity Database, data on labour skills and investment have been collected for the US and 4 European countries (France, Germany, The Netherlands and the UK). This allows for a decomposition of output growth into into the contributions of quantity and quality of labour and capital, and total factor productivity using the growth accounting methodology outlined in Jorgenson (1995).

Growth Accounting Methodology

The growth accounting approach to total factor productivity estimation has been used to estimate the impact of ICT on productivity by amongst others Jorgenson and Stiroh (2000) and Oliner and Sichel (2000). It allows for the decomposition of output growth into contributions from factor inputs and underlying productivity growth. Assume the production function of an industry in country (j) may be written:

$$Q^j_t = A^j_t f_{jt} (L^j_t, K^j_t) \quad (1)$$

Where Q is real output (here measured as real value added), K and L are the capital and labour inputs, respectively, and A is technical progress or multi-factor productivity (hereafter, MFP). Assuming perfectly functioning markets and constant returns to scale, MFP can be calculated as an index. Assuming a translog production function, the Törnqvist index is the appropriate approximation of the Divisia index (Jorgenson *et al.*, 1987). Then output growth can be decomposed into its various components in the following way:

$$\ln(Q^j_t/Q_{t-1}) = a^j(t,t-1)\ln(L^j_t/L^j_{t-1})+(1- a^j(t,t-1))[\ln(K^j_t/K^j_{t-1})]+\ln(A^j_t/A^j_{t-1}) \quad (2)$$

Where a(t,t-1) is the share of labour in value added averaged over the two time periods.

The need for a quality adjustment to factors of production stems from the work of Denison (1967) and Jorgenson and Griliches (1967). In studies on the impact of ICT on productivity, this has involved quality adjustment of capital, accounting for substitution between ICT capital and non-ICT capital (Oliner and Sichel, 2000, Jorgenson, 2001). In addition this analysis includes a labour quality adjustment using information on skill shares and relative wage levels of skill categories. Following Jorgenson *et al.* (1987) the growth in aggregate labour and aggregate capital can be estimated as Törnqvist indexes of their components. Suppose there are *i* types of labour and *s* types of capital. Then these indexes are given by:

(3a) $$\ln(L^J_t / L^J_{t-1}) = \Sigma_i \alpha_i^J(t,t-1)\ln(L_i{}^J_t / L_i{}^J_{t-1})$$

(3b) $$\ln(K^J_t / K^J_{t-1}) = \Sigma_s \alpha_s^J(t,t-1)\ln(K_s{}^J_t / K_s{}^J_{t-1})$$

where $\alpha_l^J(t,t-1)$ is the share of type l labour in the total wage bill and $\alpha_s^J(t,t-1)$ is the share of type s capital in the value of capital.

Capital is composed of six asset types of which three are ICT-related assets, defined here (and elsewhere) as computing, software and communications. Investment series at constant prices are converted into estimates of productive capital stocks using the perpetual inventory method with geometric depreciation rates. Depreciation rates vary between asset types and industries. Further details on capital services estimation are provided in O'Mahony and Timmer (2002).

Coverage

The dataset covers 26 industries and cover the period 1979-2001.[18] The list of industries is given in Table VII.3. This database is an extension and update of the work described in O'Mahony (1999) and O'Mahony and de Boer (2002).

[18] Investment series for most asset types cover longer periods.

Table VII.3 Industries in growth-accounting database

	Industry Name	ISIC rev 3
1	Agriculture, Forestry and Fishing	01-05
2	Mining and Quarrying	10-14
3	Food, Drink & Tobacco	15-16
4	Textiles, Leather, Footwear & Clothing	17-19
5	Wood & Products of Wood and Cork	20
6	Pulp, Paper & Paper Products; Printing & Publishing	21-22
7	Mineral Oil Refining, Coke & Nuclear Fuel	23
8	Chemicals	24
9	Rubber & Plastics	25
10	Non-Metallic Mineral Products	26
11	Basic Metals & Fabricated Metal Products	27-28
12	Mechanical Engineering	29
13	Electrical and Electronic Equipment; Instruments	30-33
14	Transport Equipment	34-35
15	Furniture, Miscellaneous Manufacturing; recycling	36-37
16	Electricity, Gas and Water Supply	40-41
17	Construction	45
18	Repairs and wholesale trade	50-51
19	Retail trade	52
20	Hotels & Catering	55
21	Transport	60-63
22	Communications	64
23	Financial Intermediation	65-67
24	Real Estate Activities and Business Services	70-74
25	Other Services	90-99
26	Non-Market Services	75-85

Labour Skills

Estimating labour quality requires total labour input to be divided into a number of skills categories. Unfortunately skills classifications differ across countries, but these disparities are not a major issue for examing the growth contribution, since the contribution from each skill group is weighted by its wage share (with the implicit assumption that wages equal marginal products). As long as the number of skill groups does not vary too much across the countries and the divisions are roughly equivalent, then the relative wage shares pick up differences across countries in the growth in labour quality.[19] There are additional complications if the calculations do not control for other impacts on wages such as gender, age, minimum wages and the impact of collective bargaining. The sample size in the survey data used in this study precludes the division of workers by age and gender – in addition to skills – by industry group. Similarly there is no information to take account of other influences which may cause deviations of wages from marginal products.

