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**Productivity Measurement, National Accounts Data  
and the System of National Accounts:  
Lessons from the EUKLEMS-project\***

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## 1. Introduction

In the past decades, important changes in the pattern of economic growth in OECD countries have taken place. Recent improvements in productivity and employment have been interpreted as a movement towards a knowledge-based economy (OECD, 2003). Currently, output and employment are expanding fast in high-technology industries such as computers and electronics, as well as in knowledge-based services such as financial and other business services. More resources are spent on the production and development of new technologies, in particular on information and communication technology. Computers and related equipment are now the fastest growing component of tangible investments. At the same time, major shifts are taking place in the labour market in particular the increased demand for skilled labour whereas demand for low-skilled workers is falling across the OECD.

The blessings of the knowledge economy, however, seem to differ between OECD countries. For example, during the second half of the 1990s the comparative growth performance of the European Union (EU) vis-à-vis the United States has undergone a marked change. For the first time since World War II labour productivity growth in most countries that are now part of the European Union (EU) has fallen behind the U.S. for a considerable length of time. This has become a major source of concern within the European Union, as appears for example from the increased pressure to comply with the Lisbon and Barcelona goals of the Union which aim to support competitiveness and raise R&D performance. The urgency to better grasp the causes of Europe's growth deficit has been underlined in the recent review by the Kok Commission of the Lisbon agenda for reform in Europe, which aims to improve Europe's competitiveness (European Commission, 2004).

To adequately conduct policies that support a revival of productivity and competitiveness in the European Union, comprehensive measurement tools are needed to monitor and evaluate progress. In this regard the EU makes extensively use of the Structural Indicators, which includes a wide range of indicators measuring European policy targets, including GDP per capita, labour productivity, the employment rate, educational attainment, R&D expenditure, etc.. Unfortunately the Structural Indicators do not provide an analytical framework that can establish the relationship between those indicators. Hence it provides insufficient policy guidance on how the various policy targets interact. Moreover, the Structural Indicators do not provide industry detail, which has proven to be very important for understanding differences in economic performance.

Growth accounts provide an additional tool to assess changes in economic growth, productivity and competitiveness. A major advantage of growth accounts is that it is embedded in a clear analytical framework rooted in production functions and the theory of economic

growth. It provides a conceptual framework within which the interaction between variables can be analysed, which is of fundamental importance for policy evaluation.

This paper introduces a European set of growth accounts, named the EU KLEMS Growth and Productivity Accounts, that is presently under construction by a consortium of 15 research institutes across the European Union (see Appendix A). The consortium works closely together with various statistical offices across the European Union (see <http://www.euklems.net>). The EU KLEMS Growth and Productivity Accounts will include quantities and prices of output, capital (K), labour (L), energy (E), material (M) and services (S) inputs at the industry level. Output and productivity measures are provided in terms of growth rates and (relative) levels. Additional measures on knowledge creation (R&D, patents, embodied technological change, other innovation activity and co-operation) will also be developed. These measures are developed for individual European Union member states, and will be also linked with “sister”-KLEMS databases in the U.S., Canada and Japan. As the EU KLEMS project is still in its initial phase, a dataset cannot yet be provided. A preliminary test version (with limited access to participating institutions including several NSIs) was made available in May 2006. A full public version will be made available in the first quarter of 2007 through our website.

The present paper proceeds as follows. In *Section 2*, the EU KLEMS project and the relationships with the National Accounts are explained. In *Section 3*, the growth accounting methodology is briefly introduced which forms the guiding principle of the set-up of the EUKLEMS database. In *Section 4*, current progress on the major statistical aspects of the EU KLEMS project are discussed, including the construction of supply and use tables, labour and capital accounts for growth accounting purposes. The work on purchasing power parities is also briefly discussed. In *Section 5*, we provide a taste of the sort of analytical applications that the EU KLEMS Growth and Productivity Accounts can provide. It presents results from two recent studies on a comparison of productivity growth rates and levels of seven advanced economies (Australia, Canada, France, Germany, Netherlands, the United Kingdom and the United States), described in more detail in Inklaar, Timmer and van Ark (2006) and Inklaar and Timmer (2006). The growth accounts developed for this paper are a bridge between our earlier GGDC *60-Industry Database* and *Industry Growth Accounting Database* which we used in O’Mahony and van Ark (2003) and Inklaar, O’Mahony and Timmer (2005) and the new *EU KLEMS Growth and Productivity Database*. Finally, *Section 6* discusses the main challenges ahead.

## 2. Background on EU KLEMS Growth and Productivity Accounts

The EU KLEMS Growth and Productivity Accounts are rooted in the tradition of national accounting, input-output analysis and growth accounting, as pioneered by – among others – Simon Kuznets, Wassily Leontief, Moses Abramovitz, Robert Solow, Zvi Griliches and Dale Jorgenson. The most sophisticated measure of productivity is that of gross output relative to a broad range of inputs, including capital (K), labour (L), energy (E), materials (M) and service inputs (S). The KLEMS growth accounting approach has a long tradition going back to 1960s and 1970s when key publications by Jorgenson, Griliches, Christensen and others gave rise to a new era in identifying sources of growth. The KLEMS method is distinguished from earlier growth accounting studies which were based on value added. Despite their shortcomings, especially at the industry level, the value-added variant of growth accounting is still widely used. The KLEMS methodology moves beyond the aggregate value added production function, by primarily focusing on gross output and the inputs contributing to gross output creation, and by providing detailed breakdown of factor and intermediate inputs into their components.<sup>1</sup>

Most KLEMS growth accounting studies are carried out over time for individual countries and industries. Jorgenson, Gollop and Fraumeni were the first scholars to outline and apply the basic KLEMS-methodology for detailed industry-level analysis of productivity growth in the post-war US economy, which eventually evolved in their seminal 1987 publication (Jorgenson, Gollop and Fraumeni, 1987; Jorgenson, Ho and Stiroh 2005). Over the past years, KLEMS studies have been carried out in various European countries, including Denmark (Fosgerau and Sørensen, 2000), Italy (Basinetti et al., 2004), the Netherlands (van der Wiel, 1999) and the United Kingdom (O'Mahony and Oulton, 1994). Meanwhile new work has been embarked upon in these countries and elsewhere in Europe.

The intertemporal comparison of productivity can be converted into a cross-country (panel) comparison by integrating the time dimension with a country dimension. Recently, growth accounts have received renewed interest to study the effects of ICT on growth (Jorgenson and Stiroh, 2000; Colecchia and Schreyer, 2002, Basu et al., 2004; Timmer and van Ark, 2005, Inklaar et al. 2005). Growth accounts measures by industry, including a breakdown for ICT assets, are now available from the Groningen Growth and Development Centre (GGDC) for seven countries (Australia, Canada, France, Germany, Netherlands, UK and USA) but only with national accounts-based value added as the output concept (see Section 4).

So far little attention has been paid to the international comparability of growth accounts in various countries. The primary aim of the European KLEMS project is to arrive at an internationally comparable dataset to enhance the analysis of economic growth. This database

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<sup>1</sup> For notation and the underlying production function framework of KLEMS, see Appendix B.

will include time (1970 to present), industry (72 industries) and the country dimensions (25 EU member states). The European dataset will also be linked with Canada-Japan-USA databases to allow for international comparisons (see e.g., Gu, Lee and Tang, 2001; Jorgenson and Nomura, 2005). Also a consortium coordinated by RIETI in Japan is developing an Asian database, called the ICPA–database (International Comparison of Productivity among Asian countries; see <http://www.rieti.go.jp/en/database/data/icpa-description.pdf>) along the same lines as EU KLEMS, for China, Japan, Korea and Taiwan. Links between EU KLEMS and these databases will allow for truly global comparisons of growth and productivity.

The EU KLEMS growth accounts are based on the principles as established in the latest System of National Accounts (1993) and the European System of Accounts (1995). In particular the recommendations to move towards the use of an input-output system for the construction of national accounts, the use of chain indices for the measurement of prices and quantities, and the capitalization of software are key ingredients for improved productivity measurement using a KLEMS input structure. Most recently the various methods to measure output, productivity and (capital) inputs have been described in two OECD documents (OECD, 2001a, 2001b) and in two Eurostat manuals (Eurostat, 2001, 2002).

The EU KLEMS Growth and Productivity Accounts is intended to be available for National Statistical Institutes (NSIs) for future implementation in official statistical practice. At the same time the database is intended to explore new methodological applications and to maximize international comparability for economic and policy research. Hence the accounts will consist of two interdependent modules:

- The *Analytical Module* is the core of the EU KLEMS accounts. It provides a (research) database at the highest possible quality standards for use in the academic world and by policy makers. It uses “best practice” techniques in area of growth accounting, focuses on international comparability, and aims at full coverage (country \* industry \* variable) at least for the revision period of the national accounts. It will also consider alternative or pioneering assumptions regarding statistical conventions on, for example, the output and price measurement of ICT goods and non-market services, comparisons of skill levels, the measurement of capital services and the capitalization of intangible assets.
- The *Statistical Module* of the database will be developed parallel to the analytical module. It includes data which are as much as possible consistent with those published by NSIs. Its methods will usually correspond to the rules and conventions on national accounts, supply and use tables, commodity flow methods, etc. (SNA 1993, ESA 1995), and any deviations from these standard rules should at least be supported by the NSIs.

The EU KLEMS project is an interactive project, in which a clear trajectory is established that allows for a convergence between the analytical and statistical modules of the databases in due time. To achieve this the EU KLEMS consortium will continuously seek NSIs advice to work jointly on aspects of the database and to ensure that the pioneering methodologies are further improved to achieve the statistical standards of NSIs, so that the data produced within the analytical module (once meeting the NSI standards) can be transferred to the statistical module. Alternatively, data produced within the analytical module (that do not meet statistical standards adopted by the NSIs) will remain in the database of the analytical module.

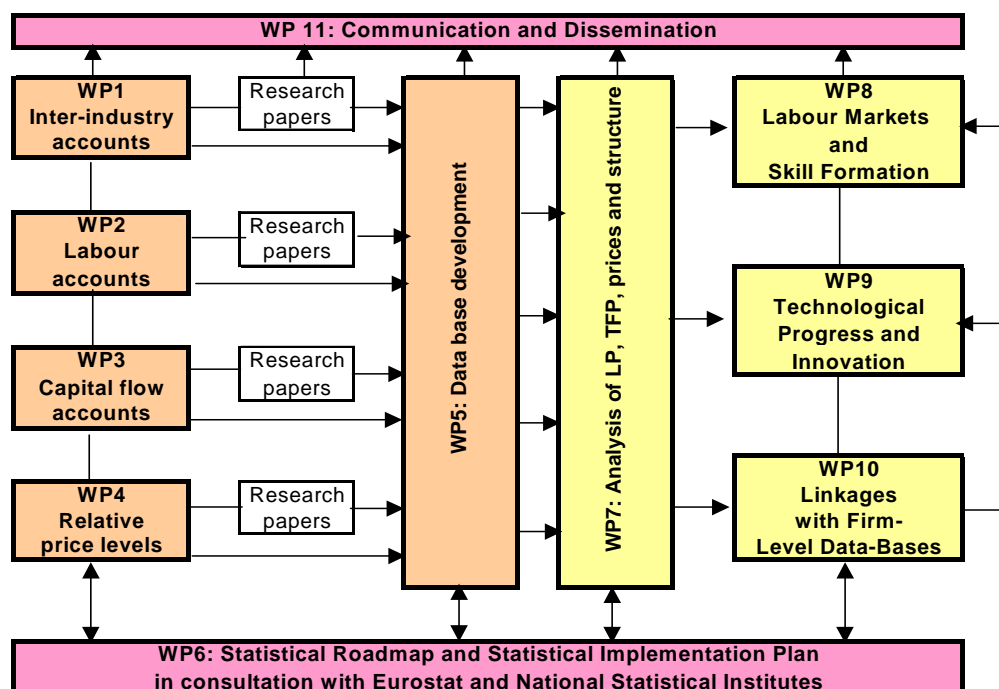
The EU KLEMS project is divided up in three types of work (see **Figure 1**):

- Workpackages 1-5 focus on the construction of the EU KLEMS Growth and Productivity Accounts. WP1 develops the Supply-Use Tables that are used to measure output and intermediate inputs in current and constant prices. WP 2 constructs the series of labour quantity (employment and hours) and labour quality (disaggregation to gender, age and skill level) by industry. WP3 deals with the construction of the capital accounts, in particular measures of investment by asset and industry and the construction of capital and capital service estimates. WP4 provides industry output and input purchasing power parities which are needed for the measurement of comparative levels of output and inputs. Finally, WP5 focuses on the actual construction of the database. Section 3 deals in more detail with sources and methods for the statistical workpackages WP 1-4.
- Substantial methodological research will be carried out on, for example, the measurement of output, inputs and prices in Supply-Use tables for the purpose of growth accounting, the measurement of education qualifications in the labour force statistics, the measurement of capital services, and the construction of indicators of knowledge creation (such as the capitalization of R&D, etc).<sup>2</sup> This research contributes to issues which presently top the agenda of statistical agencies and institutions involved in empirical economic research. They are directly related to the implementation of the guidelines under SNA 1993 and ESA 1995 and the development of new conventions on measures of non-tangible assets (including technology indicators such as R&D) by the Canberra II group.
- Workpackages 7-10 deal with analytical applications of the EU KLEMS database. The analytical part of the project consists of four research areas: (1) analysis of Productivity, Prices, Structures and Technology and Innovation Indicators (WP7); (2) Research on labour market and skill creation (WP8); (3) research on technological progress and innovation (WP9); and (4) research on linkages to firm level databases (WP10). In Section 4 below an application is shown of research based on pre-EU KLEMS data related to WP7 and WP9.

