THE EU KLEMS PROJECT*

Towards an Ingrated System of Growth, Productivity and National Accounts for the European Union

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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 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 test version (with limited access to participating institutions including several NSIs) will be available in the first quarter of 2006. A full public version will be made available in the final quarter of 2006.

The present paper proceeds as follows. In *Section 2*, the EU KLEMS project and the underlying growth accounting framework is briefly explainedl. In *Section 3*, 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 4*, we provide a taste of the sort of analytical applications that the EU KLEMS Growth and Productivity Accounts can provide. It presents results from a recent study on the contribution of ICT to the divergence in productivity growth between countries. In the latter case, we still rely on a pre-EU KLEMS data as obtained from the GGDC 60-Industry Database. Finally, *Section 5* discusses the main challenges ahead.[1]

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[1] More detailed background information on Sections 2 and 3 can be obtained from the EU KLEMS Statistical Roadmap (http://www.euklems.net). A more detailed discussion of issues discussed in Section 4 is available from Van Ark and Inklaar (2005).

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.[2]

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). 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 five countries (France, Germany, Netherlands, UK and USA) but only with national accounts-based value added as the output concept (see Section 4).

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[2] For notation and the underlying production function framework of KLEMS, see Appendix B.

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 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 comparibility, 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**):

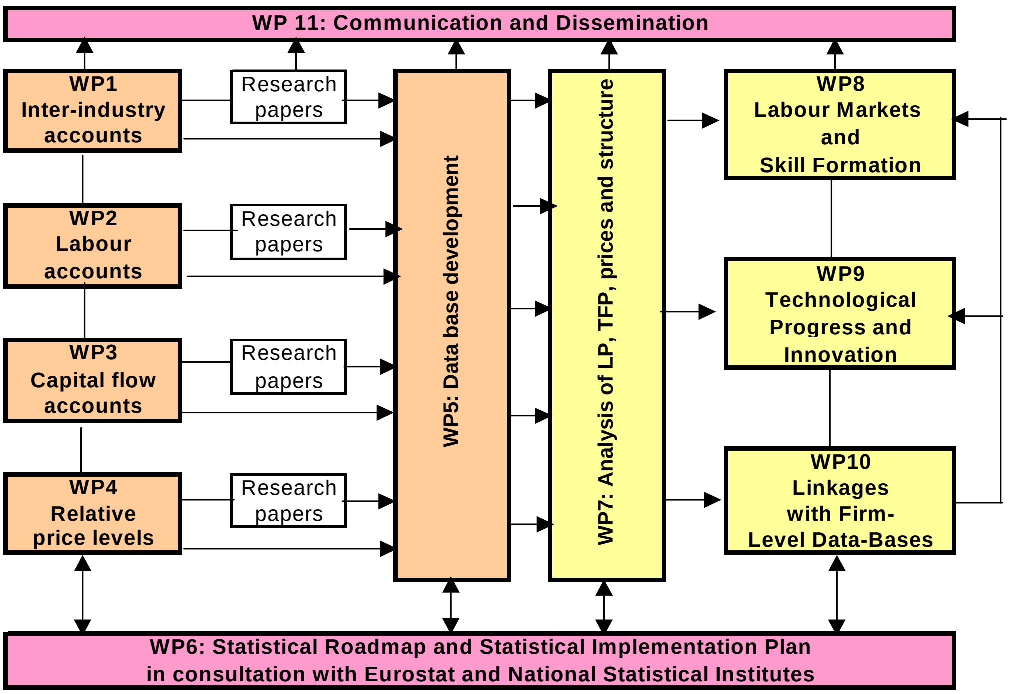
- Workpackages 1-5 focus on the construction of the EU KLEMS Growth and Productivity Accounts. WP1 develops the Supply-Use Tables that are used to measure output and intermediate inputs in current and constant prices. WP 2 constructs the series of labour quantity (employment and hours) and labour quality (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).[3] 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

[3] Papers and notes on EU KLEMS research can be downloaded from http://www.euklems.net

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.

Figure 1: Workpackages in EU KLEMS prject



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 obtaining firm level data, alternative classifications of industries, labour components or asset types can be obtained.

3. 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.[4] 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 taking 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. Therefore real estate has been split into two separate industries. Imputed rents should be available from national accounts statistics.

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[4] Country-specific data on output and inputs are read into a meta database. The construction of the growth and productivity accountd 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)

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 difficult for most countries and periods to realize EUK72, and a higher level of aggregation should 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.[5]

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.

[5] 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. The alternatives are ordered by increased level of detail and sophistication, starting with the most basic set up:

Alternative 1

The minimum requirement for EU KLEMS is to enable basic productivity analysis. Hence at the very least the following series are needed, if necessary directly taken from the national accounts:

- time series of intermediate inputs at purchaser prices in current and previous year prices by industry and input type: $p^X_{ij0}X_{ij0}$ and $p^X_{ij0}X_{ij1}$.
- time series of gross output at basic prices in current and previous year prices by industry: $p^Y_{j0}Y_{j0}$ and $p^Y_{j0}Y_{j1}$.
- time series of value added components (labour and capital compensation) in current prices

This approach (but without intermediate inputs) has been applied in the Industry Growth Accounting database of the GGDC and NIESR (Inklaar et al., 2005).

Alternative 2

By adding the final demand block to the series from alternative 1, full Use matrices can be constructed, so:

- time series of use tables at purchase prices (U_{Pur}) in current and previous year prices.

Alternative 3

The split of these Use tables into domestic (U^D_{Pur}) and import (U^M_{Pur}) tables, such that $U_{Pur} = U^D_{Pur} + U^M_{Pur}$, gives:

- time series of use tables of domestically produced goods at purchase prices in current and previous year prices
- time series of use tables of imported goods at purchase prices in current and previous year prices

Alternative 4

For many applications a split of the Use table at purchase price into the Use table at basic price (U_{Bas}) and valuations matrices is needed: $U_{Pur} = U_{Bas} + TR + TT + TV + T$. So:

- time series of use 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:

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

Addition

Finally, a supply table can be added, so:

- time series of supply tables at basic prices in current and previous year prices

In sum, ideally the inter-industry accounts should consist of a set of eleven matrices in current and previous year prices for each year. Of course, the level of detail will differ across countries, for example concerning valuation matrices. 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). Roughly, based on data availability, five groups of countries can be distinguished:

A. NSIs which already have produced historical series of SUTs in current and constant prices which are ESA 1995 compatible, or will do so in the coming months: Denmark, Finland, Netherlands, France.