[19] No attempt is made to match the categories across countries (but see Table III.13 in Chapter III for a comparison of high skill levels).

The number of labour skill types (based on educational attainment or qualifications) varies from three in Germany to seven in the Netherlands. Table VII.4 summarises the categories included for each country but some further explanation is required.

The most transparent case is the US where the division at the post-secondary level depends on the number of years of college attendance and/or whether a degree was awarded. First degrees and above in the US are awarded after 3-4 years of study and tend to be dominated by academic subjects. Associate degrees are shorter, 2–3 years, and are dominated by vocational subjects areas. The final two categories distinguish those who have graduated from high school from others and so is more an attendance than an attainment measure.

The categories in the UK are somewhat different at the intermediate/lower end, although degrees and higher level below degree (other NVQ4) are roughly equivalent to the US first degree and above and associate categories, respectively. The category NVQ3 includes school leavers who have achieved at least one pass at A-level and equivalent vocational qualifications. NVQ12 includes school leavers with passes in the main examinations taken at age 16 (GCSE) plus lower level vocational qualifications.

For France, the categories Bachelor degrees and Baccalaureate plus two years are again broadly equivalent to the US university degrees and associate degrees. Baccalaureate is similar to the UK A levels whereas the vocational qualifications can be achieved at a number of different levels. BEPC is similar to the UK GCSE.

In the case of the Netherlands, there are seven levels of educational attainment. The higher level categories are less comparable to other countries in that most students in academic subject areas complete a masters degree or above. The next level down (HBO) is tertiary education, but more of a vocational type. MAVO/HAVO/VWO is general education which normally leads to entry into a higher level, taking up 4 to 6 years of study after primary school. LBO/VBO and MBO are vocational schooling, taking up a maximum of 4 years after primary school. Primary schooling (the lowest category) ends at age 12. People in the final category have the lowest educational attainment which is completed primary schooling or below.

The German skill categories are the least satisfactory, as they only show a three way division into higher education, vocational and other. Although a finer classification is available for employment, dividing in particular the two lowest groups, corresponding wage data are not available.

Table VII.4 Skills categories employed in the analysis

France	**The Netherlands**
1. Bachelor degrees and above	1. Master degree and above
2. Baccalaureate plus 2 years college	2. HBO
3. Baccalaureate	3. HAVO/VWO
4. Vocational(CAP, BEP ou autre de ce niveau CAP, BEP ou autre de ce niveau)	4. MAVO
5. General Educational (BEPC)	5. MBO
6. No formal qualifications (Aucun diplôme ou CEP)	6. LBO/VBO
	7. Primary education or below

US	**UK**
1. Bachelor degrees and above	1. First degrees and above
2. Associate degrees	2. Other NVQ4
3. Some college, no degree	3. NVQ3
4. High school graduate	4. NVQ2 and NVQ1
5. Did not complete high school	5. No formal qualifications

Germany
1. Higher education (16-17 years education or above)
2. Vocational degree
3. No degree

Series on number of persons engaged by type of education are benchmarked on total employment in each industry to maintain consistency with the Industry Labour Productivity Database. Therefore, education shares derived from sources described below are used to subdivide series on total persons engaged from the industry database. In general, education shares are based on data for employees and refer to the distribution of number of employees, rather than hours worked.[20]

Capital input

In total six asset types are distinguished, including computing equipment, communication equipment, software, transport equipment, other non-ICT equipment, and non-residential structures and buildings (see Table VII.5). Residential buildings are not taken into account which allows a sharper focus on the productivity contribution of business-related assets and facilitate the analysis of effects of ICT on capital and productivity growth. Consequently in the analysis of contributions of factor inputs to aggregate economic growth, the real estate

[20] In the case of France it refers to hours worked by employees.

sector (in which the imputed rents of residential buildings is recorded as part of output) is left out from output and inputs.

Table VII.5 Asset types employed in the analysis

Non-ICT assets
1. Non-residential buildings and Structures
2. Transport equipment
3. Other non-ICT equipment
ICT assets
4. Computing equipment
5. Software
6. Communication equipment

Harmonised ICT deflators

Generally there is support for the adoption of hedonic deflators in particular for the measurement of real ICT output and investment but there is still some discussion as to how these should be calculated (Triplett, 1996). The US approach leads to significantly higher rates of computer price declines than other industrial countries. Deflators based on the US hedonic price index, adjusted for international price or exchange rate movements, have been employed in many international or individual country studies of the impact of ICT capital on growth, primarily because a viable alternative is generally not available for other countries countries (for example, Colecchia and Schreyer, 2001; Oulton, 2001; van Ark *et al.*, 2002a). This is also the approach adopted in the current analysis. Deflators for IT-equipment, communication equipment and software are based on US deflators, adjusted for differences in non-ICT and non-software investment deflators, by industry (see also above under section A).