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<sup>2</sup> Papers and notes on EU KLEMS research can be downloaded from <http://www.euklems.net>

**Figure 1: Workpackages in EU KLEMS project**



Concerning WP10, it should be stressed that this project also leverages the analytical power of the work by providing an explicit link to existing micro (firm-level) databases from statistical agencies, using the same basic statistical material as the industry and macro sources used for the EU KLEMS Growth and Productivity Accounts. Immediate gains will come from confronting the EU KLEMS series with cross-country comparisons of firm level datasets. The more important analytical gains will come from integrating micro databased measures of “within-industry” firm-level distributions with the EU KLEMS “between-industry” results. In addition, the integration of micro data may create a foundation for reducing the costs and increasing the quality of a future extension of the EU KLEMS database. For example, by using firm level data, alternative classifications of industries, labour components or asset types can be obtained.

### 3. Growth accounting methodology

A key objective of the EU KLEMS database is to move beneath the aggregate economy level and examine the productivity performance of individual industries and their contribution to aggregate growth. Previous studies have shown that there is enormous heterogeneity in output and productivity growth across industries, so analysts should focus on the industry-level detail to understand the origins of the European growth process. In this section we summarize the methodology used to develop our measures of industry-level productivity growth. We begin with the industry-level production function and show how this allows us to

quantify the sources of output growth. In general, we follow the growth accounting methodology as developed by Dale Jorgenson and associates as outlined in Jorgenson, Gollop and Fraumeni (1987) and more recently in Jorgenson, Ho and Stiroh (2005). We follow their notation as close as possible. It is based on production functions where industry gross output is a function of capital, labour, intermediate inputs and technology, which is indexed by time,  $t$ . Each industry, indexed by  $j$ , has its own production function and purchases a number of distinct intermediate inputs indexed by  $i$ , capital service inputs indexed by  $k$ , and labour inputs indexed by  $l$ . The production functions are assumed to be separable in these inputs, so that:

$$Y_j = f_j(K_j, L_j, X_j, T) \quad (1)$$

where  $Y$  is output,  $K$  is an index of capital service flow,  $L$  is an index of labour service flows and  $X$  is an index of intermediate inputs, which consists of the intermediate inputs purchased from the other domestic industries and imported products. Under the assumptions of constant returns to scale and competitive markets, the value of output is equal to the value of all inputs:

$$P_j^Y Y_j = P_j^K K_j + P_j^L L_j + P_j^X X_j \quad (2)$$

where  $P_j^Y$  denotes the price of output,  $P_j^X$  denotes the price of intermediate inputs,  $P_j^K$  denotes the price of capital services and  $P_j^L$  denotes the price of labour services. All variables are also indexed by time, but the time subscript is suppressed in the remainder of this paper wherever possible for brevity. This expression is evaluated from the producer's point of view and thus excludes all taxes from the value of output, but includes producer subsidies. This is the basic price concept in the System of National Accounts 1993. The inputs are valued at purchasers' prices and reflect the marginal cost paid by the user. Therefore they should include taxes on commodities paid by the user (non-deductible VAT included) and exclude the subsidies on commodities. Margins on trade and transport should be included as well. The measurement of prices and quantity of outputs is further discussed in section 4. In section 6, capital service prices and quantities are discussed in more detail. It is important to note at this stage that the price of capital services is defined as a residual such that equation (2) holds. The measurement of prices and quantities of labour services is discussed in section 5.

Under the standard assumption of competitive markets, such that factors are paid their marginal product, and constant returns to scale, we can define MFP growth ( $\Delta \ln t_j$ ) as follows



$$\Delta \ln t_j = \Delta \ln Y_{jt} - \bar{v}_{jt}^X \Delta \ln X_{jt} - \bar{v}_{jt}^K \Delta \ln K_{jt} - \bar{v}_{jt}^L \Delta \ln L_{jt} \quad (3)$$

Growth of MFP is derived as the real growth of output minus a weighted growth of inputs where  $\Delta x = x_t - x_{t-1}$  denotes the change between year t-1 and t, and  $\bar{v}_{jt}$  with a bar denoting period averages and  $\bar{v}$  is the two period average share of the input in the nominal value of output. The value share of each input is defined as follows:

$$v_{jt}^X = \frac{P_{jt}^X X_{jt}}{P_{jt}^Y Y_{jt}}; \quad v_{jt}^L = \frac{P_{jt}^L L_{jt}}{P_{jt}^Y Y_{jt}}; \quad v_{jt}^K = \frac{P_{jt}^K K_{jt}}{P_{jt}^Y Y_{jt}} \quad (4)$$

The assumption of constant returns to scale implies  $v_{jt}^X + v_{jt}^L + v_{jt}^K = 1$  and allows the observed input shares to be used in the estimation of MFP growth in equation (3). This assumption is common in the growth accounting literature (see e.g. Schreyer 2001). Alternatively, one can perform growth accounting without the imposition of constant returns to scale and use cost shares, rather than revenue shares to weight input growth rates (Basu, Fernald, and Shapiro 2001).

Rearranging (4) yields the standard growth accounting decomposition of output growth into the contribution of each input and MFP (denoted by  $A_{jt}^Y$ ):

$$\Delta \ln Y_{jt} = \bar{v}_{jt}^X \Delta \ln X_{jt} + \bar{v}_{jt}^K \Delta \ln K_{jt} + \bar{v}_{jt}^L \Delta \ln L_{jt} + \Delta \ln A_{jt}^Y \quad (5)$$

where the contribution of each input is defined as the product of the input's growth rate and its two-period average revenue share. These contributions are captured by the following variables in the EU KLEMS database:

$$\begin{aligned} GO\_Q &= \Delta \ln Y_{jt} \\ GOconI &= \bar{v}_{jt}^X \Delta \ln X_{jt} \\ GOconK &= \bar{v}_{jt}^K \Delta \ln K_{jt} \\ GOconL &= \bar{v}_{jt}^L \Delta \ln L_{jt} \\ GOconMFP &= \Delta \ln A_{jt}^Y \end{aligned}$$

In order to decompose growth at higher levels of aggregation (see discussion below) we also define a more restrictive industry value-added function, which gives the quantity of value added as a function of only capital, labour and time as:

$$V_j = g_j(K_j, L_j, T) \quad (6)$$

where  $V_j$  is the quantity of industry value added. Value added consists of capital and labour inputs, and the nominal value is:

$$P_j^V V_j = P_j^K K_j + P_j^L L_j \quad (7)$$

where  $P^V$  is the price of value added. Under the same assumptions as above, industry value added growth can be decomposed into the contribution of capital, labour and MFP ( $A^V$ ).

$$\Delta \ln V_{jt} = \bar{w}_{jt}^K \Delta \ln K_{jt} + \bar{w}_{jt}^L \Delta \ln L_{jt} + \Delta \ln A_{jt}^V \quad (8)$$

where  $\bar{w}$  is the two period average share of the input in nominal value added. The value share of each input is defined as follows

$$w_{jt}^L = (P_{jt}^V V_{jt})^{-1} P_{jt}^L L_{jt}; \quad w_{jt}^K = (P_{jt}^V V_{jt})^{-1} P_{jt}^K K_{jt} \quad (9)$$

Analogous to the decomposition of gross output growth, the following variables capture the contributions of inputs and MFP to value added growth:

$$\begin{aligned} VA\_Q &= \Delta \ln V_{jt} \\ VAconK &= \bar{w}_{jt}^K \Delta \ln K_{jt} \\ VAconL &= \bar{w}_{jt}^L \Delta \ln L_{jt} \\ VAconMFP &= \Delta \ln A_{jt}^V \end{aligned}$$

In order to define the quantity of value added, we assume that the production function is separable in intermediate input and value added. To remain consistent with the gross output function, one needs to define the quantity of value added implicitly from a Tornqvist expression for gross output:

$$\Delta \ln Y_{jt} = (1 - \bar{v}_{jt}^V) \Delta \ln X_{jt} + \bar{v}_{jt}^V \Delta \ln V_{jt} \quad (10)$$

or rewriting

$$\Delta \ln V_{jt} = \frac{1}{\bar{v}_{jt}^V} \left( \Delta \ln Y_{jt} - (1 - \bar{v}_{jt}^V) \Delta \ln X_{jt} \right) \quad (10')$$

where  $\bar{v}_{jt}^V$  is the average share of value added in gross output. The corresponding price index of value added is also defined implicitly to make the following value identity hold:

$$P_j^V V_j = P_j^Y Y_j - P_j^X X_j \quad (11)$$

If value added quantity and price is defined in this way, MFP measured for gross output (as in 5) and MFP as measured for value added (as in 8) are proportional to each other with the ratio of gross output over value added as the factor of proportion (Bruno 1984)<sup>3</sup>

$$\Delta \ln A_{jt}^V = \frac{1}{\bar{v}_{jt}^V} \Delta \ln A_{jt}^Y \quad (12)$$

## 4. Sources and Methods for EU KLEMS

### Data Sources

The data for the EU KLEMS database are essentially obtained from the national accounts, labour statistics, etc. from National Statistical Institutes, and therefore as much as possible in line with statistical harmonisation, in particular the implementation of ESA 1995, by Eurostat. Data collection is primarily done through local EU KLEMS consortium members in consultation with representatives from the NSIs (see Appendix A). The national databases are stored and harmonised in the international EU KLEMS database, which is maintained by the EU KLEMS data hub.<sup>4</sup> In Appendix B we provide an overview of the variables included in

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<sup>3</sup> However, note that this is only valid as long as there are no adjustments made to the capital compensation shares, due to negative rental prices (see section 5).

<sup>4</sup> Country-specific data on output and inputs are read into a meta database. The construction of the growth and productivity accounts are then carried out through the central data hub of EU KLEMS using a software programme, called ProdSys© (Productivity Research Data System). ProdSys© is programmed as an application layer on top of SAS, designed to overcome practical data hurdles in productivity calculations and growth accounts, and is presently also in use at the Federal Reserve Board in Washington D.C. (Bartelsman and Beaulieu, 2004)

the preliminary EUKLEMS database. The set of variables in the final data base will be the same, but we are open for suggestions for inclusion of other variables. Data availability is discussed below in more detail on a workpackage basis.

### EU KLEMS Industry Classification

Appendix C provides an overview of the EU KLEMS (EUK) Industry Classification, which includes 72 industries. The EUK classification is designed with the aim to provide industry detail which will be useful in further analysis of output and productivity growth in a later stage of the project, taking into account the constraints of the commonly used classifications, notably NACE. The NACE A60 list has therefore been taken as the point of departure. Firstly, further industry detail was added because of specifics concerning skill, R&D and ICT investment intensity. These additional industries were: (1) pharmaceuticals (244); (2) insulated wire (313); (3) electronic valves (321); (4) telecommunication equipment (322); (5) scientific instruments (331t3); (6) boats (351); (7) aircraft (353); and (8) legal/technical/advertising services (741t4). Secondly, there was a need to anticipate the upcoming revision of NACE in 2007. This led to a split-up of (1) electricity from other utilities (40x from 40); (2) publishing from publishing and printing (221 from 22) and (3) media services from recreational activities, etc. (921t2 from 92). Finally, it is important to separate imputed rents of owner occupied housing from other real estate (70imp from 70). Imputed rents make up a big share of real estate output but do not have a labour input equivalent. Including these rents in productivity analysis can be highly distorting. However, it appears that in many countries this distinction is not feasible, and it will be dropped in the final database.

EUK-72 list is only a target list. Data availability will differ by country, by time period and by variable. For example, for value added this level of detail should be attainable at least for the revision period, and (with some additional work on the basis of industry surveys or censuses) even for the historical data back to 1970. For the investment series, however, it will be difficult for most countries and periods to realize EUK72, and a higher level of aggregation will be used.

### Workpackage 1: Inter-Industry Accounts

An important advantage of the EU KLEMS framework compared to other productivity databases is that it provides for the analysis of output and intermediate inputs by way of Supply & Use Tables (SUTs). Unfortunately, only very few countries have full time series of SUTs. In several cases interpolations of benchmark tables and a reworking of Industry by Industry Tables to SUTs will be necessary. For the historical period (i.e., the period before the present revision period), it will in some cases be necessary to rely solely on output and

input series from the national accounts. The procedures laid out below provide a guidance on the various alternatives that are being applied for the individual countries.<sup>5</sup>

We can derive growth of both outputs and intermediate inputs, and the weights, from a time series of inter-industry transaction tables in current and constant prices. The weights for intermediate inputs can be derived from a Use table at current purchase prices. Volume growth rates of output and intermediate inputs in the period (0,t) can be derived from a Use table at 0 and t in constant prices. Following the recommendations in the ESA95, chained Laspeyres volume indices are used. Hence, the deflators should be of the chained Paasche type. The main reason for working with Laspeyres volume indices (rather than say Fisher, or Tornqvist) is the advantage of additivity, which is needed for working in a balanced SUT framework.