B. Countries with only short series of constant price SUTs for 1990s and IO tables for earlier years: Germany, Luxembourg, Sweden

C. Countries with historical series of current price SUTs and IO tables and reasonable deflators: Italy, Austria, UK, Spain

D. Countries with long-term series of current price SUT and IO but without reasonable deflators: Belgium, Ireland

E. Countries with no SUTs or IO tables before 1995: Eastern European countries, Greece, Portugal

In principle, the tables of countries in group A contain all the information needed. For the countries in group B and C long-term constant price SUTs should be constructed. Group D countries need special attention concerning the availability of deflators. Finally, tables for countries in group E can only be made for the revision period using the same techniques as for group B and C.

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 trough 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 next three years all European NSIs will move 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 recommende 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.

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 populatoin census. Generally EU KLEMS aims to split up both age and education level into at least three categories (below 30, 30-45 and above 45 for age, and universities, middle group, and no education for education). 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:

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

where Sw_{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 s2 to s1, s3 to s1 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, *s1*, were constant across industry:

$$w^i_{sj,ga} / w^i_{s1,ga} = w_{sj,ga} / w_{s1,ga} = \omega, \forall i$$

the aggregate relative wage for *sj* relative to *s1*, for given *g* and *a*, will not equal ω 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 industry\ies 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, 1997; 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.

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

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 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.

An 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.

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 fixed and intangible capital 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 seets 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.

Workpackage 4: Relative Price Levels

The EU KLEMS project will also provide measures of comparative levels of output and productivity by industry. This requires the use of purchasing power parities to adjust for differences in price levels between countries. These PPPs can be based on the prices of two countries or on a set of international prices. Typically, one can make use of four different types of prices:

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

For aggregate comparisons, expenditure prices are the common basis for measures of GDP PPP (hereafter, named, E-PPPs). For industry comparisons, however, the conceptually correct prices to make the comparisons are basic output prices by industry (hereafter named, O-PPPs). Until recently, however, basic output prices have not been not available on a large scale for the purpose of PPP comparisons, and certainly not for all industries. Moreover, the use of industry-of-origin PPPs has often been criticised on practical grounds because:

1) industry PPPs are only available for a small number of countries which hampers generalizations;
2) there are conceptual, measurement and data difficulties with industry PPPs, such as the lack of readily available price surveys, and problems with double deflation of output and intermediate inputs;

3) most industry PPP studies are based on bilateral/pair wise comparisons instead of multilateral comparisons of prices;
4) there is usually incomplete coverage of industries, with several studies for agriculture and manufacturing, but a lack of industry PPPs for services and no possibility to develop aggregate PPPs for the total economy based on industry aggregation
5) if mentioned at all, there are difficulties in making a precise reconciliation of industry and expenditure PPPs, in particular because of the handling of relative prices for the trade balance.

As an alternative to industry of origin PPPs, proxy PPPs have often been used (Jorgenson et al., 1987; Hooper and Vrankovich, 1995). These proxy PPPs are based on expenditure prices (E-PPP) which are re-allocated from expenditure categories to industry groups (which we will call *component* E-PPPs), and in some cases adjusted to a basic price concept by 'peeling off' trade and transport margins and net taxes. We call these PPPs *'adjusted component'* E-PPPs.[6]

Using a SUT framework, Van Ark and Timmer (2005) established the principles under which these various price sets can be related to each other used, taking into account the following principles:

A. Only for final goods, which are not internationally traded, final expenditure prices (adjusted for transport and distribution margins) are equal to the basic output prices by industry.
B. When a product is only used for intermediate consumption, the domestic output price cannot be proxied by a final expenditure price.
C. In all other cases, the 'adjusted component' final expenditure price (which adjusts the expenditure price for transport and distribution margins and – in some cases – relative export and import prices) provides a biased estimator of the basic output price. The size of the bias depends on the differences in purchasers' prices and the ratio of import, export and intermediate consumption to total output

In Table 1 an assessment is made of the usefulness of E-PPPs and O-PPPs for 19 major sectors of the economy. PPPs are ranked from 0 (not useful) to 5 (very useful) depending on the appropriate use of the PPP alternatives as discussed above. For an industry in which the share of final expenditure in total use is low, adjusted E-PPPs might serve as a bad proxy for domestic output prices (e.g. agriculture, mining, basic manufacturing, transport). A high share of imports in total supply of goods also indicates the possibility of measurement failures (e.g. durable and non-durable

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

Table 1: Assessment of usefulness of adjusted E-PPPs and O-PPPs for industry output comparisons in the OECD

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

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

Source: Van Ark and Timmer (2005); assessment based on E-PPPs for OECD from 1999 round and O-PPPs for 1997 from Groningen Growth and Development Centre.

manufacturing). E-PPPs are acceptable proxies for domestic output prices when expenditure shares are high and import ratios low as, for example, is the case in sectors such as construction, hotels and catering and real estate.

There are basically three sets of comparable prices which can be used for the construction of PPPs: E-PPPs based expenditure prices from the ICP (Kravis et al., 1982; OECD, 1999, 2002), O-PPPs based on industry output prices from ICOP (Van Ark and Timmer, 2001; Maddison and van Ark, 2002) and, more recently, trade prices (Feenstra et al., 2004, Timmer and Richter 2005). For prices of labour, one can typically make use of Earnings Surveys, etc.[7]

At industry level, the O-PPP approach (as traditionally developed in the ICOP programme) is the most preferable one at industry level, at least in theory. E-PPPs may be acceptable as an alternative to O-PPPs if properly adjusted for relative margins and taxes. A practical disadvantage of E-PPPs is that they require detailed adjustments for margins, taxes and terms of trade effects, which are often not available. This is especially true for the adjustments for import and export prices, which at the detailed level has not been done by anyone so far.[8] In other cases E-PPPs are not an option because no price data are available for intermediate product items. Finally, in some industries (e.g., public administration, education and health) the emphasis is typically on the use of relative input prices. The main practical objection against using O-PPPs is that these are mostly based on ratios of unit values. Basic prices for specified items at producer level are often not available. Unit values often suffer from 'product mix' problems in international comparisons. Unit value ratios may also be biased towards samples of products which are relatively homogeneous, less sophisticated goods. The O-PPPs are then not representative of the more upgraded, high-quality varieties in the same industry. Finally, there are also a number of service industries for which ICOP O-PPPs do not exist due to a lack of appropriate value data and the difficulty of defining quantities.