Compensation shares to weight factor inputs

The inputs of labour and capital are weighted according to their compensation in total value added. The share of labour in value added includes an adjustment for compensation for self-employed and family workers. The standard approach is to impute compensation for self-employed on the basis of compensation for employees. The simplest assumption is to assume that both types of workers earn a similar compensation. However, a closer look at the figures for the US provided by Jorgenson, Ho and Stiroh (2002) show that this assumption is not valid. On the basis of detailed data for the US it appears that compensation for self-employed is generally lower than for employees due to its particular characteristics (for example in general educational attainment of self-employed is lower than for employees). On the basis of this information it was assumed that the compensation of self-employed was 70% of compensation for employees.[21]

In a few cases labour compensation was still higher than total value added. This is possible in cases where an industry incurs lossess, or when an industry receives significant net subsidies. In either case, TFP calculations become impossible as shares need to be positive. Therefore, the labour share was constrained to a maximum of 95%.In some cases rental prices become negative due to large swings in investment deflators, for example in non-residential buildings. To avoid these cases, a lower bound has been put to the rental price of 0.05.

Data sources for skills and investment

France

Investment series, hours worked by skill type and wage bills by skill type were unpublished data provided by the CEPII in Paris (and obtained from INSEE) under the EC 5th framework project 'Employment Prospects in the Knowledge Economy.

Germany

Investment series.

Investment series on the six asset types by industry in both current and constant prices were constructed for 1970 to 2001. The main problems relate to the linking of investment series for West Germany and unified Germany and the estimation of series for software and ICT-equipment. The starting point were unpublished investment series by asset type at the aggregate level for West Germany (1970-1991) and for Germany as a whole (1991-2001) from the Statistisches Bundesamt (see Timmer, Ypma and van Ark, 2003). These contained information for eight asset types, but not separately for software (which was included in "intangible investment") and for IT-equipment (which was included in "office, computing and accounting equipment"). Software was split off from total intangible investment by using the average corresponding share from France, Finland and Italy. To split off office machinery from IT-equipment the US ratio by industry of IT-equipment to IT-equipment plus office equipment (IOT) were applied.

Investment by industry is available for West Germany (1970-1991) and for unified Germany (1991-2001) from the Statistisches Bundesamt. These datasets contain a breakdown into only

[21] In the case of household services in the Netherlands, compensation of self-employed is assumed to be 35%. This is due to the way Statistics Netherlands estimates labour in this industry. A large part of the workers in this industry consist of informal small-job labourers whose earnings are well below formal employees.

two asset types, namely investment in structures and investment in equipment and other assets. For Germany as a whole, the industry detail was sufficient to distinguish the 26 industries until 2000. For 2001 it was necessary to extrapolate some industries using share development for previous years. For the pre-1991 series for West Germany the distribution sector and the transport and communications sector were not split up into more disaggregated industries. To distinguish wholesale from retail trade and transport from communications investment data were used from the West German National Accounts for 1990This means that, for example, wholesale trade and retail trade are separately distinguished, but trade and repair of motor vehicles are not.

To further disaggregate industry investment into asset types, the following procedures were used:

- Investment in transport equipment was derived using the average share of transport investment in total non-structures investment by industry for France, Netherlands, UK and US
- Industry shares in aggregate communication equipment investment were derived using industry shares from the *Ifo Investitionenrechnung*, which covers 1970-1994 for West-Germany and 1995-1998 for Germany as a whole. Series for unified Germany from 1991-1994 were estimated by assuming industry shares in 1994 to be the same as in 1995 and then link with West-German shares in the period 1991-1994.
- A similar procedure as for communication equipment was used for Office, computing and accounting machinery (IOT), which includes IT-equipment. To split off IT-equipment, industry-specific ratios of IT to IOT for the US were applied (see below for US sources).
- Investment in software was derived using the average ratio of software investment to IT-equipment investment by industry for France, Netherlands, and the US
- Investment in non-ICT equipment was calculated as a residual.[22]

To derive complete series for the period 1970-2001, growth rates of the West-Germany data to total Germany were linked in 1991. Historical investment data were derived from *Volkswirtschaftliche Gesamtrechnungen, 1950-1990* (Statistiches Bundesamt) and Kirner (1968). Initial capital stocks in 1970 were estimated for structures and equipment using historical information back to 1870 (structures) and 1960 (equipment).

[22] This led to balancing proble ms in the case of the communication industry between 1970 and 1991 (i.e. investment in Non-IT equipment was negative for most years). This was resolved this by constraining Non-IT equipment investment to zero.

Labour quality

Data on wage bills and employment for the three categories were from unpublished data received from Statistiches Bundesamt, originally from the German Employment Statistics and Wage and Salary Statistics.