In principle, one only needs data from the intermediate and value added blocks in the Use table. The final demand columns are not directly needed, neither is the Supply table. However, there are good reasons for also collecting and constructing complete SUTs, including valuations matrices. In many applications (e.g., analysis of tax reforms, role of trade and transport margins, macro-economic modelling, IO-analysis etc.) full SUTs are needed. More specifically with respect to the construction of the EU KLEMS database, a full SUT framework is needed to intra- and extrapolate benchmark tables when full time series of Use tables are not available (see below). A full SUT framework is also useful when a distinction between domestically produced goods and imported goods is aimed for.

Ideally, the inter-industry accounts should consist of a set of supply table, two use tables and eight valuation matrices in current and previous year prices for each year:

- time series of use tables at basic prices in current and previous year prices.
- time series of supply tables at basic prices in current and previous year prices.
- Trade margin table in current and previous year prices (retail and wholesale separate if possible)
- Transport margin table in current and previous year prices (by mode of transport if possible)
- Non-deductible VAT on commodities in current and previous year prices
- Other taxes net of subsidies on commodities in current and previous year prices

This decomposition of the U table at purchase prices can be combined with a split into domestically produced and imported goods such that

$$U_{Pur} = (U_{Bas}^D + TR^D + TT^D + TV^D + T^D) + (U_{Bas}^I + TR^I + TT^I + TV^I + T^I)$$

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<sup>5</sup> For notation and the underlying production function framework of KLEMS, see Appendix B.

As this ideal setup may not always be achieved in the short term, EU KLEMS considers a number of alternatives for the collection of output and intermediate input data and countries will differ in the amount of detail provided. According to the ESA 95 only one margin column and one net tax column is required so this is the level of detail which most NSIs will certainly have. Under some kind of proportionality assumption, detailed valuation matrices can be generated on the basis of vector totals.

Unfortunately not all countries have all these sets of tables presently available, and if they do it is quite often limited to the revision period. For the historical period there often is some information on inter-industry deliveries but not in the form of product by industry SUTs. Instead, symmetric input-output tables (industry by industry) are mostly available for certain benchmark years (also provided on a comparable basis by OECD). However, incorporating old IO-tables into the new SUT-framework appears to be cumbersome. In **Table 1**, we provide an overview of the SUT series in the preliminary database by country, and our aim for the final database for each country.

#### *Link between data from National Accounts and SUTs*

The general principle is that the time series of SUTs in current and constant prices to be used in EUKLEMS should be consistent with the National Accounts (NA). To be more precise: in *current prices*, gross output and intermediate input use by industry in SUTs should match NA data. The only industries for which a difference might arise between SUTs and NA is in non-market services. Part of the output of non-market services is estimated through the cost of capital use. Depending on the results of the capital accounts (WP3), this estimate might be revised by including a rate of return, capital gains and possibly different depreciation patterns.

Another possible deviation between the SUTs for EU KLEMS and the NA in current prices is the treatment of FISIM. In the past year most European NSIs moved to an allocation of FISIM to industries, which is the preferred method also from the perspective of productivity measurement. But not all countries will implement the FISIM adjustment also for their historical series. As the default option for the distribution of FISIM to the users, possible methods to allocate FISIM include:

- distribution proportional to output (this is the shortcut recommended by Eurostat),
- distribution proportional to directly measured financial services, or
- distribution proportional to outstanding loans.

Possible data sources which can be used are loan data available from central banks, or perhaps firm-level data in international data sets such as Amadeus and BIS. This will give insight in the FISIM to be allocated between intermediate users, but not for final consumers.

For the constant price table, the SUTs should match gross output from the NA, provided the NA also uses chained Laspeyres indices. In EU KLEMS real value added is derived as a residual (double deflation) by subtracting weighted growth of intermediate input from growth of output. This value added might differ from the NA measures of value added, for example in cases where no double deflation has been used in the NA. Also as NSIs often have more industry detail than EU KLEMS has access to, aggregation may lead to EU KLEMS deflators which vary from more detailed national data. For further details on the actual derivation of time series of current price SUTs and derivation of time series of output and input volumes, interested readers are referred to the EU KLEMS Statistical Roadmap (<http://www.euklems.net>).

### Workpackage 2: Labour Accounts

Labour accounts in the EU KLEMS project deal with information on the quantity (persons and working hours) and quality (distribution of quantities by age, gender and education level) of labour input by industry.

#### *Labour quantity*

The latest SNA and ESA encourages countries to include labour accounts in their national accounts, and most countries have committed to do so by 2006 at the latest. The default option for EU KLEMS is therefore to work on the basis of national accounts figures on labour quantity. However, as there are substantial inconsistencies across countries in terms of their preferred sources and concepts of employment and working hours, adjustments to the national accounts figures will be considered for the analytical module. Gerard Ypma and Bart van Ark (2006) provide a more detailed discussion of the various sources underlying employment series in the National Accounts of OECD countries.

To provide a national accounts-based employment series some countries use enterprise surveys while others use labour force surveys (LFS) or a mixture of sources. This may lead to inconsistencies in definitions, the most important being the distinction between persons and jobs. Thus employment estimates in Austria, Denmark, France, Italy, the Netherlands and the UK are for persons, whereas Germany and Belgium use jobs. Ireland is likely to use persons, whereas Spain has changed their definition through time. Finally, Finland appears to use a mixture of jobs and persons. Separate series on persons employed and hours worked per person are the preferred measure of employment in EU KLEMS, if possible with a subdivision in employees and self-employed workers. The “person concept” is used in most countries and provides more information on the employment situation than total working hours or full-time equivalent units. A complication with the use of persons as the main employment measure is the allocation across industries for multiple job holders. This issue will be addressed in the allocation of working hours per person.

A second issue concerning labour quantity is the treatment of agency workers. Individual surveys such as the LFS allocate agency workers mostly to the industry where they work whereas enterprise surveys tend to allocate them to business services. In the statistical module, EU KLEMS will mostly follow the practice of NSIs. But the analytical module will use a consistent definition by making sure that at least the output from agency workers and their labour input are reported for the same industry.

There are two basic methods in use to construct annual average hours worked, using either estimates of actual hours from surveys or information on paid hours which then need to be adjusted to take account of hours paid but not worked. For most countries data on actual hours are only available from the LFS (the only exception appears to be Spain). But hours data in the LFS by industry seem very volatile (and will be even more so if one attempts to divide by characteristic) because of the low sample sizes. In many countries, however, the range of sources on paid hours is greater. One possible way forward is to use aggregate LFS hours (or by broad sector) as control totals. Further disaggregation to detailed industries could then be achieved by using variations in paid hours from enterprise surveys.

### *Labour quality*

In most countries there are reasonable data available to distinguish employment by gender, age and skill, but the source and level of detail different substantially. The sources typically are LFS, social security data, business registers and the population census. In incorporating educational attainment as a measure of skill, we have not attempted to force all member countries into a rigid high-medium-low skill split. We consider this to be too restrictive, given the differences in educational systems throughout Europe. We therefore assume comparability only across the bachelor degrees educational level. The average number of educational groups recommended is around 5.

Numbers and wages are also collected on the basis of age bands. The following split was agreed: 15 to 29, 30 to 49, 50 and above. Discussions on the appropriateness of this split were held during a labour accounts workshop (November, 2005). It was felt that it would be increasingly important not to cap the retirement age over time, as working lives increased beyond the traditional 60/65 retirement ages. A more detailed age breakdown may be available in the analytical model for some countries, and these will provide an opportunity for research.

Other variables that could also be included are occupational splits and gender splits. The former has been used in a number of studies of this type (Jorgenson et al 1987), however an important issue is the trade-off between detail in labour characteristics and reliability. The possibility to have more detail will to a large extent depend on the sample sizes of the surveys. And in most countries, these will be binding, that is, they are too small to split labour by 5 educational categories x 3 age groups x 72 euk industries. We therefore recommend to give priority to the educational and age characteristics, compromising on the



level of industry detail. It is not unrealistic to assume that labour characteristics do not vary widely across closely related industries. The wage data to aggregate labour quality are less readily available. A particular problem with LFS is that the sample size is often too small to handle the breakdown. This can be resolved in case consortium partners can access the underlying micro-data from the LFS.

EU countries can be divided into three groups on the basis of data availability on labour quality:

1. Countries with sufficient data for all variables

Countries where sufficient data exist to allow a division of both employment and earnings by industry, gender, age and skill (except possibly for a few small industries in manufacturing). Few if any countries fall into this group, except possibly Denmark and Germany.

2. Countries with sufficient data for some of the variables

Countries where reasonable data exist to carry out a division by numbers employed but not by earnings. This group includes the UK, and is likely to include many other countries. In this case, EU KLEMS will devise methods to divide the labour force up by a subset of dimensions. One workable assumption is to assume that returns to different types of education/qualification are the same across industries. In that case, one can use aggregate based measures for skills to fill in the matrix. Let  $g$  denote gender,  $a$  denote age,  $s$  denote skill and  $i$  denote industry. For each industry  $i$ , the quality adjusted labour input is then calculated as:

$$LQ^i = \sum_g \sum_a \sum_s 0.5 [Sw^i_{gas,t} + Sw^i_{gas,t-1}] \ln \left( \frac{E^i_{gas,t}}{E^i_{gas,t-1}} \right)$$

where  $Sw^i_{gas}$  is the wage bill share of type  $g,a,s$  in industry  $i$ 's total wage bill and  $E$  is employment.

If one is not confident about the three way division of wage rates, alternative approaches may be used to estimate the components of the above equation. For example, if reliable estimates can be obtained for gender and age but not for skill, one may assume that the relative returns to education/qualification are equal across industry. One way to do this is to divide total economy employment and average wages by all three categories and then apply the relative wages of skilled workers, cross classified by the remaining two dimensions, to all industries. First calculate  $w^T_{gas}$  for each  $s$  in groups  $g$  and  $a$  and assume that the relative wage rates of  $s_2$  to  $s_1$ ,  $s_3$  to  $s_1$

etc. are the same across industries for given  $g$  and  $a$ . Note, even if relative wage rates for skill level  $sj$  relative to some numeraire group,  $sI$ , were constant across industry:

$$w_{j,ga}^s / w_{sI,ga}^s = w_{j,ga} / w_{sI,ga} = \omega, \forall i$$

the aggregate relative wage for  $sj$  relative to  $sI$ , for given  $g$  and  $a$ , will not equal  $\omega$  except in the unlikely event that the wage levels are constant across industries.

An alternative more sophisticated approach is to estimate the average relative skill wage rates with regression equations that allow for age and gender. The regression approach also involves assuming that the relative wage rates within any one category  $s$  are the same across industries for given values of the other variables, but it treats each observation as equivalent and is therefore not subject to the same aggregation problems as in the aggregate method above. This has the added advantage that (subject to data limitations) other variables that might put a wedge between wages and marginal products, such as ethnic backgrounds, can be incorporated.

The above two methods assume all people of type  $s$  are identical. This may not be the case, e.g. if the use of computers gives higher returns to more numerate graduates. This could be allowed for by splitting samples across broad industry groups, e.g. splitting into ICT producing, ICT using, non-ICT etc. or by one digit NACE groups.

### 3. Countries with proxy data

Reliable information on skills is not available for these countries but data exist for a proxy such as occupations. In this case it will be necessary to consider the extent to which dividing by occupation reflects the skill dimension.

### Workpackage 3: Capital Flow Accounts

The capital accounts in EU KLEMS will be built on the basis of investment figures on asset by industry. Capital stocks, capital service flows can be derived from the investment series, following the methodology set out elsewhere (Jorgenson, Gollop, Fraumeni, 1987; OECD, 2001a). The OECD National Accounts make a subdivision of total assets into 6 asset categories (Residential structures, Non-residential structures, Transport equipment, Machinery and other equipment, Products of agriculture and forestry and other products). For analytical purposes we also want to break out ICT assets (Computing equipment, Communication equipment and Software). Furthermore a distinction needs to be made between non-residential structures and infrastructure. Hence at the most detailed level the EU KLEMS classification of assets consists of 10 investment categories, of which three are in structures, four in machinery and equipment, two in intangible assets and an additional category representing products of agriculture and forestry (see **Table 2**).

The construction of capital stocks and capital services is preferably done on the basis of long run investment series, which – for assets with long lives – needs to extend back in time to well before 1970. Depreciation procedures and assumptions, however, may differ strongly by country. The analytical module of EU KLEMS will use a harmonized depreciation method, probably using deflators for ICT goods and depreciation rates from the U.S. Bureau of Economic Analysis (BEA). Capital services can be computed using either ex ante assumptions or ex post measurement of the nominal rate of return. As this issue is still under discussion among experts, EU KLEMS will leave options open to apply either approach or a combination of the two (Schreyer, 2004; Oulton, 2005).