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

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[7] Prices of capital are not easily obtained for the purpose of international comparisons. The main problem is the price of capital services which cannot be easily derived.

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

4. ICT and Industry Productivity

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 account.

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..[9] 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.

[9] 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).

With the availability of industry data on ICT and productivity growth for the U.S. and four European countries (France, Germany, the Netherlands and the UK) from the 60-industry database of the Groningen Growth and Development Centre (GGDC), and with updates of these estimates to 2003, the link between productivity and ICT can be investigated in detail. The analysis below suggests that a declining rate of productivity growth in Europe may be a reflection of a slow transition process towards so-called “soft savings” from ICT usage, in particular in market services. These follow the earlier “hard savings” which could be immediately obtained from ICT investment. Along the lines of the literature on general purpose technologies, the results suggest that “soft savings” require investments in intangible capital and organizational innovations, which are most likely to be important in market services.

The GGDC 60 Industry Database

The 60 Industry Database of the GGDC is a predecessor of the EU KLEMS Growth and Productivity Accounts. It contains information on value added (but not gross output or intermediate inputs) and employment for 56 industries (see van Ark, Inklaar and McGuckin, 2003; O’Mahony and van Ark, 2003). For five countries (France, Germany, the Netherlands, the UK and the U.S) the database is extended with measures of capital services, with a breakdown between ICT capital assets and other assets and covering a total of 25 market industries (Inklaar et al., 2005). Together, the four European countries cover about 70 percent of output in the EU-15. The database has now been updated to the year 2003.

The growth accounting methodology is comparable to that described for EU KLEMS in Sections 2 and 3 (see also Appendix C), although intermediate inputs have not been measured here. The estimates include a separate measure for the contribution of labour quality and a reallocation component.[10] Table 2 shows the growth accounts for the total market economy (i.e., excluding government) as well as for the contributions from two industry groups, namely the (broad) ICT production sector and total market services from 1995 to 2003.[11] In addition to the four European countries, we also added a column showing the (weighted) average results for these countries (referred to as EU-4). The main findings are that labour productivity growth in the U.S. is higher than in Europe due to a mix of higher contributions from ICT capital deepening and TFP growth. The EU-U.S. gap in TFP growth from ICT production is relatively small compared to the TFP growth gap for market services.

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[10] A detailed description of the dataset, including sources and methods for the investment data by asset to estimate capital services growth and the employment and wage data by educational attainment to estimate labour quality growth is given in Inklaar, O’Mahony and Timmer (2005). Estimates for recent years follow similar procedures. No educational attainment data has been collected for years after 2000, so labour quality growth is assumed to be zero for the latest years.

[11] The broad ICT production sector includes electrical and optical equipment (ISIC 30-33) and telecommunications (64). Investment data is not available to distinguish computer services (72) in all countries

Table 2: Sources of industry labour productivity growth, 1995-2003

	France	Germany	Netherlands	United Kingdom	EU-4	United States
Market Economy Labour Productivity Growth	***1.80***	***2.08***	***1.41***	***2.59***	***2.12***	***3.51***
of which:						
ICT capital deepening	0.46	0.54	0.81	0.77	0.63	1.27
Non-ICT capital deepening	0.32	0.37	0.71	0.71	0.54	0.60
Labour quality growth	0.21	0.05	0.12	0.23	0.14	0.11
Reallocation of hours	0.01	0.25	-0.35	-0.26	-0.08	-0.26
Total factor productivity growth	0.79	0.88	0.14	1.13	0.89	1.78
Contribution of ICT producing sector	*0.71*	*0.84*	*0.41*	*0.87*	*0.83*	*1.15*
of which:						
ICT capital deepening	0.03	0.06	0.08	0.14	0.09	0.23
Non-ICT capital deepening	0.02	0.07	0.11	0.05	0.05	0.08
Labour quality growth	0.02	0.01	0.03	0.02	0.03	0.01
Total factor productivity growth	0.64	0.69	0.19	0.65	0.67	0.83
Contribution of market services	*0.12*	*0.34*	*0.63*	*1.29*	*0.57*	*2.02*
of which:						
ICT capital deepening	0.33	0.38	0.60	0.53	0.44	0.84
Non-ICT capital deepening	0.00	0.13	0.25	0.40	0.20	0.27
Labour quality growth	0.15	0.02	0.07	0.15	0.07	0.07
Total factor productivity growth	-0.36	-0.19	-0.29	0.21	-0.14	0.85

Source: Van Ark and Inklaar (2005)

Testing for ICT spillovers

Table 2 suggests that, at the level of market services, the U.S. has managed to combine high levels of ICT investment with rapid TFP growth. This may be suggestive of positive spillover effects from ICT use at industry level. The industry data allow us to investigate this issue more rigorously, by estimating the following regression:[12]

$$\Delta \ln A_{it} = \alpha + \beta\left(\bar{v}_{it}^{ICT} \Delta \ln K_{it}^{ICT}\right) + \varepsilon_{it} \equiv \alpha + \beta ICTContr_{it} + \varepsilon_{it}$$

This equation tests the hypothesis that ICT capital has an additional impact on output, after accounting for the “normal” contribution of ICT capital to output which relates to its cost share. The equation is similar to one of the equations estimated in the more extensive study of Stiroh (2002a) for U.S. manufacturing.[13]

[12] For a more extensive discussion of this specification as well as the subsequent results, see Inklaar (2005).

[13] Stiroh also (simultaneously) estimates the impact of the other inputs on TFP, but these are omitted here to facilitate the focus on ICT capital.