Netherlands

Investment series

Investment series for 50 sectors and 20 asset types for the period 1949-2001 were obtained from unpublished data from Statisics Netherlands (March 2003). Investment has been aggregated to 26 industries and 6 asset types using summation. For initialisation of the PIM in the start year 1948 an estimate of the gross stock from the same data set was used

Labour quality

For employment shares by educational attainment for the period 1990-2000 use has been made of the CBS, *Enquête Beroepsbevolking*, annual issues. Wages by educational type are provided by the CBS, *Loonstructuuronderzoek* for the years 1995, 1997 and 1998. For about 10 broad sectors reliable estimates could be derived. Due to small sample sizes a finer disaggregation was not possible. Consequently it is assumed that sub-sectors have the same educational attainment shares and relative wage structure as higher level aggregates.

UK

Investment series

Data series on the six asset types in both current and constant 1995 prices were constructed by industry from 1948 to 2000. Investment in computing equipment and software were assumed to begin in 1959, otherwise series were constructed for the entire sample period. The starting point were unpublished series by industry from the Office of National Statistics (ONS) which underlie their PIM estimates, and which contain data for three asset types: structures, plant & machinery and vehicles. Plant & machinery includes computing equipment and communications equipment but not software.

Industry estimates of investment in all three ICT components were based on information on capital formation from input-output tables for selected years, with linear interpolation used to complete any missing years. This started with series for nominal investment in ICT for the total economy showing separately computers, software and communications equipment, and aggregate series on investment by industry from 1948 to 1999. The nominal aggregate series for computers and communications equipment were those reported in Oulton (2001) from 1974 onwards. Software is also based on Oulton's time series but the level in 1999 was derived in a different way using data on software sales from *The Computer Services Survey*

(Servcomm feasibility Survey) - data for 2000 (ONS, 2001), and adjusting for net exports and consumer spending on software. These three series were backdated to 1960 employing data on production and trade.

For each industry its share of total aggregate investment in ICT assets was estimated using 1992-1998 input output tables and data from investment surveys for 1999 and 2000. For prior years ICT shares were calculated by interpolating between periodic input output tables. Industry shares of investment in the three ICT assets were then applied to the aggregate series for the three types of ICT to yield industry nominal investment series. Full details of the method and additional sources are given in O'Mahony and de Boer (2001).

Labour quality

The UK's labour force survey (LFS) contains matched information on wages and skill categories for labour force groups from 1992 onwards. Before 1992 wage data were not available so the LFS employment series were linked to wage trends from the General Household Survey. Further details on the construction of this dataset are available in Mason *et al.* (2003).

US

Investment series

Data series on the six asset types in both current and constant prices were constructed by industry from 1901 to 2001. A two-stage procedure is used in which first total investment series for 57 industries are constructed, which subsequently are broken down into the six asset types. To derive investment series by private industry, data is used from the National Income and Product Accounts (NIPA) on gross fixed capital formation (which contains data from 1901 onwards for 62 industries). This information was supplemented with investment data from the *NBER Manufacturing Industry Database* (data available from 1958 onwards), the *Annual Survey of Manufacturers 2001* and the *BEA Capital Flow Tables* for 1982 and 1992. The additional information was needed to match the 62 NIPA industries with the industries used in the 56-industry database.[23]

The BEA also provides a dataset on private investment by industry and type which covers the 1901-2001 period. Total investment both by industry and by asset type is consistent with the

[23] Additional data is used to reallocate the computer industry from machinery to electrical and electronics, to move restaurants out of retail trade and combine it with hotels and to reallocate radio and TV broadcasting from communications to community, social and personal services. This does not resolve all classification problems but it solves the most pressing ones. For some industries not separately identified in NIPA, extrapolations had to be made for the period before 1958. However, these extrapolations will not generally have a large impact as they mostly involve the pre-1958 period and industries like computers, which were marginal before that data.

more aggregated NIPA tables. The BEA distinguishes 62 asset types for 62 industries. The first step aggregates the 62 asset types to six types.[24] Since the BEA table contains more detail in some industries than required for this purpose, the 62 industries were aggregated to 40. For each of the 56 industries, the asset investment composition of the appropriate BEA 40-industry classification was used. So, for example, the computer industry gets the same asset composition as other industrial machinery.

Government investment is contained in separate NIPA tables. Although the NIPA classify a wide range of defense purchases as investment, most were excluded to ensure consistency with national accounts in other countries and the SNA93. This means 'destructive' assets such as planes and tanks are excluded while 'dual-use' assets like military hospitals are included. The asset composition of government investment is less extensive than for other industries so one can only separately distinguish non-residential and other investment. The asset composition from other non-market services (health and education) is applied to break the 'other' investment down into non-IT equipment, transport equipment, IT-equipment, communication equipment and software.

The final step is to aggregate across the 56 industries to arrive at the 26-industry classification. In all aggregation steps current investment was summed and Törnquist aggregation was used to obtain the investment deflators.

Labour quality

Skill shares in total employment by industry and relative wage levels are derived from the US Current Population Survey (CPS). Crucially for the purposes of this report, the CPS contains matched information on wages and skill categories for labour skill groups. The CPS data set extends back to 1976, although adjustments were required to yield series based on consistent definitions throughout. For example, years of education was replaced in 1992 by variables that were a mixture of attainment and qualifications. So use was made of a matrix that had both series for an overlapping survey. Further details on the construction of this dataset are available in Mason *et al.* (2003).