In sum, the distinction between the Statistical and Analytical Modules of the EU KLEMS database is very important for the capital accounts in EU KLEMS. NSIs do generally not publish capital service data and do not use harmonized deflators or depreciation rates. The statistical module of the EU KLEMS database will therefore stay relatively close to the published data of the NSIs and only include measures of capital stock (unless indicated differently by NSI's). For the analytical module, however, EU KLEMS will provide alternative time series for capital services.

#### *ICT capital*

ICT capital can be classified in three categories, namely computing equipment, communication equipment and software. In particular computing equipment will be difficult to distinguish, especially on the detailed EUK industry classification, and may require some assumptions. In some cases, the category “computing equipment” may be ideally restricted to computers and peripheral equipment (which is the preferred option), whereas in other cases it may not be possible to split this category off from a broader category including other types of office machinery and equipment (like typewrites, photocopiers, etc.) or even additional ICT goods, like medical equipment, industrial process control equipment, and instruments and appliances for measuring, checking, testing and navigating.

Another problem on ICT concern the estimation of own account software. In the U.S., the estimates of own account software are based on the wage bill of computer programmers employed outside the computer services industry, grossed up for overhead costs (Parker and Grimm, 2000). Adjustments are made for the proportion of programmers whose software is bundled into products, and therefore already counted as hardware investment, and for the proportion of such people's time which is devoted to non-investment activities. The EUKLEMS project will give consideration to gathering data on the number of employees who can be classed as computer programmers, software engineers and the like. Such occupational data are generally available from household surveys like the LFS or from employer-based surveys such as the UK's New Earnings Survey.

In order to obtain ICT investment series at constant prices, EU KLEMS will primarily use the U.S. price index (adjusted for exchange rate changes) unless the computer deflators which are used in the national accounts of the individual countries are perceived to adequately reflect quality changes in IT equipment.

There are a couple of other issues related to capital measurement, which need more attention in the follow-up of this database: land and inventories, the role of taxes and infrastructure.

#### *Land and inventories*

The other forms of capital recognized in the SNA are land and inventories. In principle, growth accounting should incorporate all forms of capital recognized in the SNA. This will be necessary because the weights to be applied will be too high since some part of gross operating surplus is a return to land and inventories. In principle, one needs to estimate the value of land and inventories, impute a rate of return, and then exclude the profit attributable to these assets from the weight to apply to fixed and intangible capital. A natural assumption to make is that the rate of return to land and inventories is the same as that of other assets.

At the aggregate level, the change in inventories is part of GDP. So with a bit of work it should be possible to develop estimates of the stock of inventories and the proportion of gross operating surplus attributable to inventories. Land presents more of a problem. Data on the value land are often available only from sectoral balance sheets, mostly as current prices, without a disaggregation by industry and with certain inconsistencies relation to the valuation of assets in the national accounts. One possibility is to use estimates of the number of hectares of land devoted to various uses (agricultural, commercial, residential, industrial, etc) and apply estimates of average commercial rents per hectare.

#### *The tax factor in the cost-of-capital formula*

The rental value of assets, as used for the calculations of capital services, preferably requires an adjustment for taxes on assets. The Institute for Fiscal Studies (IFS) in London has done a great deal of work on company tax, including the statutory tax rate (inclusive of local taxes), the present discounted value of depreciation allowances and effective marginal tax rates (EMTR) and average tax rates (EATR) under a number of different assumptions. These estimates could form the basis for the EU KLEMS estimates of the tax factor in the cost-of-capital formula. One concern, however, is the possible inconsistency between the depreciation rates that are used in the IFS calculations and those used for EU KLEMS. These will need to be reconciled.

#### *Public and private infrastructure*

The framework for EU KLEMS is an industry, not a sectoral, breakdown. Therefore, a distinction between public and private investment in infrastructure is not our direct concern,

as long as they are recorded according to using industry. But normally they are not. Hence, if assets shift from the public to the private sector, capital and productivity measures will be incomparable over time, and between countries. Examples include investment in toll-roads, railways, school and hospital buildings which are made by both public and private investors. Therefore it might be important to have more detail in the investment flows of infrastructure assets, and have a breakdown in e.g. road, water and port, airport, railways and others. In that case, the various infrastructure assets can be allocated to the sector of use, independently of ownership (public or private). For some countries, such as Spain, this information is available, and further investigation is needed for the others.

#### Workpackage 4: Relative Output and Input Price Levels

Levels of outputs and inputs between countries can be compared by using relative prices to express these outputs and inputs in a common currency. It is well known that the use of exchange rates may be highly inaccurate, since relative prices and exchange rates may differ considerably. Since long, international comparisons of output are based on expenditure PPPs from the International Comparisons Project which provide relative prices for a range of expenditure items (Kravis, Summers and Heston 1982). But comparisons of productivity also require PPPs for inputs. Nishimizu and Jorgenson (1978) introduced the methodology to derive PPPs for labour and capital input, based on relative wages and investment prices. This system was extended by Jorgenson, Kuroda and Nishimizu (1987) to include PPPs for intermediate inputs. They were also the first to adjust expenditure PPPs, which are based on a purchasers' price concept, into basic prices, eliminating trade and transportation margins and net indirect taxes. This is required as industry output in the National Accounts is measured in basic prices, not purchasers' prices. However, it is well known that this procedure has several drawbacks. First, the adjustment factors for expenditure PPPs are often not available. Second, expenditure PPPs are not always a feasible option for all industries because no price data are available for products which are typically used as intermediates rather than for final consumption.

Recently, Timmer, Ypma and van Ark (2006) presented a new and comprehensive dataset of output PPPs at an industry-by-industry basis which addresses these weaknesses. Output PPPs are defined from the producer's point of view and are at basic prices, which measures the amount receivable by the producer for a unit of a good or service produced. These PPPs have partly been constructed using unit value ratios for agricultural, mining, manufacturing and utilities products and transport and communication services. For the other industries, PPPs are based on specified expenditure prices from Eurostat and the OECD, which were adjusted to industry level by using relative transport and distribution margins and adjusting for differences in relative tax rates. PPPs have been made transitive by applying the

multilateral EKS-procedure for the set of 26 countries.<sup>6</sup> This set of gross output PPPs for 1997 covering 45 industries at (roughly) 2-digit industry level is the basic starting point for our current study. The gross output PPPs are allocated to the industries in the Input-output tables.

Intermediate input PPPs should reflect the costs of acquiring intermediate deliveries and match the price concept used in the input-output tables, hence at basic prices plus net taxes. We assume that the basic price of a good is independent of its use.<sup>7</sup> That is, we use the same gross output PPP, of an industry to deflate all intermediate delivers from this industry to other industries. Unfortunately, (net) tax matrices are not available for most countries, so gross output PPPs could not be adjusted for differences in tax rates across countries. As net taxes on products are minor for most market industries, this will probably not greatly affect our level estimates, but further investigation is needed to substantiate this claim, especially for comparisons at a low level of detail. The aggregate intermediate input PPP for a particular industry can be derived by weighting intermediate inputs at the output PPP from the delivering industries. Imports are separately identified for which exchange rates are used as PPP.

To obtain relative PPPs for capital and labour input, we follow Nishimizu and Jorgenson (1978) Under the assumption that the relative efficiency of new capital goods is the same in both countries, the relative capital rental price is calculated as (the asset subscript  $k$  is dropped for convenience):

$$\frac{p_{t,C}^K}{p_{t,US}^K} = \frac{p_{t,C}^I}{p_{t,US}^I} \frac{\left( \frac{p_{t-1,C}^I}{p_{t,C}^I} \tilde{r}_{t,C} + \delta \right)}{\left( \frac{p_{t-1,US}^I}{p_{t,US}^I} \tilde{r}_{t,US} + \delta \right)} \quad (13)$$

with  $\tilde{r}$  the real rate of return. This can be simplified to

$$PPP_t^K = PPP_t^I \frac{u_{t,C}^K}{u_{t,US}^K} \quad (14)$$

where  $u$  indicates the user cost of one currency unit's worth of capital stock,  $PPP^I$  is purchasing power parity for investment, and  $PPP^K$  the PPP for capital services. Capital PPPs

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<sup>6</sup> One is referred to Timmer, Ypma and van Ark (2006) for further details about the construction and data sources underlying these PPPs.

<sup>7</sup> We assume net taxes on intermediates to be zero. Aulin-Ahmavaara and Pakarinen (2005) provide a discussion of sectoral measures which explicitly account for differences in net tax rates of intermediates.

represent the price of a unit of domestic currency's worth of capital input in terms of a common currency. Capital service input depends on the investment made in the past and hence the capital input PPP will differ from the new investment good PPP. The user cost of capital input depends on the rate of return to capital, the depreciation rate and the investment price change. Investment PPPs are available for 35 capital assets from OECD (2002) for 1999. The PPPs for the 35 assets are aggregated to the six assets in this study using an EKS aggregation procedure. Investment deflators by asset and industry are used to move these PPP to the benchmark year, which is 1997. The required rate of return is set equal to the aggregate internal rate of return.

The PPP for labour represents the price of one unit of domestic currency's worth of labour input in terms of a common currency. The procedure for labour is more straightforward than for capital as it simply involves aggregating relative wages across different labour types using labour compensation for each type as weights.

## **5. International Comparisons of Levels and Growth rates at the Industry Level**

The "analytical" research projects within the framework of the EU KLEMS project will mainly focus on studies on the determinants of productivity growth, labour market analysis, technology and innovation and the link between EU KLEMS and micro-level research. This Section provides an example of how these various aspects of growth and productivity can be analyzed on the basis of a KLEMS growth and productivity accounts. It is based on the results reported in two more elaborate papers: Inklaar, Timmer and van Ark (2006) and Inklaar and Timmer (2006). ). The growth accounts developed for these papers are a bridge between our earlier GGDC *60-Industry Database* and *Industry Growth Accounting Database* which we used in O'Mahony and van Ark (2003) and Inklaar, O'Mahony and Timmer (2005) and the new *EU KLEMS Growth and Productivity Database*.

### *Background*

As indicated in the introduction to this paper, the comparative growth performance of Europe vis-à-vis the United States has undergone a marked change during the second half of the 1990s. For the first time since World War II labour productivity growth in most countries that are now part of the European Union (EU) has fallen behind the U.S. for a considerable length of time. The striking acceleration in U.S. output and productivity growth since the mid 1990s has been much discussed in the literature. A consensus has emerged that faster growth can at least in part be traced to the effects of the information and communication technology (ICT) revolution (Oliner and Sichel 2000, 2002; Jorgenson and Stiroh 2000; Jorgenson, Ho and Stiroh, 2003). ICT had an impact on growth through a surge in ICT investment, strong productivity effects from ICT-producing industries and a more productive use of ICT in the

rest of the economy. While ICT spillovers are typically not found at industry level (Stiroh, 2002a, 2003), there is firm-level evidence that ICT in the U.S. has a larger impact on productivity than suggested by its share in total cost (Brynjolfsson and Hitt, 2000, 2003; OECD, 2004).

In Europe, ICT investment, ICT production and the productive use of ICT in Europe generated less productivity growth during the late 1990s than in the U.S.. See e.g. Van Ark, Inklaar and McGuckin (2003), O'Mahony and van Ark (2003), Inklaar, O'Mahony and Timmer (2005) and Timmer and van Ark (2005). The main question this section poses is to what extent Europe's slow productivity growth is due to a failure to exploit the growth potential of ICT. Specifically, slower ICT investment could be a reflection of a time lag relative to the U.S. or indicate a more structural failure to exploit new technologies. A time lag may be due to the more fragmented nature of the European market. The greater scale of the U.S. market can make certain investments more profitable early on, while ICT prices have to fall further before it is profitable in Europe too. On the other hand, ICT investment in Europe might permanently lag the U.S., because regulations hold back the diffusion of complementary innovations. For example, young, innovative firms may face obstacles to rapid growth, such as restrictive land-use regulations. This in turn reduces the incentives for incumbent firms to innovate too.

#### *Data sources*

For the growth accounts in this paper we developed a database on output and labour and capital inputs for seven countries, including Australia, Canada, France, Germany, the Netherlands, the United Kingdom and the United States, covering the period 1987 to 2003.<sup>8</sup> Our output and labour input measures for France, Germany, the Netherlands and the UK are obtained from the Groningen Growth and Development Centre *60 Industry Database* at the level of 57 industries (GGDC, 2005), which were collapsed into 26 industries for the purpose of this study. Data on labour quality and capital input were based on the *Industry Growth Accounting database* (GGDC, 2003) and updated to 2003. Data for the U.S. and Canada and Australia have been significantly revised since the last release of the *60 Industry Database*, and data for Australia have been added to the database for the first time.

Output is value added at constant prices and is primarily taken from national accounts complemented with measures from industrial and business surveys. Deflators for ICT producing manufacturing industries have been harmonised across countries as discussed by Inklaar et al. (2005). Labour input is measured as hours worked defined as the total number of persons employed (including self-employed) times the average number of hours worked.

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<sup>8</sup> Together, the four European countries cover about 70 percent of output in the EU-15. See O'Mahony and van Ark (2003) and van Ark and Inklaar (2005) for figures for the aggregate EU-15. The Australian data covers fiscal years running from July to June. Following OECD convention, we allocate data for July 2000 to June 2001 to the year 2000.