Table 2: Sources of industry labour productivity growth, 1995-2003

	France	Germany	Netherlands	United Kingdom	EU-4	United States
Market Economy Labour Productivity Growth	***1.80***	***2.08***	***1.41***	***2.59***	***2.12***	***3.51***
of which:						
ICT capital deepening	0.46	0.54	0.81	0.77	0.63	1.27
Non-ICT capital deepening	0.32	0.37	0.71	0.71	0.54	0.60
Labour quality growth	0.21	0.05	0.12	0.23	0.14	0.11
Reallocation of hours	0.01	0.25	-0.35	-0.26	-0.08	-0.26
Total factor productivity growth	0.79	0.88	0.14	1.13	0.89	1.78
Contribution of ICT producing sector	*0.71*	*0.84*	*0.41*	*0.87*	*0.83*	*1.15*
of which:						
ICT capital deepening	0.03	0.06	0.08	0.14	0.09	0.23
Non-ICT capital deepening	0.02	0.07	0.11	0.05	0.05	0.08
Labour quality growth	0.02	0.01	0.03	0.02	0.03	0.01
Total factor productivity growth	0.64	0.69	0.19	0.65	0.67	0.83
Contribution of market services	*0.12*	*0.34*	*0.63*	*1.29*	*0.57*	*2.02*
of which:						
ICT capital deepening	0.33	0.38	0.60	0.53	0.44	0.84
Non-ICT capital deepening	0.00	0.13	0.25	0.40	0.20	0.27
Labour quality growth	0.15	0.02	0.07	0.15	0.07	0.07
Total factor productivity growth	-0.36	-0.19	-0.29	0.21	-0.14	0.85

Source: Van Ark and Inklaar (2005)

Table 3 shows the regression results for all market industries together. The equation is estimated using ordinary least squares (OLS) and the standard errors of the parameters have been corrected for autocorrelation and heteroscedasticity using the procedure of Newey and West (1987). The estimates are shown with a single constant term as well as for fixed effects models. With only a single constant, one aims to determine whether a higher ICT contribution is directly related to higher TFP growth. The fixed effects models, which include a dummy for each country/industry pair, may be relevant if certain unmeasured industry- and country-specific factors are important. For example, it could be the case that the regulatory environment of an industry in a country influences TFP growth, but not ICT investment. Eliminating this unobserved heterogeneity may be important to identify the impact of ICT on TFP growth (see e.g. Griliches and Mairesse, 1998).[14]

[14] Experiments with demand-side instruments to take further endogeneity problems into account, show comparable results

Table 3: The effect of ICT on TFP growth

TFP=a+b*ICT+e	*All countries*	*France*	*Germany*	*Netherlands*	*UK*	*U.S.*
Single constant	-1.01*	-0.99	-1.43	-1.25*	-0.78	-0.96*
	(0.27)	(0.9)	(0.81)	(0.48)	(0.66)	(0.42)
Fixed effects	-1.47*	-1.98	-3.14*	-1.49	-0.71	-1.11
	(0.45)	(1.39)	(1.5)	(0.89)	(0.5)	(0.69)

Notes: * denotes significantly different from zero at 5% level. Standard errors, consistent for heteroscedasticity and autocorrelation are shown in parentheses. Dependent variable is industry TFP growth between 1979 and 2003. Independent variable is the contribution of ICT capital to output growth. In the fixed effects estimates, a dummy is introduced for each country/industry pair. Estimates for all market industries and all countries include 2875 observations (23 years, 25 industries, 5 countries), the other columns include 525 observations.
Source: Van Ark and Inklaar (2005)

The estimates in Table 3 suggest little impact of ICT on TFP growth. When pooling across countries, a higher (or rising) ICT contribution actually leads to lower TFP growth. Most of the country estimates are insignificantly different from zero or even negative.[15] Overall, these results are in line with those reported in Stiroh (2002a), who also reports a number of significantly negative estimates of ICT on TFP growth.

One reason why no positive relationship is found in the industry data may be that the effect of ICT on TFP occurs only with a lag. For example, complementary investments in organizational change may need to be made first before the productivity effect from ICT kicks in. Basu *et al.* (2004) explain TFP growth by industry in the U.S., averaged over 1995 to 2000, with the ICT contribution to growth for 1980-1990, 1990-1995 and 1995-2000. They find a negative effect of ICT for 1995-2005 on TFP and positive effects for the first two periods. This suggests that lags may be important. The analysis of Basu *et al.* (2004) though, is strictly cross-sectional and the choice of periods and lags is somewhat ad-hoc.[16]

Brynjolfsson and Hitt (2003) test a similar hypothesis on possible time lags using firm-level data. They argue that the best way to pick up the effects of earlier ICT investment on current TFP is by taking longer differences of the data. So instead of looking at 1-year growth rates, they take growth rates over 2, 3 and more years. Their main finding is that the ICT impact on

[15] Removing the ICT producing manufacturing industry from the sample does not change the qualitative results. Estimates for only services industries are also not noticeably different. Similarly, experiments using demand side instruments as in do not produce qualitatively different results. The fixed effects estimates are mostly larger, in absolute sense, than the single constant estimates. The reason for this is not immediately clear since this result also shows up for individual countries. However, in a statistical sense the two sets of estimates do not differ, so the issue is not all that important.

[16] Other methods have also been used to distinguish short-run and long run effects of ICT use. O'Mahony and Vecchi (2003) apply the pooled mean group (PMG) estimator of Pesaran et al. (1999) to estimate the output contribution of ICT capital. With this methodology, O'Mahony and Vecchi (2003) find a long-run effect of ICT on output that is higher than is expected on the basis of cost shares. This again implies evidence of spillovers from ICT use.

TFP growth rises as longer differences are taken, with the 7-year difference showing an impact of ICT that is 5 times as large as the 1-year difference.

It is rather straightforward to use these two methods (long differences and time lags) for testing our industry data. Figure 2 shows the parameter as well as confidence bands for fixed effects estimates, ranging from 1-year to 23-year differences.[17] The estimate for the 1-year difference is the same as shown for OLS with fixed effects from Table 3. This estimate is significantly negative at the 5% level. From 5-year differences to 12-year differences, the coefficient is insignificantly different from zero and afterwards, the upper bound fluctuates around zero.[18] This result is confirmed when looking at the specification with lags in Figure 3. The contemporaneous effect is negative, just as Table 3 showed, but from a lag of two years onwards, the effect is insignificantly different from zero. Although these results, based on the full sample of industry and country observations, do not suggest any significant positive spillover, it also does not support Stiroh's finding of significant negative coefficients over longer periods of time (Stiroh, 2002a).