Other sources

Output at constant prices, labour input and labour compensation are derived from the 56-Industry Labour Productivity Database.

[24] Ideally the 62 assets should be aggregated using capital stocks and type-specific rental prices. For the moment, however, current investments were simply summed and Törnquist aggregate the investment deflators across asset types.

EU aggregation

EU aggregates are all made using Törnqvist aggregation across countries

C. Manufacturing Productivity and Unit Labour Cost database for the European Union and the US

Introduction

This database consists of unit value ratios for 20 manufacturing industries for 14 countries in the European Union and the US for 1997 to allow for comparisons of output, productivity and unit labour cost across countries. They have been derived using the industry-of-origin approach developed in the International Comparisons of Output and Productivity (ICOP) project at the University of Groningen since 1983.[25] Unit value ratios are industry-specific conversion factors derived on the basis of relative producer prices and as such have important advantages over alternatives like the use of exchange rates or PPPs derived from the expenditure side in the International Comparisons Project (ICP).[26] The list of manufacturing industries covered is provided in Table VII.6.

Table VII.6 Manufacturing Industries covered in UVR database

	Industry Name	ISIC rev 3
1	Food, drink & tobacco	15-16
2	Textiles	17
3	Clothing	18
4	Leather and footwear	19
5	Wood & products of wood and cork	20
6	Pulp, paper & paper products	21
7	Printing & publishing	22
8	Chemicals	24
9	Rubber & plastics	25
10	Non-metallic mineral products	26
11	Basic metals	27
12	Fabricated metal products	28
13	Mechanical engineering	29
14	Office machinery	30
15	Electrical machinery nec	31
16	Radio, television and communication equipment	32
17	Instruments	33
18	Motor vehicles	34
19	Other transport equipment	35
20	Furniture, miscellaneous manufacturing; recycling	36-37

[25] See http://www.ggdc.net/dseries/icop.html

[26] As expenditure represents not only the production value of the industry in question but also the added value of industries further down the chain, these PPPs require adjustment for taxes and trade and transport margins. While these margins can be "peeled off", this does not solve all problems. Firstly, at industry level, expenditure PPPs also need to be adjusted to exclude the relative prices of imported goods and include the relative prices of exported goods. Secondly, and most importantly, expenditure PPPs exclude price ratios for intermediate products, which account for a substantial part of output in manufacturing. See van Ark and Timmer (2003) for an elaborate discussion.

Sources

To derive unit values for 14 European countries use is made of the data for 1997 from Eurostat PRODCOM database.[27] The use of this database has significant advantages over earlier ICOP comparisons between European countries, as products are now recorded on the basis of a common classification. This significantly increased the number of product matches that can be made between countries. The physical volume and value of production are recorded in the PRODCOM list for more than 4,000 detailed products. The products are classified using the same coding as for the NACE Rev. 1 classification of economic activities. The first six digits of the product code are the CPA code (Community Classification of Products by Activity), while the last two digits show the classification of a heading within this CPA heading. The first four digits of the code correspond to the classes of NACE Rev. 1. The value of production sold is calculated on the basis of the "ex-works selling price" obtained during the reporting period. It also includes packaging costs, even if they are charged separated. Turnover taxes, consumer taxes, separately charged freight costs and any discounts granted to customers are not included in the value of production. The PRODOCM statistics normally cover all undertakings/local units, which manufacture products contained in the PRODCOM list. The list does not include the products of manufacture of coke and refined petroleum products and recycling (Divisions 23 and 37 of NACE Rev. 1).

The PRODCOM database needed to be somewhat cleaned up before starting computations. By comparing quantities and unit values across countries outliers have been removed, or obvious mistakes in the original dataset corrected. Also products with output-quantity observations for only one country have been removed. In the final data set, in total 2,408 products had an output and quantity observation for at least two countries. The distribution of these observations across industries is rather uneven. While the coverage of output in sectors like food and chemical products is very high (frequently more than 50 products covering more than 30% of produced output), coverage for sectors producing machinery and electronics is much less for most countries (see Table VII.7).

In contrast to earlier ICOP studies, that are usually done on a binary basis between two countries, PRODCOM allows the construction of multilateral unit value ratios (UVRs) for the European Union (see below). To allow for comparisons with the United States, a binary comparison between Germany and the US has been made for 1997. Comparisons of EU countries with the US are made through Germany as the link country. This binary comparison is based on data from the manufacturing census in both countries. In total data for 516

[27] Due to the small number of observations, Luxembourg has been excluded in the analysis.

manufacturing products have been used for the binary match with the US covering about 25% of total manufacturing output in both countries (see Table VII.8).