In addition, for each country we distinguish between three and seven different types of labour based on educational attainment. To construct our capital input measures we use data on investment in current and constant prices for six asset types. Three assets refer to ICT goods (computers, communication equipment and software) and three to non-ICT goods (transport equipment, other (non-ICT) machinery and equipment and non-residential structures).<sup>9</sup> To estimate capital stocks we use industry-specific geometric depreciation rates for detailed assets in the U.S., provided in Fraumeni (1997), in combination with industry shares of these assets from the BEA NIPA.

The series for the European countries were published earlier by Inklaar et al. (2005), but were revised and updated to 2003 using the same sources and methods as before (GGDC, 2003, 2005).<sup>10</sup> For the United States, we have developed an entirely new dataset, which is largely based on the latest releases by the Bureau of Economic Analysis (BEA) of GDP- by-Industry data that cover the period 1947-2004. These data are organized according to the NAICS 1997 classification system and are consistent with the *2003 Comprehensive Revision of the National Income and Product Accounts* (NIPA). In addition to the GDP by Industry data, we had to make use of numerous other sources, most notably industry output and employment data from the BLS, to obtain a complete set of growth accounts. For U.S. investment we used two main sources, namely the BEA *1997 Capital Flow Table* (CFT), showing the use of different types of investment goods by 123 NAICS industries in 1997, and the BEA *Detailed Data for Fixed Assets* (DFA) with time series on purchases of different types of investment goods by 63 NAICS industries for the period 1901-2004. We also made substantive adjustments to the U.S. data to fit the ISIC rev. 3 industrial classification, which is the basis of our international comparative database.<sup>11</sup> A full explanation of our methods and procedures to build the U.S. growth accounts is available on request from the authors.

Data for Canada and Australia were developed specifically for the purpose of this paper. In the case of Canada the new NAICS-based use tables for the period 1961-2001 have been used

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<sup>9</sup> Residential buildings are not taken into account to allow for a sharper focus on the productivity contribution of business-related assets. Since most of the outputs and inputs of the real estate industry consists of housing and imputed rents from housing we have to make an adjustment for this. However, it is hard to separate imputed rents only, so we decided to leave out the real estate industry from both outputs and inputs.

<sup>10</sup> Presently the *60 Industry Database* is largely rooted in the OECD STAN database, but additional information from industrial and business surveys was used to provide a greater industry breakdown. In the beginning of 2007, a new series of growth accounts for European countries will be published as part of the EU KLEMS project. See [www.euklems.net](http://www.euklems.net) for further details.

<sup>11</sup> For the U.S., no educational attainment data has been collected for years after 2000, so labour quality growth is assumed to be zero for the latest three years.

for the output series. These data were extrapolated to 2003 using industry output series.<sup>12</sup> Employment data were drawn mostly from the OECD STAN database (2004 release). Detailed tables on investment by industry and asset tables from Statistics Canada were obtained for the purpose of a study for Industry Canada (van Ark and Inklaar, 2006). For manufacturing industries, we supplemented those tables with information from the final demand part of the input-output tables. Ho, Rao and Tang (2004, Tables 10-12) provide data on labour quality growth for Canada, which were compiled in a broadly comparable fashion to our methodology for the other countries.

Output series for Australia are mainly taken from the national accounts, supplemented by industry surveys, and data on employment are taken from the Australia's labour force statistics. Detailed investment by industry and asset tables are part of the Australian national accounts, and were supplemented with data from manufacturing surveys to distinguish investment by detailed manufacturing industries. Investment in communication equipment had to split off from the broader category of electrical and electronic equipment using data from input-output tables. For Australia we only had access to information about labour quality growth for the aggregate market sector from the national accounts. This rate was applied to each of the individual industries.

#### *Industry contributions to labour productivity growth*

On the basis of this dataset, measures of labour productivity growth and the contribution of individual industries and major industry groups to aggregate productivity growth can be calculated. **Table 3** shows the results of this decomposition for the 3 major industry groups that constitute the market sector of the economy for the 1987-1995 and 1995-2003 periods.<sup>13</sup> At the level of the market economy as a whole, the table shows a large acceleration in productivity growth in Australia, Canada and the U.S. since 1995. Labour productivity growth in France and Germany slowed down substantially, while growth in the Netherlands

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<sup>12</sup> Industry output series for 2002 and 2003 are at constant prices. Current price data are estimated using producer price indices for most goods-producing industries and the GDP deflator for other industries. The 2002 input-output tables were released by Statistics Canada after we completed the dataset for this paper.

<sup>13</sup> The exact definition of the market economy (or business sector) differs by country and organization. We classify government (ISIC 75), education (ISIC 80) and health (ISIC 85) as non-market services, even though some or even most of education and health may be operated or owned by non-governmental organizations. Table 1 also shows the total economy aggregates, including non-market services. The reason for excluding these sectors from the analysis is mainly due to severe measurement problems in these industries. Moreover the international comparability of non-market output measures is very weak, which makes affects the interpretation of differences in growth performance at the total economy level. However, for the seven countries in this study the dynamics in growth performance for the market economy are largely reflected in those for the aggregate economy. Only in the case of France we find a bigger deceleration in productivity growth for the market economy compared to the total economy performance.

stagnated. In the UK, growth also slowed down somewhat, but it remained high compared to the continental European countries.

When decomposing the performance of the market economy into industry groups, we first distinguish the ICT production sector, which includes both ICT manufacturing and services (communications, software, etc.). The other sectors are ‘other’ goods-producing industries (excluding ICT producing manufacturing), market services (excluding ICT services) and the reallocation of hours.<sup>14</sup> A first point of interest is that the reallocation effects are generally negative, which supports the idea that industries with an above-average labour productivity level are declining in relative importance in terms of employment shares. A second important observation is that the contribution of ICT production differs between countries. The U.S. and the UK show rather high contributions from ICT-producers to productivity growth, whereas the continental European countries take an intermediate position and Australia and Canada show very small contributions. Thirdly, in contrast to ICT production, the differences in average contributions of goods production (other than ICT) have been very small since 1995. Of course, there are differences between contributions of individual goods-producing industries which would be interesting to analyze in more detail, but mostly these contributions are positive and small and therefore matter relatively little for the aggregate.

Finally, and most importantly, the differences in contributions of market services are quite large between the countries. All Anglo-Saxon countries show accelerations in contributions from market services since 1995, ranging from 0.5 percentage point acceleration in the UK to 1.5 percentage points in Australia. In the U.S., labour productivity in market services increased by 0.9 percentage point from 0.9 per cent per year in 1987-1995 to 1.8 per cent per year from 1995-2003. In the Netherlands market services showed a slight increase in contribution of 0.2 percentage point, but France and Germany experienced a deceleration of 0.1 and 0.6 percentage points, respectively.

#### *Growth accounts for market services*

Using data on capital services and labour quality, it is now also possible to decompose labour productivity growth rates for each industry and industry group into contributions from ICT capital deepening, non-ICT capital deepening, labour quality growth and TFP growth (see equation 5). Since market services are the most intensive users of ICT assets, a generic strategy is to analyze the role of ICT investment vis-à-vis total factor productivity (TFP) growth in this specific industry group. The results are given in **Table 4**. Here we focus

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<sup>14</sup> In earlier work, such as van Ark et al. (2003a, b), we also distinguished between industries that used ICT intensive and those that did not – based on U.S. estimates of ICT investment relative to total investment. This approach necessitates a somewhat arbitrary distinction that has been criticized by, for example, Daveri (2004). More importantly though is the fact that it has become less important to make this distinction because we now have actual measures of ICT use for countries outside the U.S.

exclusively on an input decomposition of labour productivity growth in market services. It is clear that ICT capital deepening plays an important role in labour productivity growth in market service industries. All countries in the table show a moderate to substantial acceleration in the contribution of ICT capital deepening in market services. However, the most striking observation from Table 4 is the rapid acceleration in TFP growth in market services in the Anglo-Saxon countries (Australia, Canada, United Kingdom and United States). Before 1995, TFP growth in market services was negative in these countries, but turned positive after 1995. In contrast, all continental European countries (France, Germany and the Netherlands) showed deteriorating TFP growth in market services after 1995. Germany and the Netherlands experienced negative TFP growth in market services after 1995 and France shows only a small positive growth rate.

The precise reasons for the differences in productivity dynamics of market services are difficult to generalize. One possible reason is that in some countries investments in ICT do not lead to faster TFP growth whereas in other countries they do. There may be many reasons for this, among which cyclical effects and the effects of unmeasured intangible investments stand out. Inklaar (2005) and van Ark and Inklaar (2005) investigate whether the output elasticity of ICT capital on TFP suggests productive returns which are above the marginal cost assumption, which would violate a basic assumption of the growth accounting methodology. However, in line with, for example, Stiroh (2002b) it appears that industry data do not exhibit supra-normal returns. There is even some evidence that it takes a number of years of below-normal returns before the productive returns of ICT become high enough to outweigh the cost.<sup>15</sup>

This also emerges from studies that take a more industry-specific orientation. For example, McGuckin, Spiegelman and van Ark (2005) analyze labour productivity growth in European and U.S. wholesale and retail trade in detail. They find that technology adoption in Europe lags the U.S. by several years, which has been holding back European productivity growth. They also find that this lag can be (partly) attributed to stricter regulations in European countries.<sup>16</sup> But the explanation for the slowdown since 2000 has so far remained unexplained, and more work in this area (for retail and other service industries) is therefore required.

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<sup>15</sup> An alternative approach is to directly estimate each of the output elasticities separately as done by, for example, O'Mahony and Vecchi (2005). They find super-normal returns on ICT, which they attribute (at least in part) to the returns to unmeasured intangible investment, such as organizational change or training programs. An advantage of their approach is that no assumptions about the other output elasticities have to be made, but disadvantage is that it requires a rather restrictive functional form for the production function (such as Cobb-Douglas) for the estimation (see van Ark and Inklaar, 2005).

<sup>16</sup> For a more detailed statistical analysis of growth differences in the trade sector, see Timmer and Inklaar (2005).

Another missing piece of evidence which might shed new light on the reasons for large differences in the contribution of market services to productivity growth, is to focus not exclusively on comparisons of growth rates but also on comparative levels of productivity. For example, rapid TFP growth might point to catching-up and imitation when starting from a relatively low productivity level. Similarly, stagnating TFP growth at a relatively high level of TFP might be indicative of a lack of innovation. Therefore, we turn to level comparisons for the remainder of this paper.

#### *Labour productivity level comparisons*

The first step in presenting our level results, it to focus on the comparative levels of labour productivity for the same major industry groups (ICT production, other goods production and market services) as in the first part of the paper. **Table 5** shows comparative levels of labour productivity, measured as value added per hour worked. The results for 1997 are for our benchmark year, and developed according to the methodology outlined above, so value added is double deflated.

Table 5 shows that, especially when it comes to productivity in the market economy, the U.S. shows a labour productivity level which is similar to that of the three continental European countries, ranging from France at 97 per cent of the U.S. level to the Netherlands at 106 per cent.<sup>17</sup> The other Anglo-Saxon countries show between 15 and 20 percent lower levels than the U.S, ranging from Australia at 73 per cent of the U.S. level to Canada at 85 per cent. Strikingly, the relative total economy levels are all higher relative to the U.S. than the market economy levels, signalling high relative levels in non-market services in countries outside the U.S. These differences are largest in European countries, like France and the Netherlands. As before, when dealing with the growth, it is not clear how to interpret the results for the non-market sector given the substantial measurement problems that remain.

Table 5 also shows relative labour productivity levels in ICT production, other goods-producing industries and other market services in 1997. The relative productivity levels in market services correspond most closely to those at the level of the market economy, with productivity levels in France, Germany and the Netherlands relatively close to that of the United States, and Australia, Canada and the UK at a large distance from the other countries. Productivity levels in goods-producing industries are generally much closer together, with the exception of Canada which is doing much better in some resource-intensive and heavy manufacturing industries, like oil refining, metal products and machinery. The high productivity levels in ICT production in France, Germany and the UK can mostly be traced to

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<sup>17</sup> Indeed the margin of error around level estimates is non-negligible. Although (formal) research on this issue is limited, Baldwin *et al.* (2005) argue that a confidence interval of (at least) 10 percent should be used. Schreyer (2005) arrives at a similar figure using a simulation exercise.

high productivity level in communications services, with again smaller differences in ICT manufacturing.

Table 5 also shows an extrapolation of the benchmark results for labour productivity in 1997 to 2003. Starting from the relative labour productivity levels for 1997, we have applied the relative growth between 1997 and 2003 at the aggregate and industry group level (see Table 1).<sup>18</sup> The faster productivity growth in the U.S. since 1997 has resulted in lower productivity levels relative to the U.S. for the other countries, but the cumulative impact is still relatively modest over a period of only six years. Given the margin of uncertainty surrounding levels estimates, the analysis of the 1997 results more or less holds up for 2003.