So far, we have analyzed the full sample of observations for all countries and all years. One might argue, however, that the relationship between ICT and TFP growth has changed over time. To investigate this, we also estimated equation (8) for each 5-year period in our sample.[19] Figure 4 first shows the regression coefficient for 1979-1984, then the 1980-1985 coefficient up to the 1998-2003 coefficient. Throughout the 1980s, the ICT effect remains significantly negative, but starting with the 1991-1996 period, the coefficient becomes indistinguishable from zero. So during the 1990s, ICT capital generated productivity effects in line with the cost of ICT capital, suggesting normal returns.

[17] To estimate fixed effects, at least two observations per industry are needed, so 23-year differences is the maximum possible.

[18] If only a single constant is used, the coefficient remains significantly negative, even for very long differences. This is mainly the result of tighter confidence intervals and not so much lower point estimates. As the fixed effects model removes certain unobserved heterogeneity, it seems preferable.

[19] Five-year differences were chosen since Figure 2 shows that on average over the full period, the ICT effect is not significantly different from zero. Using differences of other lengths does not alter the qualitative results.

Figure 2: The relation between ICT contribution and TFP growth in all market industries and countries, 1-year to 23-year differences

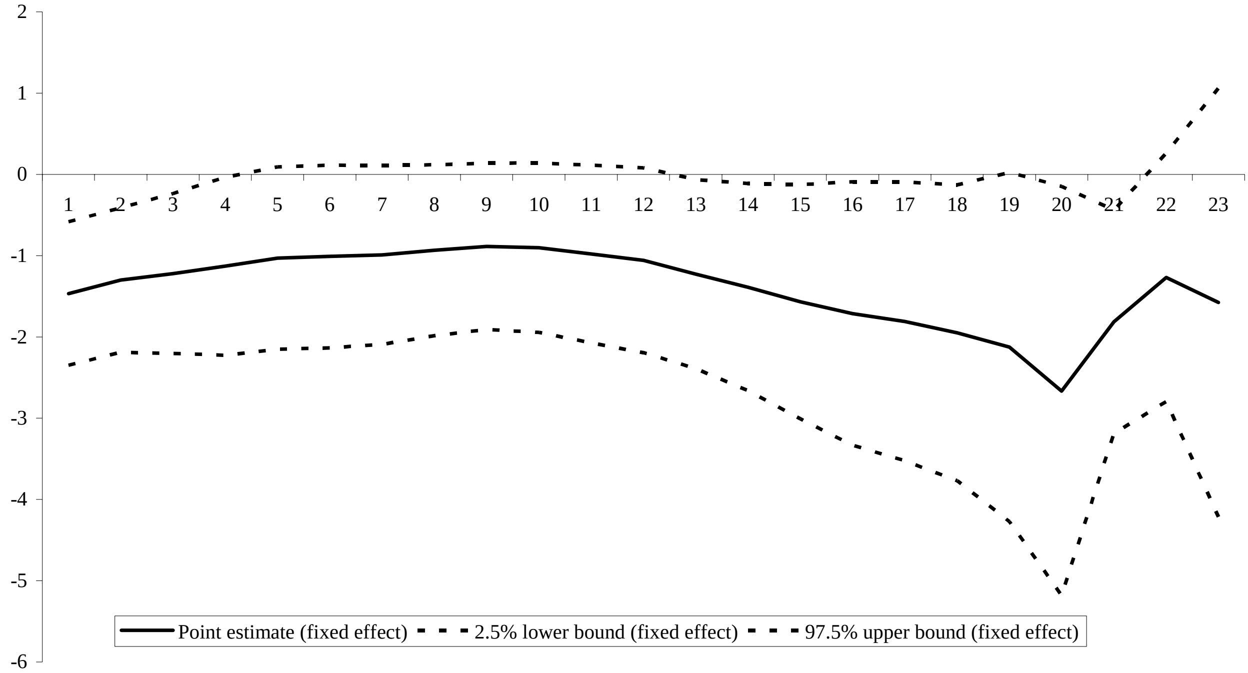

Figure 3: The relation between ICT contribution and TFP growth in all market industries and countries, contemporaneous effect to 22-year lag

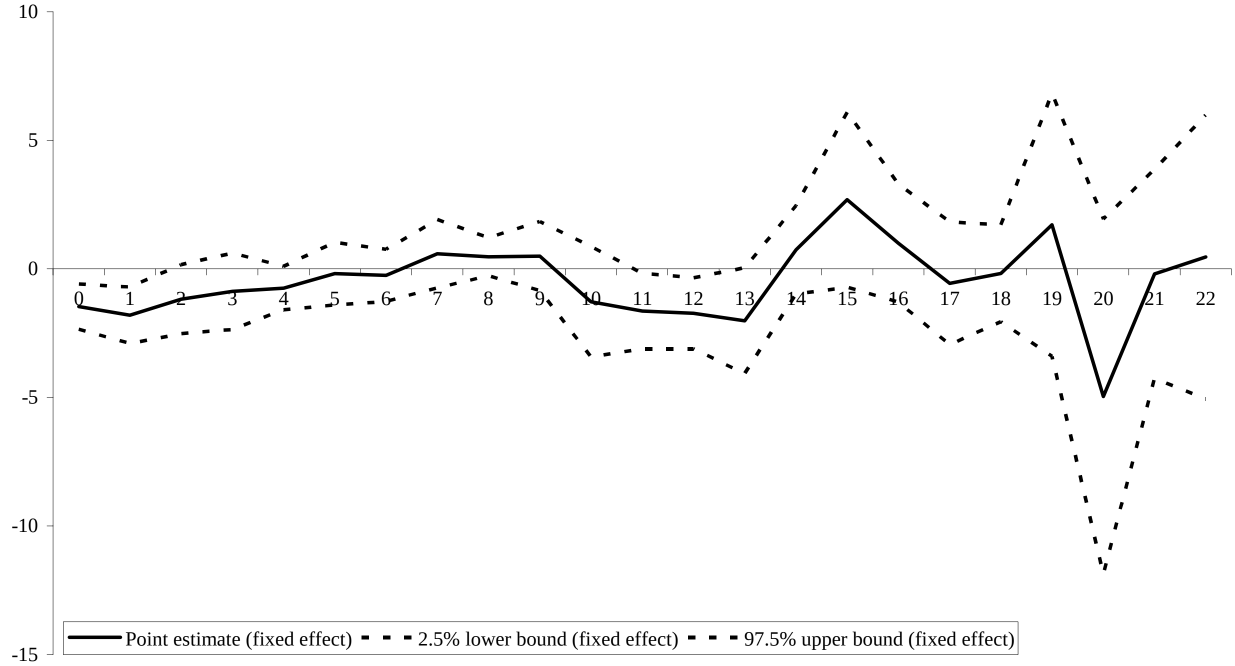

Figure 4: The relation between ICT contribution and TFP growth for subsequent sets of 5-year differences, 1979-1984 to 1998-2003