Methodology

By dividing value of production by quantities, unit values are derived. These unit values can be considered as an average price, i.e., averaged throughout the year for all producers and across a group of nearly similar products. Subsequently products with similar product codes are matched. For each matched product, the ratio of the unit values in both countries is taken. This unit value ratio (UVR) indicates the relative producer price of the matched product in the two countries. Product UVRs are used to derive an aggregate UVR for industries (see also van Ark and Timmer, 2003).

For the European countries multilateral UVRs are derived using the Elteto-Koves-Szulc (EKS) method. This method is designed to construct transitive multilateral comparisons from a matrix of binary/pairwise comparisons which have been derived using a formula which does not satisfy the transitivity property. The EKS method in its original form uses the binary Fisher PPPs between country j and k (F_{jk}: j,k=1,..M) as the starting point. The computational form for the EKS index is given by

$$EKS_{jk} = \prod_{l=1}^{M} \left[F_{jl} \cdot F_{lk} \right]^{1/M} \qquad (4)$$

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 in (4) produces comparisons which are transitive, that is a direct comparison I_{jk} should result in the same measure as an indirect comparison between j and k through a link country ℓ. Since 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.

The Germany-US UVRs are of a bilateral nature and are constructed according to the standard ICOP-methodology (see van Ark and Timmer 2003). The results are given in Table VII.8.

Results

In Table VII.9 the multilateral unit value ratios for the 14 European countries are given for the year 1997. Prices of all countries have first been converted to euros using conversion rates given in Table VII.10. Germany is taken as the benchmark country which means that the UVRs of all other countries are expressed relative to Germany.[28] If for a particular sector a country has a lower UVR than another country this means that prices in this sector are lower. For example, the lowest producer prices for food are found in Spain (0.90), while the highest prices for food are found in Greece (1.22, which is about 35% higher).

Unit labour costs

Estimates of unit labour cost trends are regularly published by statistical agencies such as the BLS for a large number of industrialised countries and by Eurostat for the EU member states. Comparisons of unit labour costs levels across countries are much less frequently made, primarily because suitable conversion factors for sectoral output are often not available. The manufacturing unit value ratios derived in this study can be used to overcome this problem.[29] Unit labour cost in country U in national prices ($ULC^{U(U)}$) can be written as

$$ULC^{U(U)} = \frac{LC^{U(U)}}{Y^{U(U)}} \qquad (1)$$

where $LC^{U(U)}$ is the labour cost in country U in domestic prices, $Y^{U(U)}$ is output in country U at domestic prices.[30] Using the UVRs, unit labour cost of country X can be expressed in prices of country U ($ULC^{X(U)}$) as follows:

$$ULC^{X(U)} = \frac{LC^{X(X)} / ER^{XU}}{Y^{X(X)} / UVR^{XU}} \qquad (2)$$

where $LC^{X(X)}$ is the labour cost in country X in domestic prices, $Y^{X(X)}$ is output in country X at domestic prices, ER^{XU} is the exchange rate between country X and U and UVR^{XU} is the unit value ratio between country X and U. By dividing through the unit labour costs in country U at country U prices ($ULC^{U(U)}$), relative unit labour costs between country X and U ($RULC^{XU}$) for a particular benchmark year can be derived:

$$RULC^{XU} = \frac{ULC^{X(U)}}{ULC^{U(U)}} \qquad (3)$$

This benchmark is extrapolated through time using national trends in unit labour costs.

---

[28] Note that due to the multilateral nature of the dataset, this choice does not affect the results. Any other country can be used as benchmark as well.
[29] See, for example, van Ark (1996).
[30] Alternatively one can divide the numerator and denominator by hours worked. In that case unit labour cost is written as a ratio of labour cost per hour worked and labour productivity (output per hour worked).

Hedonic UVRs for motor vehicles

It is well known that characteristics and quality of cars differ across countries. The product classification in PRODCOM is not detailed enough to pick up these differences. Therefore use is made of UVRs for car production derived by van Mulligen (2003) who uses a hedonic approach in which various car characteristics are taken into account. The hedonic unit values are available for France, Germany, Italy and UK.

Table VII.7 Descriptive statistics of multilateral dataset based on PRODCOM, 1997