### *Multifactor productivity levels*

For total factor productivity comparisons, we adopt the multilateral approach which originates from Caves, Christensen and Diewert (CCD, 1982) and is based on translog production functions. Importantly, in the CCD methodology the indices of relative inputs and output are transitive, which makes the indices base-country invariant.<sup>19</sup> It assumes a translog production function with constant returns to scale, price taking in factor markets and cost minimization for each industry. The parameters of this function are allowed to differ across countries. In addition, we specify aggregate output and inputs as constant returns to scale translog functions of their components.<sup>20</sup> Hence, translog multilateral indices of output in country  $c$  relative to the U.S. can be derived as follows:

$$\ln Y_c - \ln Y_{US} = \sum_i \bar{v}_i [\ln Y_{i,c} - \ln Y_{i,US}] \quad (15)$$

with  $\bar{v}_i = \frac{1}{2} [v_{i,c} + v_{i,US}]$ .  $v_{i,c}$  is the share of product  $i$  in total output of industry  $j$ , with  $i$  the components of  $Y$ . Similarly, we can express differences in input levels for any country relative to the US. Analogously to output, translog multilateral indices of inputs, used in country  $c$  relative to the U.S. can be derived as follows:

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<sup>18</sup> The data requirements for a level comparison for one year are quite substantial, and in many cases these data only become available with a considerable lag. As a result, a fully consistent level accounting exercise cannot yet be done for a later year than our benchmark year 1997. Extrapolating the 1997 benchmark results forward is also not straightforward since ideally this should be done at most detailed level before re-aggregating using the CCD-method. As the data requirements for such an extrapolation would be comparable to that of a new benchmark, this is also not feasible at the moment.

<sup>19</sup> All binary pairs of comparisons pass the following test:  $I_{ik} = I_{ij} I_{jk}$  where  $I_{ij}$  is an index comparing countries  $i$  and  $j$ .

<sup>20</sup> In fact our level comparisons are based on the so-called sectoral output and input measures, which net out intra-industry deliveries. See Inklaar and Timmer (2006).

$$\ln X_c - \ln X_{US} = \sum_j \bar{v}_j [\ln X_{j,c} - \ln X_{j,US}] \quad (16)$$

with  $\bar{v}_j = \frac{1}{2}[v_{j,c} + v_{j,US}]$ . The translog multilateral productivity indices relative to the U.S. ( $A_c/A_{US}$ ) can now be defined as follows :

$$\ln \frac{A_c}{A_{US}} = \ln \frac{Y_c}{Y_{US}} - \ln \frac{X_c}{X_{US}} \quad (17)$$

We will divide our inputs into a number of groups: two types of labour (university education and below) , two types of capital (ICT- and non-ICT capital), and intermediate inputs, which is further subdivided into energy (E), materials (M) and services (S). For each of these groups we specify a constant returns to scale translog function of its components analogously for total inputs as in equation (16). Relative input per unit of output levels are defined simply as the ratio of the quantity used of a particular input over produced output in a country relative to the same ratio for the U.S., e.g. the relative energy intensity (E-INT) of industry j is given by:

$$\ln E - INT = \ln \frac{E_c}{Y_c} - \ln \frac{E_{US}}{Y_{US}} \quad (18)$$

By applying the input and output PPPs to the nominal input-output tables, we derive relative input levels, expressed per unit of output, as given in equation (18). These levels are used to calculate relative TFP levels, using equation (17). Our analysis is done at the lowest level for which comparable data on inputs and outputs could be found. Capital inputs is the most constraining factor as data on investment cross-classified by both asset type and industry (the so-called capital formation matrices) is scarce. It was possible to make consistent and comparable accounts for 26 industries, based on the ISIC revision 3 industrial classification. These industries together cover the total economy. For expositional reasons we limit our discussion of the results to two major sectors: goods-production, which includes agriculture, mining and manufacturing industries, and market services, which includes all service industries except education, health and government services. We choose these two sectors as they will be different in their production structures, and previous research on productivity growth has shown that Europe lags behind the U.S. especially in market services.<sup>21</sup> The

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<sup>21</sup> Note that we do not include utilities in either of the groups to highlight the role of energy inputs in the economy. We also do not present results for non-market services due to the measurement problems in non-market services output. Much of the output in this sector is measured by input indicators, and hence productivity growth is zero by construction which is not very meaningful.

results for individual industries are used to validate the empirical patterns found for these two broad groups. In the Appendix table, a complete list of the 26 industries is given.

The upper panel of **Table 6** shows the results for goods-producing industry and the lower panel for market services. One has to bear in mind that the levels shown in the table are levels for the integrated sectors, in which intra-industry flows have been netted out. So for example material inputs in goods production will come exclusively from imports, as domestic deliveries have been excluded. This explains the high levels of material input use in most countries compared to the U.S., as imports are generally much higher.

On the basis of Table 6 a number of general observations can be made. First, with respect to total factor productivity (TFP) levels, it is clear that production processes in Europe are at least as efficient as in the U.S. This is especially true for goods production as all four European countries show TFP levels which are at least 5 per cent higher than in the U.S. In market services comparable levels are closer. Only productivity levels in Australia seriously lag behind the U.S., both in goods production and in market services. This finding for the two broad groups is pretty robust when looking at the detailed industry results. In **Figure 1**, we provide TFP levels in both sectors, based on unweighted averages of the industries belonging to each group. For goods production it is the average of 13 industries and for market services 8 industries are included.<sup>22</sup> Error bars in the graph indicate plus and minus one standard deviation within each group based on the detailed industry scores. Unweighted averages are different from the group TFP levels but are generally close. The standard deviation around the group means indicate that one can safely conclude that only Australia is lagging the US in productivity levels. And that Europe, if anything, is ahead, especially in goods production.

Second, there are clear patterns in the use of primary inputs, labour and capital, for both groups. A clear distinction can be made between the Anglo-Saxon countries where production is relatively labour intensive, and continental Europe where labour input is lower, especially the use of labour with university degrees in market services, see Table 6. Most outstanding however, are the high levels of ICT capital in the U.S. Per unit of output, ICT use in the U.S. is typically twice the level in any other country, both in goods production and in market services. This confirms earlier findings by Timmer and van Ark (2005) which stressed the Trans-Atlantic gap in ICT investment. In contrast, relative input levels of non-ICT capital are not radically different across countries. If anything, non-ICT use in market services seems to be higher outside the U.S. This might indicate that a substitution process is taking place of new ICT capital for older non-ICT capital assets, and that this process has progressed much faster in the U.S. than elsewhere. These patterns of capital input use are also evident from the detailed industry comparisons, as shown in **Figure 2**. The high ICT levels in the U.S.

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<sup>22</sup> The average for goods production excludes mining and petroleum manufacturing which, due to their small size and volatile price behaviour often have outlying levels of productivity which would distort the unweighted averages.



compared to the other countries are found in all industries, suggesting that there are economy-wide forces which stimulate ICT investment in this country. One can note that the standard deviations around the group means are rather large for capital inputs. This might be partly due to the quality of data on investment by industry and asset, as well as the investment PPPs. For example, the recording of assets by industry of ownership, or by industry of use, still differs across countries. And the measurement of ICT assets, especially of own-account software, is still far from internationally harmonised. As a result, differences in leasing propensity or own-account software production across countries might muddle the picture. These are clearly areas for data improvement. But even with these caveats, it seems save to say that the use of ICT inputs in the U.S. has progressed much further than in Europe.

Third, the use of various intermediate inputs (energy, materials and services) varies greatly across countries. European countries use much less energy in production, often less than half the energy use of the U.S. Especially Canadian production seems to be very energy-intensive. A similar pattern is found at the detailed industry level, see **Figure 3**.<sup>23</sup> When looking at material inputs, the picture is reversed: U.S., and to a lesser extent Canadian, production processes consume relatively fewer material products. In market services, European countries typically use 40 per cent or more materials than the U.S. However, standard deviations around the means are high as indicated in Figure 3. Consumption of services inputs are clearly the highest in the U.S. and in Australia. In goods production, U.S. levels of services inputs are almost double the levels in Europe and these findings are robust at the detailed industry level. One potential explanation for these differences is that the ‘services content’ of purchased materials is higher outside the U.S. So this would mean that manufacturing firms that provide materials also provide some of the services, such as perhaps transportation, while in the U.S., separate firms supply those services. If the ‘services content’ argument holds, it would explain both higher materials and lower services input levels in Europe compared to the U.S. While much of this derives from anecdotal evidence, Pilat and Wölfl (2005) have investigated this issue in more detail, but find comparatively little evidence that can help resolve this issue. Furthermore, if supply tables are constructed properly and based on complete data, then services provision by manufacturing firms would be recorded as secondary production. Alternatively, instead of the purchased inputs being different, the degree and nature of outsourcing could also be different. This would mean that non-U.S. firms have more aggressively outsourced their materials provision but have kept many services in-house. Obviously, more research is needed to explain these international differences in material and services consumption in production.

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<sup>23</sup> Energy use as measured here only includes the direct use of energy. Indirect energy use, through the consumption of other intermediates, is not taken into account.

## 6. Conclusions

The implementation of the revised System of National Accounts and the European System of Accounts provides an excellent opportunity for a stronger integration of growth and productivity accounts with the national accounts system. The latter is now providing most of the building blocks for a KLEMS approach to growth measurement, and with the upcoming extensions (such as the capitalization of R&D, and the harmonization of measurement of capital services). The EU KLEMS project is specifically designed to achieve a full integration of national accounts, growth and productivity accounts.

However, there are still a range of fundamental issues to be resolved, which require further research on methodological aspects. Such issues include, for example, the exact procedures concerning interpolation and backward extrapolation of Supply and Use tables, the reconciling of current and constant prices between SUTs and national accounts, the comparability of national accounts-based labour accounts across countries, and the underlying assumptions concerning depreciation patterns and computations of the cost of capital. For this reason, EU KLEMS has adopted a gradual integration of growth and productivity accounts with national accounts. The Analytical Module of the database, which will adopt harmonised procedures based on best international practice will serve as the main database for research purposes. The Statistical Modules for individual countries will be more directly tied to the present practices in national accounts, but may also show more inconsistencies between countries. Ultimately the analytical and statistical modules may be integrated and serve as a satellite account to the core system of SNA and ESA.

There is a strong need for empirical research on growth in international comparative perspective which is solidly rooted in international harmonized growth and productivity accounts. It will help to answer fundamental questions about the drivers of growth, the causes of differences related to the performance of labour and capital markets and technological progress and innovations. It will also give a sounder empirical foundation to the debate on globalisation issues, dealing with the mobility of capital, labour and trade in goods and services between countries.

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**Table 1 SUT years included in preliminary database and aim for final database**

Countries	In preliminary database		Aim for final database	
	Nominal SUT	Volume SUT	Nominal SUT	Volume SUT
Austria	88-04	-	88-04	88-04
Belgium	01	-	95-02	95-02
Czech Republic	95-03	95-02	95-04	95-04
Denmark	70-02	70-02	70-03	70-03
Spain	86-00	86-00	70-03	70-03
Finland	70-03	70-03	70-04	70-04
France	99-02	-	70(?) -03	78-03
United Kingdom	92-02	-	70(?) -04	70(?) -04
West-Germany	-	-	70-91	70-91
Germany	00	-	91-04	91-04
Greece	-	-	95-04	95-04
Hungary	00-02	00-02	95-04?	95-04?
Ireland	98	-	95-04	95-04
Italy	70-04	70-04	70-04	70-04
Luxembourg	-	-	95-04?	95-04?
Netherlands	70-04	87-04	70-04	70-04
Poland	96-00	-	95-04?	95-04?
Portugal	-	-	95-04	95-04
Slovakia	95-00	95-00	95-04	95-04
Slovenia	00-02	-	95-04	95-04
Sweden	93-03	93-03	80-04	80-04
United States	70-00	70-00	70-04	70-04

**Table 2 EU KLEMS asset classification****EUKLEMS ASSET CLASSIFICATION**

GFCF	Total investment
GFCFT	...Total tangible assets
Con	.....Total construction
RStruc	.....Residential structures
OCon	.....Total non-residential investment
NRStruc	.....Non-residential structures
Infra	.....Infrastructure
MaEq	.....Machinery and equipment
TraEq	.....Transport equipment
Mach	.....Machinery and other equipment
IT	.....Computing equipment
CT	.....Communications equipment
OMach	.....Other machinery and equipment
Agri	.....Products of agriculture and forestry
GFCFI	...Total Intangibles
Soft	.....Software
OGFCFI	.....Other intangibles
Inven	Inventories
Land	Land

**TABLE 3 Industry Contributions to Market Economy Labour Productivity Growth, 1987-2003**  
(value added per hour worked, percentage growth and contributions)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
<b>1987-1995</b>							
Market economy	1.1	1.2	2.7	2.8	1.7	2.9	1.9
<i>contributions from:</i>							
ICT production	0.3	0.3	0.4	0.6	0.2	0.7	0.6
Goods-producing industries	1.1	0.7	1.3	1.2	1.2	1.8	0.5
Market services	0.0	0.3	0.7	0.8	0.5	1.0	0.9
Reallocation of hours	-0.3	0.0	0.3	0.2	-0.2	-0.6	-0.2
Total economy	1.2	0.8	2.0	2.5	1.6	3.0	1.3
<b>1995-2003</b>							
Market economy	2.4	2.0	2.0	2.0	1.7	2.7	3.0
<i>contributions from:</i>							
ICT production	0.2	0.2	0.6	0.6	0.4	0.9	0.8
Goods-producing industries	0.7	0.7	0.8	0.9	0.8	0.6	0.7
Market services	1.5	1.3	0.6	0.2	0.7	1.5	1.8
Reallocation of hours	-0.1	-0.2	0.0	0.3	-0.2	-0.3	-0.2
Total economy	2.2	1.9	1.8	1.7	1.5	2.5	2.5

Source: GGDC Industry Growth Accounting Database, see [www.ggdc.net](http://www.ggdc.net) for data. See Section 2 and Inklaar et al. (2005) for methods, and Section 3 and Appendix B for sources

Notes: Market economy includes all industries except real estate (ISIC70) government (ISIC75), education (ISIC80) and health (ISIC85). Labour productivity and TFP contributions are calculated using the share of industry value added in market economy value added. ICT/non-ICT capital contributions are calculated using the share of industry ICT/non-ICT capital compensation in aggregate value added. Labour quality contributions are calculated analogously based on industry labour compensation. Reallocation of hours is the difference between output-weighted industry growth in total hours worked and employment-weighted growth in total hours worked. ICT production includes electrical and optical equipment (ISIC30-33) and telecommunications (ISIC64). Goods-producing industries include all industries between ISIC01-41, except ICT production, market services includes all industries between ISIC45-74, except ICT production.