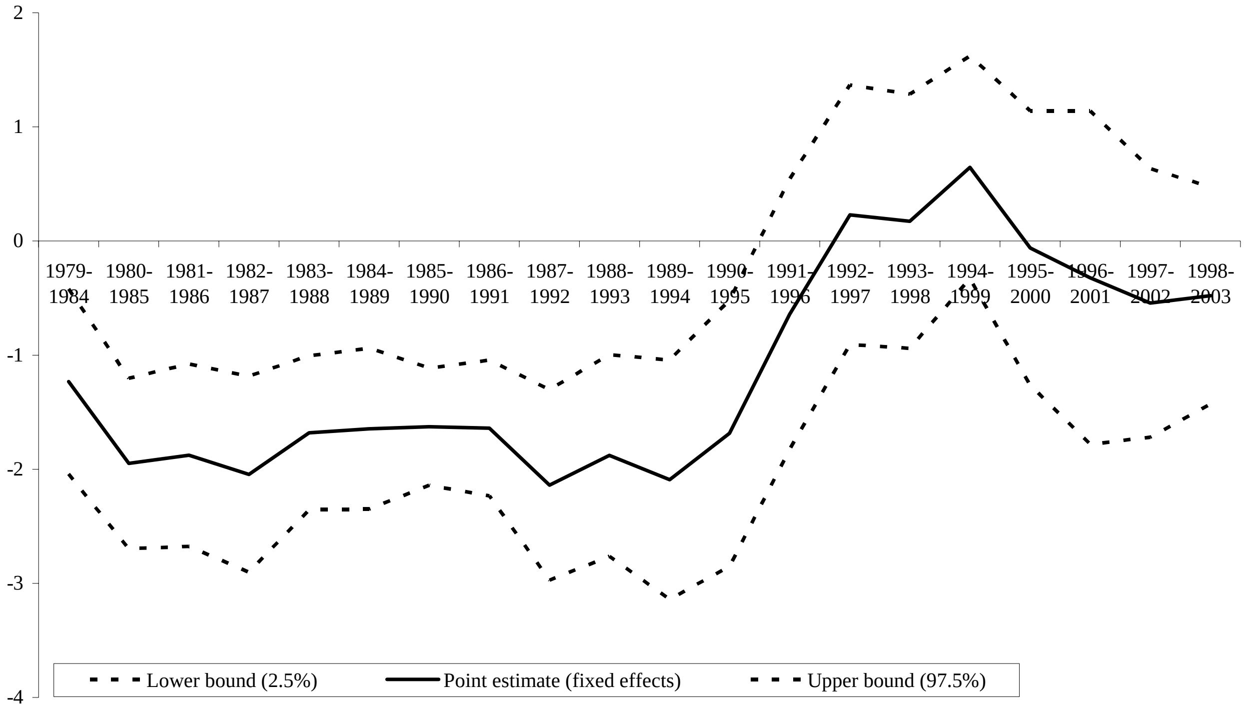

Figure 5: The upper bound of the relation between ICT contribution and TFP growth for subsequent sets of 5-year differences, Continental Europe vs. Anglo-Saxon countries