	Belgique /België	Dan- mark	Deutsch- land	Ellada	España	France	Ireland	Italia	Neder- land	Öster- reich	Portu- gal	Suomi /Finland	Sverige	UK
Maximum Coverage rate														
15-16	0.36	0.69	0.58	0.36	0.49	0.67	0.56	0.63	0.51	0.46	0.53	0.51	0.59	0.67
17	0.10	0.38	0.35	0.20	0.41	0.13	0.31		0.35	0.13	0.28	0.40	0.20	0.60
18	0.12	0.99	0.28	0.29	0.75	0.19	0.41		0.30	0.62	0.48	0.52	0.15	0.72
19		0.98	0.33	0.33	0.26	0.49	0.15	0.23	0.37	0.64	0.49	0.39	0.19	0.53
20	0.36	0.07	0.33	0.11	0.18	0.40	0.11	0.34	0.08	0.49	0.42	0.42	0.69	0.13
21	0.16	0.15	0.42	0.42	0.31	0.32	0.17	0.37	0.20	0.20	0.26	0.37	0.50	0.29
22	0.26	0.00	0.37	0.03	0.35	0.46	0.10	0.22	0.39	0.29	0.17	0.24	0.44	0.49
24	0.21	0.18	0.16	0.33	0.26	0.20	0.01	0.23	0.12	0.12	0.22	0.10	0.11	0.25
25	0.12	0.04	0.37	0.13	0.27	0.47	0.15	0.26	0.03	0.26	0.18		0.10	0.14
26	0.33	0.34	0.43	0.45	0.48	0.39	0.44	0.43	0.40	0.37	0.50	0.06	0.29	0.51
27	0.08	0.07	0.40	0.33	0.30	0.26	0.05	0.34	0.11	0.15	0.37	0.08	0.06	0.29
28	0.26	0.03	0.34	0.16	0.28	0.08	0.29	0.21	0.05	0.34	0.29	0.07	0.08	0.22
29	0.04	0.09	0.17	0.12	0.24	0.05	0.06	0.19	0.04	0.08	0.10	0.07	0.08	0.15
30		0.02	0.17				0.38					0.44	0.04	0.16
31	0.04	0.03	0.22	0.44	0.26		0.17	0.12	0.08	0.23	0.63	0.13	0.18	0.16
32	0.04	0.33	0.26		0.21		0.00	0.11	0.01	0.01		0.08	0.01	0.12
33		0.21	0.13		0.21	0.06	0.35	0.14	0.01	0.09	0.27	0.02	0.02	0.14
34	0.50	0.36	0.15	0.05	0.47	0.45	0.08	0.12	0.07	0.10	0.02	0.33	0.04	0.55
35	0.03	0.07	0.03		0.06	0.01		0.09	0.09		0.03	0.02	0.04	0.02
36	0.35	0.26	0.47	0.24	0.31	0.04	0.13	0.27	0.12	0.13	0.31	0.23	0.26	0.23
Maximum Number of Matches														
15-16	96	155	174	117	172	173	75	174	117	101	122	103	82	139
17	25	19	84	33	84	37	12	0	19	21	54	25	5	82
18	38	99	82	108	114	30	34	0	24	63	114	67	8	108
19	0	13	17	20	16	23	2	17	4	6	23	4	2	21
20	16	8	30	17	31	29	6	26	2	25	31	12	17	16
21	6	19	39	11	32	33	2	39	8	6	17	20	19	24
22	9	3	15	6	16	14	10	16	9	10	16	11	6	14
24	49	66	89	44	109	101	13	109	42	24	51	25	25	105
25	13	11	43	8	43	39	8	39	4	15	19	1	9	26
26	16	21	50	12	52	42	7	52	11	22	33	11	12	40
27	13	8	74	14	41	56	2	74	10	15	14	6	9	60
28	24	7	86	27	86	34	14	66	6	39	48	7	12	35
29	7	48	130	30	112	32	11	130	11	14	43	14	12	97
30	0	1	3	0	0	0	3	1	0	0	0	1	1	3
31	4	9	44	12	44	2	5	27	10	15	11	8	7	31
32	2	9	10	1	11	0	0	12	1	1	0	2	1	12
33	0	12	31	1	15	11	3	24	1	1	5	3	3	31
34	2	6	14	3	14	8	3	14	3	4	4	3	5	11
35	1	4	6	1	5	1	1	6	2	0	6	2	3	6
36	17	19	41	17	39	11	10	41	13	18	30	12	12	32

Note: maximum coverage ratio for a country indicates the highest coverage ratio in binary comparisons with other countries. Idem for maximum number of matches.
Source: Eurostat, Prodcom 1997.

Table VII.8 Binary comparison US and Germany, manufacturing industries for 1997

	Number of UVRs		Cover Ratio US (%)	Cover Ratio German (%)		US$/Euro Laspeyres UVR	US$/Euro Paasche UVR	US$/Euro Fisher UVR
Food & kindred products	132		61.9	65.4		1.09	1.36	1.22
Textile mill products	25		53.8	49.5		0.69	0.83	0.76
Wearing apparel	39		73.4	40.5		0.54	0.60	0.57
Leather products & footwear	12		61.7	31.2		0.88	0.92	0.90
Wood products	13		30.8	51.8		0.93	1.08	1.00
Paper products	18		47.9	61.4		1.14	1.22	1.18
Printing & publishing	1		1.1	0.2		2.12	2.12	2.12
Chemicals & allied products	59		17.5	12.9		1.10	1.04	1.07
Rubber & plastic products	4		22.9	7.4		0.98	1.11	1.04
Non-metallic mineral products	23		28.5	22.0		1.26	1.42	1.34
Basic metal products	43		69.6	71.3		1.12	1.25	1.18
Fabricated metal products	11		3.7	6.5		1.24	1.35	1.30
Machinery & equipment	53		14.8	13.9		0.95	1.04	0.99
Automotive	5		28.8	39.4		0.87	0.90	0.88
Other transport	1		2.8	6.4		1.88	1.88	1.88
Office & computing machinery	6		44.0	38.3		1.09	1.24	1.16
Electric apparatus, nec	18		41.5	15.1		0.78	1.22	0.98
Radio, TV & communication Eq.	17		9.3	16.9		0.84	0.96	0.90
Professional goods	16		3.2	14.0		1.52	1.72	1.62
Furniture, fixtures & misc.	20		16.2	23.6		1.01	1.14	1.08
Total manufacturing	**516**		**27.6**	**27.9**		**1.09**	**1.13**	**1.11**