**TABLE 4 Input Contributions to Market Services Labour Productivity Growth, 1995-2003**  
(value added per hour worked, percentage growth and contributions)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
<b>1987-1995</b>							
Market services (excl. ICT services)	0.0	0.5	1.2	1.9	0.8	1.7	1.5
<i>contributions from:</i>							
ICT capital deepening	0.7	0.4	0.3	0.4	0.6	0.6	0.9
Non-ICT capital deepening	-0.1	0.4	0.3	0.6	0.3	0.9	0.3
Labour quality growth	0.3	0.3	0.2	0.2	0.3	0.7	0.3
TFP growth	-0.8	-0.7	0.3	0.4	-0.3	-0.5	0.2
Reallocation of hours	0.0	0.0	0.1	0.4	0.0	0.0	0.0
<b>1995-2003</b>							
Market services (excl. ICT services)	2.3	2.4	0.9	0.9	1.1	2.2	2.7
<i>contributions from:</i>							
ICT capital deepening	1.0	0.5	0.5	0.6	0.9	0.9	1.3
Non-ICT capital deepening	0.0	0.2	0.0	0.3	0.4	0.6	0.4
Labour quality growth	0.2	0.1	0.2	0.0	0.1	0.2	0.1
TFP growth	1.2	1.4	0.1	-0.5	-0.4	0.5	0.9
Reallocation of hours	-0.1	0.1	0.0	0.5	0.0	0.0	-0.1

Sources and notes: see Table 3

**TABLE 5 Labour Productivity Levels Relative to United States, 1987 and 2003** (value added per hour worked, US=100)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
<b>1997</b>							
Market economy	73	85	97	104	106	74	100
ICT production	69	86	99	99	72	116	100
Goods-producing industries	82	124	95	90	101	81	100
Market services	69	64	96	113	115	66	100
Total economy	83	95	109	112	122	86	100
<b>2003</b>							
Market economy	69	80	90	93	98	73	100
ICT production	44	57	97	84	68	123	100
Goods-producing industries	77	121	95	87	100	83	100
Market services	68	64	88	102	106	64	100
Total economy	80	93	105	105	115	86	100

Source: 1997: Supply and Use tables for individual countries from Inklaar and Timmer (2006) and PPPs from Timmer, Ypma and van Ark (2006); 2003 updated from 1997 with time series underlying table 1.

Notes: For methodology, see Inklaar and Timmer (2006)

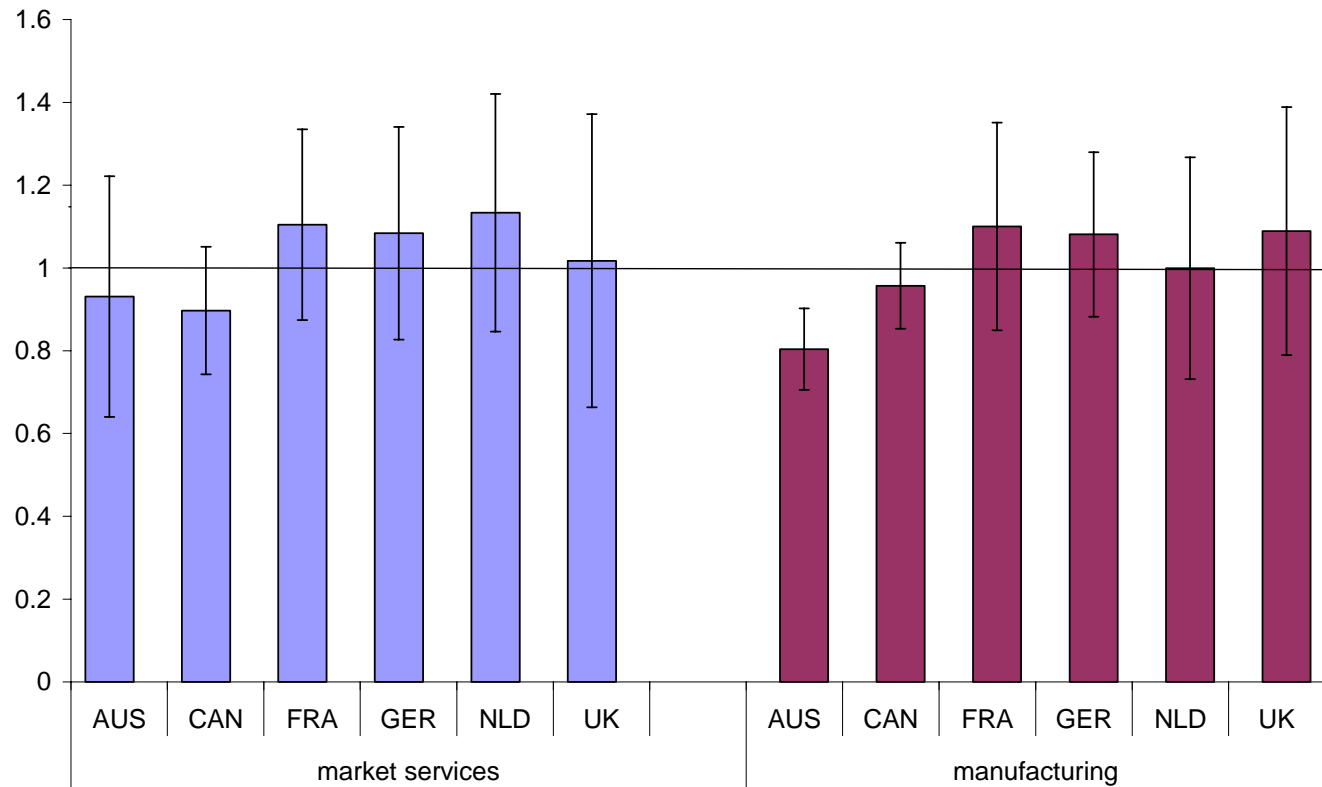


**Table 6 Relative input per unit of output, 1997, U.S.=1, goods producing industries and market services**

	France	Germany	Nether-lands	U.K.	U.S.	Australia	Canada
<i>Goods-producing industries</i>							
Energy input	0.82	0.62	0.51	0.47	1.00	1.14	1.89
Material input	2.35	2.19	3.28	2.16	1.00	1.62	1.80
Services input	0.71	0.71	0.70	0.67	1.00	0.96	0.73
ICT capital input	0.15	0.40	0.43	0.42	1.00	0.68	0.33
Non-ICT capital input	0.98	0.75	0.97	0.71	1.00	1.59	1.30
Labour input below degree	0.95	0.99	0.72	1.16	1.00	1.40	1.01
Labour input university degree	0.85	0.88	0.69	1.09	1.00	1.31	1.00
Total factor productivity	1.08	1.13	1.04	1.10	1.00	0.80	0.96
<i>Market services</i>							
Energy input	0.66	0.42	0.47	0.28	1.00	1.00	1.61
Material input	1.46	1.30	1.34	1.47	1.00	1.45	1.06
Services input	1.00	1.26	1.52	1.38	1.00	0.97	1.05
ICT capital input	0.33	0.57	0.49	0.39	1.00	0.44	0.51
Non-ICT capital input	1.35	1.67	1.03	1.07	1.00	1.30	1.12
Labour input below degree	0.98	0.87	0.84	1.24	1.00	1.21	1.34
Labour input university degree	0.89	0.76	0.84	1.17	1.00	1.14	1.31
Total factor productivity	1.00	1.00	1.07	0.91	1.00	0.88	0.87

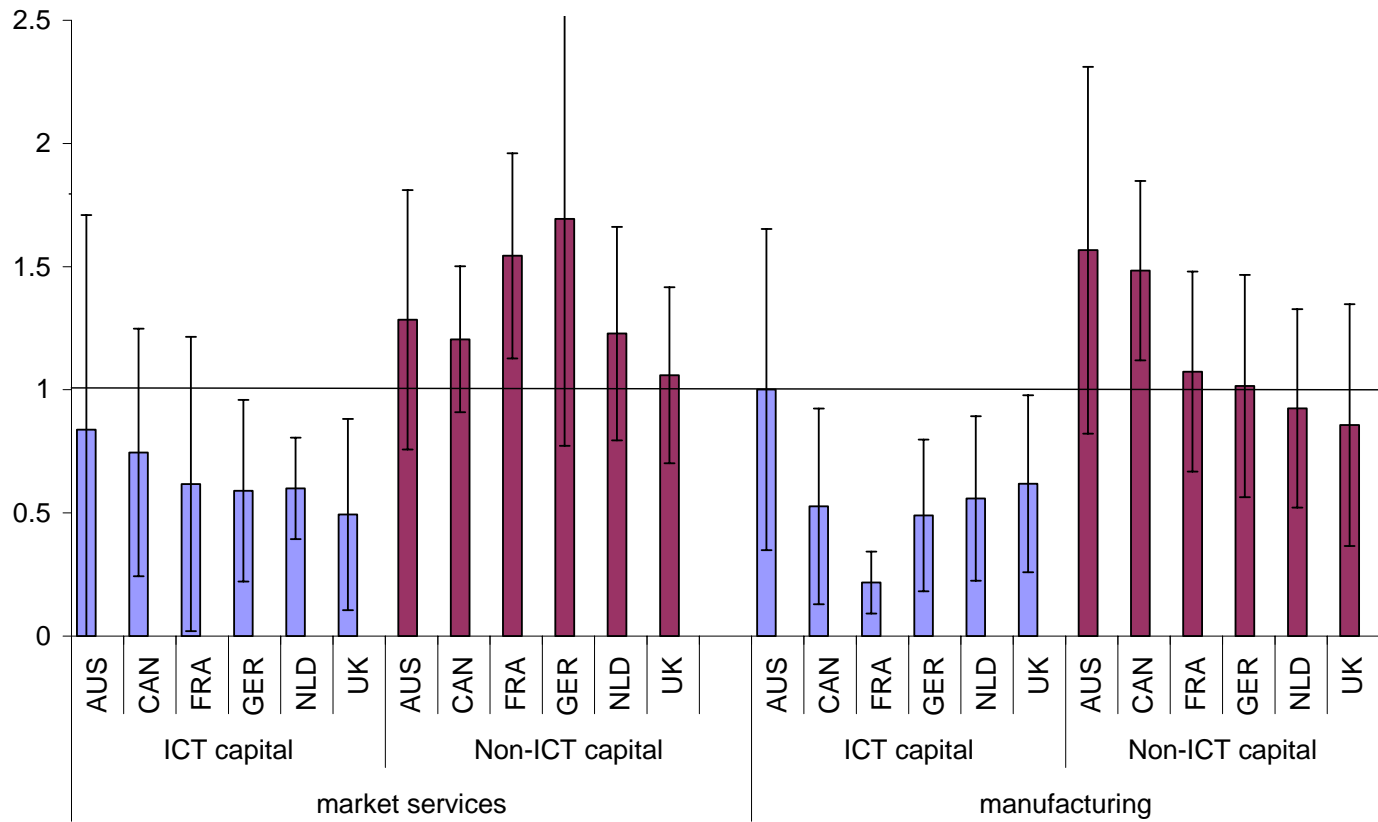
Sources: National Supply and Use tables converted with relative input and output prices, see main text.