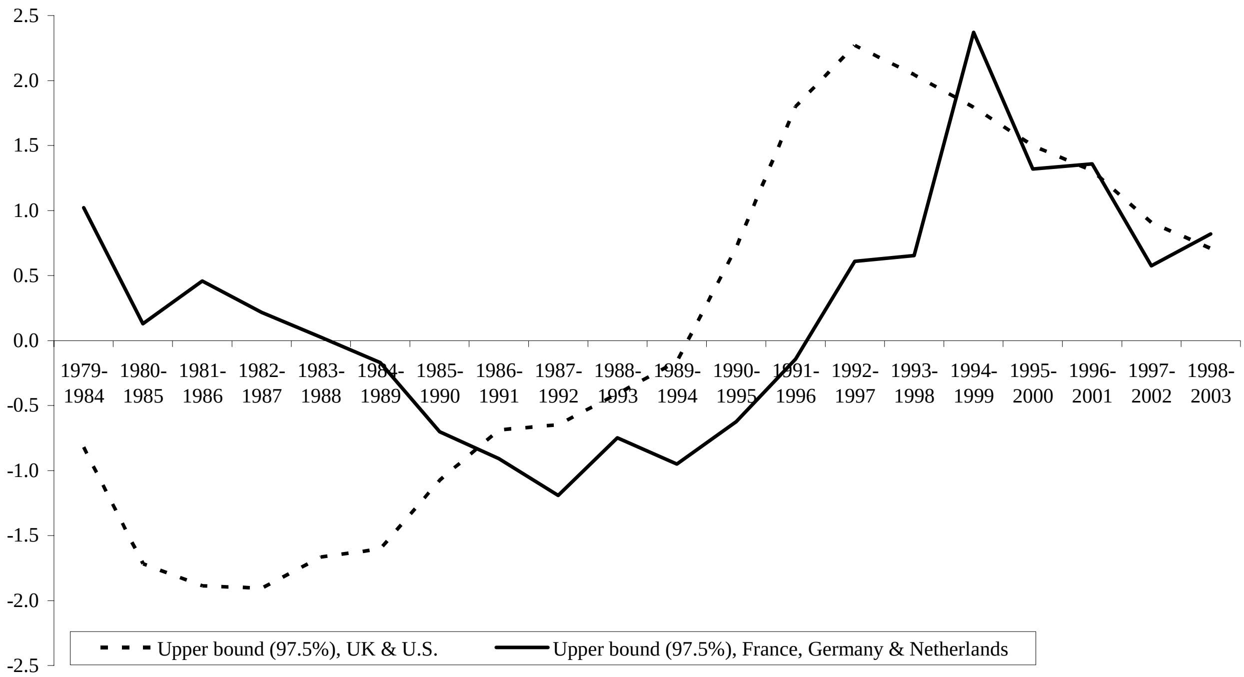

Figure 5 takes the use of subsamples one step further by carrying out the 5-year regressions separately for the three continental European countries (France, Germany and Netherlands) and Anglo-Saxon countries (UK and U.S.). As noted above, the UK stands out among the European countries as showing a relatively good productivity performance. To simplify the presentation of the results, the chart only shows the upper bound results for the two groups, because the ICT coefficient itself does not become significantly positive at any point. Figure 5 shows that the effect of ICT on TFP growth is U-shaped for the Continental European countries: zero up to the mid-1980s, significantly negative until the 1991-1996 period and again zero from the 1991-1996 period onwards. There is some suggestion that a similar U-curve might exist for the Anglo-Saxon countries, but as it is situated a couple of years earlier, the left tail of the U-shape cannot be directly observed because of lack of data. It should be stressed once again, however, that ICT has at best no effect on TFP growth in both the Continental European and Anglo-Saxon countries. The main change from the 1980s is that ICT is no longer a drag on TFP growth.

There is some corroborating evidence in the literature for a U-shape pattern in savings from ICT. Morrison (1997) shows that high tech capital in U.S. manufacturing earned its marginal cost during the early 1970s, the late-1970s and the 1980s, whereas the effect turned negative in the late 1980s, early 1990s after which it became positive again. In other words, it seems likely that the U-curve can be found in all countries in our sample.

These results might be better understood when relating them to the literature on general purpose technologies and, more specifically, to the indication that the pervasiveness of technologies, such as ICT, involves a significant amount of time before its productivity effects are exploited (see, for example, Bresnahan and Trajtenberg, 1995). One might speculate that the early normal returns on ICT are the result of the direct productivity effects of ICT production and ICT investment (which we call the "hard savings"). The "negative spillover"-period may be related to a phase of investments in human capital and knowledge capital as well as organizational innovations which do not immediately result into an acceleration of productivity growth. It takes time before the combination of ICT investment and intangible investments and innovations (here called the "soft savings"), have an effect on productivity. This interpretation of the results is also in line with the firm-level evidence which also emphasizes the importance of skills and organizational innovations (Brynjolfsson and Hitt, 2000, 2003; OECD, 2004).

This leaves open the question why firm-level studies find positive spillovers and our estimates show neutral effects. A plausible explanation would be that within an industry, some leading firms invest heavily in ICT and organizational change and reap the accompanying productivity gains. But there are also laggards with lower productivity growth. These laggards may have also invested heavily in ICT, but were less successful in realizing soft savings. Although in time these laggards are likely to either exit or catch-up with the leaders due to competitive pressures, this inevitably takes time. In the meantime, industry performance will reflect both leading and lagging firm performance. To find out whether this explanation holds in practice, further research is needed into these aggregation effects.

5. 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 wil 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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Appendix A: Participants in EU KLEMS Project

Partic. No.	Participant name	Participant short name	Country	Date enter project	Date exit project
1	Rijksuniversiteit Groningen	RUG	NL	1	36
2	National Institute of Economic and Social Research	NIESR	UK	1	36
4	Centre d'études prospectives et d'informations internationales	CEPII	F	1	36
5	Centre for Economic and Business Research	CEBR	DK	1	36
6	Netherlands Institute for Economic Policy Analysis	CPB	NL	1	36
7	Deutsches Institut für Wirtschaftsforschung	DIW	DE	1	36
8	Federaal Planbureau	FPB	BE	1	36
9	Istituto di Studi e Analisi Economica	ISAE	IT	1	36
10	Instituto Valenciano de Investigaciones Económicas	IVIE	ES	1	36
11	Helsinki School of Economics	HSE	FI	1	36
12	Österreichisches Institut für Wirtschaftsforschung	WIFO	AT	1	36
13	Vienna Institute for International Economic Studies	WIIW	AT	1	36
14	Stichting Amsterdam Business and Economic Research	AMBER	NL	1	36
15	The Conference Board Europe, Brussels	TCBE	BE	1	36
16	Fachhochschule Konstanz	FHK	DE	12	36

Appendix B: Notation and Basic Framework for EU KLEMS Growth Accounts

The following price concepts are being used: basic prices and purchaser prices. According to the ESA (see Eurostat, 2002, p. 123):

Purchasers' price
- Trade and transport margins
- Non-deductible VAT
- Other taxes on products
+ Subsidies on products
= **Basic price**

In this note we use the following notation:
Commodities i,, i=1,..,m
Industries j, j=1,..,n
Final uses f, f=1,..6

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

Quantities

S_i = the quantity of the total supply of product i

U_i = the quantity of the uses of the product i

M_i = the imported quantity of product i

Y_j = output of industry j

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

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

F_{if} = quantity of product i used in final use f

Prices

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

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

p_{if}^{F} = the purchase price paid by industry j for final consumption of commodity i

p_{j}^{Y} = the basic output price received by industry j

p_i = the basic price of commodity i

Margins, taxes and subsidies on products

TV_{ij}^{X} = non-deductible value added tax on product i used as intermediate in industry j.

T_{ij}^{X} = other taxes net of similar subsidies on product i used as intermediate in industry j.

TR_{ij}^{X} = distribution margin on product i used as intermediate in industry j.

TT_{ij}^{X} = transport margin on product i used as intermediate in industry j.

T_{if}^{F}, TR_{if}^{F}, TT_{if}^{F} and TV_{if}^{F} are the respective taxes and margins on product i for final uses

Small-case t indicate respective tax and margin rates as percentage of the basic price value

Value added components

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

T_{j}^{L} = other taxes, net of similar subsidies, on use of labour paid by industry j

T_{j}^{K} = other taxes, net of similar subsidies, on use of capital paid by industry j

LC_{j}^{E} = labour compensation of employees in industry j

LC_{j}^{S} = (estimated) labour compensation of self-employed in industry j

OS_{j} = operating surplus/mixed income in industry j

K_{j} = quantity of capital services used by industry j

L_{j} = quantity of labour services used by industry j

VA_{j} = value added of industry j at basic prices

We assume that the production frontier for industry j has distinct labour, capital and intermediate inputs, and that the function is separable in these inputs and the m outputs, so that:

$$Y_j = f(K_j, L_j, X_j, t)$$

$$g(Y_{1j},..,Y_{mj}) = f(K_{1j},..,K_{Kj}, L_{1j},..,L_{Lj}, X_{1j},..,X_{mj}, t) \quad (1)$$