Source: based on German and US census of manufacturing

Table VII.9 Unit value ratios for manufacturing industries in EU countries and US, Germany = 1, 1997

	Belgique /België	Dan- mark	Deutsch- land	Ellada	España	France	Ireland	Italia	Neder- land	Öster- reich	Portu- gal	Suomi /Finland	Sverige	UK		US
15-16	0.97	1.04	1.00	1.22	0.90	1.13	1.06	0.99	0.94	1.12	1.01	1.08	1.13	1.20		1.22
17	0.86	0.85	1.00	0.75	0.70	0.96	0.81	0.54	0.91	1.04	0.67	0.86	0.99	0.92		0.76
18	0.85	0.82	1.00	0.74	0.62	1.05	0.79	*0.54*	0.68	1.03	0.66	1.00	1.10	0.85		0.57
19	*0.85*	0.86	1.00	0.83	0.51	0.75	0.93	*0.54*	1.33	1.04	0.55	1.07	0.88	0.76		0.90
20	0.91	0.99	1.00	0.79	0.69	0.80	1.03	0.71	0.91	1.04	0.71	0.83	0.88	1.05		1.00
21	1.04	0.89	1.00	1.18	0.87	1.02	0.91	0.94	0.97	0.97	0.91	0.92	0.85	1.18		1.18
22	0.88	0.84	1.00	0.69	0.73	1.05	1.46	0.79	1.07	0.96	0.74	0.81	1.25	0.87		*1.18*
24	0.90	1.02	1.00	0.95	0.75	0.96	1.08	0.84	0.86	1.08	0.89	0.97	0.95	1.03		1.07
25	0.72	0.81	1.00	0.66	0.67	0.88	0.91	0.59	0.70	0.88	0.66	0.89	0.90	0.79		1.04
26	0.80	1.12	1.00	0.71	0.67	0.94	0.91	0.68	0.88	1.07	0.73	0.92	1.27	0.95		1.34
27	1.11	1.02	1.00	0.91	0.83	1.01	1.07	0.77	0.99	1.05	0.80	1.02	1.14	1.13		1.18
28	0.83	1.27	1.00	0.68	0.74	0.82	0.64	0.71	0.80	1.13	0.73	0.89	0.96	0.87		1.30
29	0.79	1.02	1.00	0.81	0.85	0.95	0.86	0.83	0.75	1.44	0.76	0.91	0.97	1.01		0.99
30	*0.79*	1.21	1.00	*0.81*	*0.85*	*0.95*	1.33	1.06	*0.75*	*1.44*	*0.76*	1.15	0.94	1.01		1.16
31	0.95	0.75	1.00	0.78	0.80	0.86	0.84	0.70	1.19	0.93	0.85	0.82	1.03	0.92		0.98
32	1.44	1.63	1.00	1.27	1.35	0.00	0.00	1.19	1.31	1.22	0.00	1.38	1.41	1.44		0.90
33	*0.95*	1.02	1.00	1.06	0.83	0.88	0.96	0.91	1.24	1.18	0.88	0.92	0.83	0.85		1.03
34	0.93	0.91	1.00	0.96	0.71	1.06	1.01	0.78	0.83	1.14	0.79	0.98	1.31	1.13		0.68
35	0.70	1.06	1.00	0.83	0.74	0.88	0.77	0.70	0.92	*1.14*	0.90	0.85	1.13	0.47		0.88
36	0.87	0.69	1.00	0.89	0.67	1.15	0.99	0.75	1.08	1.18	0.81	0.72	0.83	0.73		1.08

Note: Figures in italics are entries for which no reliable estimates could be made. Instead a unit value ratio of a closely related industry is taken.
Source: EU unit value ratios are multilateral ones (EKS) derived from Eurostat, PRODCOM database. US is based on binary comparison with Germany on basis of manufacturing censuses. US/Germany PPP for industry 33 based on 1999 EKS ICP PPP for instruments from OECD.

Table VII.10 Conversion exchange rates (national currency per Euro) as of 1999

Austria	13.76
France	6.56
Germany	1.96
Ireland	0.79
Italy	1,936.27
Netherlands	2.20
Spain	166.39
Finland	5.95
Sweden	8.81
Denmark	7.44
Belgium	40.34
Portugal	200.48
Greece	340.75
UK	0.66
Luxemburg	40.34

Note: For Denmark, Sweden and the UK the Euro conversion rates are the 1999 yearly average exchange rates between the national currency and the Euro, for the other countries the official conversion rate is given.