**Figure 1, Relative TFP levels by industry group in the Netherlands, France, Germany, UK, Canada and Australia in 1997, U.S.=1**



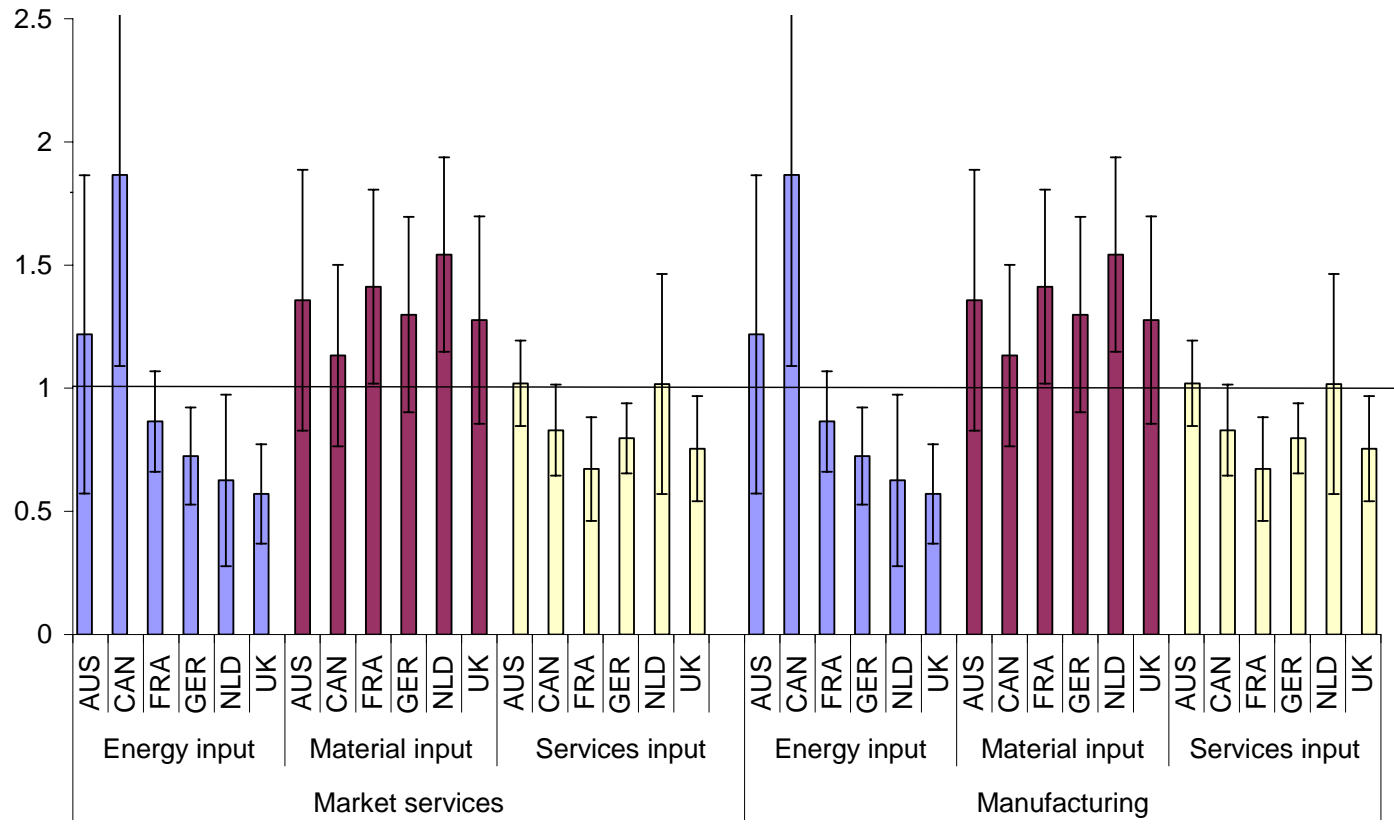
Note: The solid bars denote unweighted averages of levels in industries within manufacturing (13 industries, excluding petroleum manufacturing) and market services (8 industries). The errors bars indicate one plus/minus one standard deviation within the group. See appendix for list of industries. See main text for sources.

**Figure 2, Relative capital input levels in 1997 in the Netherlands, France, Germany, UK, Canada and Australia, U.S.=1**



Note: see Figure 1.

**Figure 3, Intermediate input levels for industry groups in 1997 in the Netherlands, France, Germany, UK, Canada and Australia, U.S.=1**



Note: see Figure 1.

## Appendix A: Participants in EU KLEMS Project

<b>Partic. No.</b>	<b>Participant name</b>	<b>Participant short name</b>	<b>Country</b>
1	Rijksuniversiteit Groningen	RUG	NL
2	National Institute of Economic and Social Research	NIESR	UK
4	Centre d'études prospectives et d'informations internationales	CEPII	F
5	Centre for Economic and Business Research	CEBR	DK
6	Netherlands Institute for Economic Policy Analysis	CPB	NL
7	Deutsches Institut für Wirtschaftsforschung	DIW	DE
8	Federaal Planbureau	FPB	BE
9	Istituto di Studi e Analisi Economica	ISAE	IT
10	Instituto Valenciano de Investigaciones Económicas	IVIE	ES
11	Helsinki School of Economics	HSE	FI
12	Österreichisches Institut für Wirtschaftsforschung	WIFO	AT
13	Vienna Institute for International Economic Studies	WIIW	AT
14	Stichting Amsterdam Business and Economic Research	AMBER	NL
15	The Conference Board Europe, Brussels	TCBE	BE
16	Fachhochschule Konstanz	FHK	DE

## Appendix B Variables in EU KLEMS database

### Values

GO	Gross output at current basic prices (in millions of local currency)
II	Intermediate inputs at current purchasers' prices (in millions of local currency)
IIE	Intermediate energy inputs at current purchasers' prices (in millions of local currency)
IIM	Intermediate material inputs at current purchasers' prices (in millions of local currency)
IIS	Intermediate service inputs at current purchasers' prices (in millions of local currency)
VA	Gross value added at current basic prices (in millions of local currency)
LAB	Labour compensation (in millions of local currency)
CAP	Capital compensation (in millions of local currency)
CAPIT	ICT capital compensation (in millions of local currency)

### Volumes

GO_QI	Gross output, volume indices, 1995 = 100
II_QI	Intermediate inputs, volume indices, 1995 = 100
IIE_QI	Intermediate energy inputs, volume indices, 1995 = 100
IIM_QI	Intermediate material inputs, volume indices, 1995 = 100
IIS_QI	Intermediate service inputs, volume indices, 1995 = 100
VA_QI	Gross value added, volume indices, 1995 = 100
LAB_QI	Labour services, volume indices, 1995 = 100
CAP_QI	Capital services, volume indices, 1995 = 100
CAPIT_QI	ICT capital services, volume indices, 1995 = 100
LP_I	Gross value added per hour worked, volume indices, 1995=100
CAPIT_QPH	ICT capital stock per hour worked, 1995 reference
CAPNIT_QPH	Non-ICT capital stock per hour worked, 1995 reference

### Growth accounting

VA_Q	Growth rate of value added volume (% per year)
VAConL	Contribution of labour to value added growth (percentage points)
VAConK	Contribution of capital services to value added growth (percentage points)
VAConTFP	Contribution of TFP to value added growth (percentage points)
TFPva_I	TFP (value added based) growth, 1995=100
GO_Q	Growth rate of gross output volume (% per year)
GOConII	Contribution of intermediate inputs to output growth (percentage points)
GOConL	Contribution of labour to output growth (percentage points)
GOConK	Contribution of capital services to output growth (percentage points)
GOConTFP	Contribution of TFP to output growth (percentage points)
TFPgo_I	TFP (gross output based) growth, 1995=100

### Additional variables

COMP	Compensation of employees (in millions of local currency)
GOS	Gross operating surplus (in millions of local currency)
TXSP	Taxes minus subsidies on production (in millions of local currency)
Hours	Total hours worked (millions)
Emp	Number of persons engaged (thousands)
Empe	Number of employees (thousands)

## Appendix C: EU KLEMS 72-industry classification (EUK72)

Code	Description	industry number
TOT	<b>TOTAL ECONOMY</b>	
AiB	<b>AGRICULTURE, HUNTING, FORESTRY AND FISHING</b>	
A	...AGRICULTURE, HUNTING AND FORESTRY	
1	.....Agriculture	1
2	.....Forestry	2
B	...FISHING	3
C	<b>MINING AND QUARRYING</b>	
10i12	...MINING AND QUARRYING OF ENERGY PRODUCING MATERIALS	
10	.....Mining of coal and lignite; extraction of peat	4
11	.....Extraction of crude petroleum and natural gas and services	5
12	.....Mining of uranium and thorium ores	6
13i14	...MINING AND QUARRYING EXCEPT ENERGY PRODUCING MATERIALS	
13	.....Mining of metal ores	7
14	.....Other mining and quarrying	8
D	<b>TOTAL MANUFACTURING</b>	
15i16	...FOOD PRODUCTS, BEVERAGES AND TOBACCO	
15	.....Food products and beverages	9
16	.....Tobacco products	10
17i19	...TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	
17i18	.....Textiles and textile products	
17	..... <i>Textiles</i>	11
18	..... <i>Wearing Apparel, Dressing And Dying Of Fur</i>	12
19	.....Leather, leather products and footwear	13
20	...WOOD AND PRODUCTS OF WOOD AND CORK	14
21i22	...PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	
21	.....Pulp, paper and paper products	15
22	.....Printing, publishing and reproduction	
22i	..... <i>Publishing</i>	16
22x	..... <i>Printing and reproduction</i>	17
23i24	...CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	
23	.....Coke, refined petroleum products and nuclear fuel	18
24	.....Chemicals and chemical products	
24i	..... <i>Pharmaceuticals</i>	19
24x	..... <i>Chemicals excluding pharmaceuticals</i>	20
25	.....Rubber and plastics products	21
26	...OTHER NON-METALLIC MINERAL PRODUCTS	22
27i28	...BASIC METALS AND FABRICATED METAL PRODUCTS	
27	.....Basic metals	23
28	.....Fabricated metal products	24
29	...MACHINERY, NEC	25
30i33	...ELECTRICAL AND OPTICAL EQUIPMENT	
30	.....Office, accounting and computing machinery	26
31i32	.....Electrical engineering	
31	..... <i>Electrical machinery and apparatus, nec</i>	
31i3	..... <i>Insulated wire</i>	27
31x	..... <i>Other electrical machinery and apparatus nec</i>	28
32	..... <i>Radio, television and communication equipment</i>	
32i	..... <i>Electronic valves and tubes</i>	29
32i2	..... <i>Telecommunication equipment</i>	30
32i3	..... <i>Radio and television receivers</i>	31
33	.....Medical, precision and optical instruments	
33i1i3	..... <i>Scientific instruments</i>	32
33i4i5	..... <i>Other instruments</i>	33
34i35	...TRANSPORT EQUIPMENT	
34	.....Motor vehicles, trailers and semi-trailers	34
35	.....Other transport equipment	
35i	..... <i>Building and repairing of ships and boats</i>	35
35i3	..... <i>Aircraft and spacecraft</i>	36
35x	..... <i>Railroad equipment and transport equipment nec</i>	37
36i37	...MANUFACTURING NEC; RECYCLING	
36	.....Manufacturing nec	38
37	.....Recycling	39
E	<b>ELECTRICITY, GAS AND WATER SUPPLY</b>	
40	...ELECTRICITY AND GAS	
40x	.....Electricity supply	40
40i2	.....Gas supply	41
41	...WATER SUPPLY	42
F	<b>CONSTRUCTION</b>	43

Code	Description	
<b>G</b>	<b>WHOLESALE AND RETAIL TRADE; RESTAURANTS AND HOTELS</b>	
50t52	...WHOLESALE AND RETAIL TRADE; REPAIRS	
50	.....Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	44
51	.....Wholesale trade and commission trade, except of motor vehicles and motorcycles	45
52	.....Retail trade, except of motor vehicles and motorcycles; repair of household goods	46
H	...HOTELS AND RESTAURANTS	47
<b>I</b>	<b>TRANSPORT AND STORAGE AND COMMUNICATION</b>	
60t63	...TRANSPORT AND STORAGE	
60	.....Inland transport	48
61	.....Water transport	49
62	.....Air transport	50
63	.....Supporting and auxiliary transport activities; activities of travel agencies	51
64	...POST AND TELECOMMUNICATIONS	52
JtK	<b>FINANCE, INSURANCE, REAL ESTATE AND BUSINESS SERVICES</b>	
J	...FINANCIAL INTERMEDIATION	
65	.....Financial intermediation, except insurance and pension funding	53
66	.....Insurance and pension funding, except compulsory social security	54
67	.....Activities related to financial intermediation	55
K	...REAL ESTATE, RENTING AND BUSINESS ACTIVITIES	
70	.....Real estate activities	
70imp	..... <i>Imputation of owner occupied rents</i>	56
70x	..... <i>Other real estate activities</i>	57
71t74	.....Renting of m&eq and other business activities	
71	..... <i>Renting of machinery and equipment</i>	58
72	..... <i>Computer and related activities</i>	59
73	..... <i>Research and development</i>	60
74	..... <i>Other business activities</i>	
741t4	..... <i>Legal, technical and advertising</i>	61
745t8	..... <i>Other business activities, nec</i>	62
LtQ	<b>COMMUNITY SOCIAL AND PERSONAL SERVICES</b>	
L	...PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	63
M	...EDUCATION	64
N	...HEALTH AND SOCIAL WORK	65
O	...OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	
90	.....Sewage and refuse disposal, sanitation and similar activities	66
91	.....Activities of membership organizations nec	67
92	.....Recreational, cultural and sporting activities	
921t2	..... <i>Media activities</i>	68
923t7	..... <i>Other recreational activities</i>	69
93	.....Other service activities	70
P	...PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	71
Q	...EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES	72