That is, we write the output of industry j as an aggregate of the m types of output (if we use the Tornqvist index):

$$d\ln Y_{jt} = \sum_{i=1}^{m} \overline{v}_{ijt}^{Y} d\ln Y_{ijt} \quad (2)$$

where $\bar{v}^{Y}_{ijt} = \frac{1}{2}(v^{Y}_{ijt} + v^{Y}_{ij,t-1})$ and $v^{Y}_{ijt} = (VY_{jt})^{-1} p^{Y}_{ijt} Y_{ijt}$; $VY_{jt} = \sum_{i} p^{Y}_{ijt} Y_{ijt}$

Under the standard assumptions, MFP growth ($d \ln t_j$) can be derived as follows

$$d \ln t_j = d \ln Y_{jt} - \sum_{i} \bar{v}^{X}_{ijt} d \ln X_{ij} - \bar{v}^{K}_{jt} d \ln K_j - \bar{v}^{L}_{jt} d \ln L_j \qquad (3)$$

with a bar denoting period averages and

$$v^{X}_{ijt} = (VY_{jt})^{-1} p^{X}_{ijt} X_{ijt}; \quad v^{L}_{jt} = (VY_{jt})^{-1} VL_{jt}; \quad v^{K}_{jt} = (VY_{jt})^{-1} VK_{jt}; \quad \sum_{i} v^{X}_{ijt} + v^{L}_{jt} + v^{K}_{jt} = 1$$

Growth of MFP is derived as the real growth of output minus a weighted growth of inputs. For the rate of volume change of the aggregate output of an industry the commodity weights should be seen from the producer's point view i.e. reflect marginal revenue products. This means basic prices, which include the subsidies on products received by the producer. The intermediate input weights should be seen from the user's point of view i.e. 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 (see e.g. OECD 2001).

The input weights for production factors labour and capital should also reflect the marginal cost of labour respectively capital usage. These can be based on value added components as given in the National Accounts. In the National Accounts the following definition holds: value added at basic price is equal to labour compensation plus operating surplus plus other taxes on production: $VA_j = LC^{E}_{j} + OS_j + T^{O}_{j}$. Operating surplus should be divided into estimated compensation for self-employed, which is part of labour compensation, and the rest which should be allocated to capital compensation. Also other taxes on production should be allocated to capital and labour inputs: ($T^{O}_{j} = T^{K}_{j} + T^{L}_{j}$). So:

$$\begin{aligned} VA_j &= VK_j + VL_j \text{ with} \\ VL_j &= T^{L}_{j} + LC^{E}_{j} + LC^{S}_{j} \\ VK_j &= T^{K}_{j} + OS_j - LC^{S}_{j} \end{aligned} \qquad (4)$$

The allocation of other taxes on production to labour and capital is not straightforward, as other taxes on production consist of a variety of taxes such as taxes on ownership and use of land, taxes on use of fixed assets, taxes on the total wage bill, taxes for licenses, taxes on pollution etc. In the absence of detailed knowledge about the various tax types, the default option is to allocate the taxes on production to capital compensation.

Annex C: EU KLEMS 72-industry classificatin (EUK72)

Code	Description	industry number
TOT	**TOTAL ECONOMY**	
AtB	**AGRICULTURE, HUNTING, FORESTRY AND FISHING**	
A	…AGRICULTURE, HUNTING AND FORESTRY	
1	……Agriculture	1
2	……Forestry	2
B	…FISHING	3
C	**MINING AND QUARRYING**	
10t12	…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
13t14	…MINING AND QUARRYING EXCEPT ENERGY PRODUCING MATERIALS	
13	……Mining of metal ores	7
14	……Other mining and quarrying	8
D	**TOTAL MANUFACTURING**	
15t16	…FOOD PRODUCTS, BEVERAGES AND TOBACCO	
15	……Food products and beverages	9
16	……Tobacco products	10
17t19	…TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	
17t18	……Textiles and textile products	
17	………*Textiles*	11
18	………*Wearing Apparel, Dressing And Dying Of Fur*	12
19	……Leather, leather products and footwear	13
20	…WOOD AND PRODUCTS OF WOOD AND CORK	14
21t22	…PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	
21	……Pulp, paper and paper products	15
22	……Printing, publishing and reproduction	
221	………*Publishing*	16
22x	………*Printing and reproduction*	17
23t24	…CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	
23	……Coke, refined petroleum products and nuclear fuel	18
24	……Chemicals and chemical products	
244	………*Pharmaceuticals*	19
24x	………*Chemicals excluding pharmaceuticals*	20
25	……Rubber and plastics products	21
26	…OTHER NON-METALLIC MINERAL PRODUCTS	22
27t28	…BASIC METALS AND FABRICATED METAL PRODUCTS	
27	……Basic metals	23
28	……Fabricated metal products	24
29	…MACHINERY, NEC	25
30t33	…ELECTRICAL AND OPTICAL EQUIPMENT	
30	……Office, accounting and computing machinery	26
31t32	……Electrical engineering	
31	………*Electrical machinery and apparatus, nec*	
313	*………… Insulated wire*	27
31x	*………… Other electrical machinery and apparatus nec*	28
32	………*Radio, television and communication equipment*	
321	*………… Electronic valves and tubes*	29
322	*………… Telecommunication equipment*	30
323	*………… Radio and television receivers*	31
33	……Medical, precision and optical instruments	
331t3	*……… Scientific instruments*	32
334t5	*……… Other instruments*	33
34t35	…TRANSPORT EQUIPMENT	
34	……Motor vehicles, trailers and semi-trailers	34
35	……Other transport equipment	
351	………*Building and repairing of ships and boats*	35
353	………*Aircraft and spacecraft*	36
35x	………*Railroad equipment and transport equipment nec*	37
36t37	…MANUFACTURING NEC; RECYCLING	
36	……Manufacturing nec	38
37	……Recycling	39
E	**ELECTRICITY, GAS AND WATER SUPPLY**	
40	…ELECTRICITY AND GAS	
40x	……Electricity supply	40
402	……Gas supply	41
41	…WATER SUPPLY	42
F	**CONSTRUCTION**	43