EU KLEMS GROWTH AND PRODUCTIVITY ACCOUNTS
Version 1.0

PART I Methodology

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Contents

1. Introduction

This document describes the procedures, methodologies and general approaches used in constructing the first public version of the **EU KLEMS database** (version March 2007). This database is part of a research project, financed by the European Commission, to analyse productivity in the European Union at the industry level. This work is meant to support empirical and theoretical research in the area of economic growth, studying the relationship between skill formation, technological progress and innovation on the one hand, and productivity, on the other. In addition the database is meant to support the conduct of policies aimed at supporting a revival of productivity and competitiveness in the European Union, requiring comprehensive measurement tools to monitor and evaluate progress. The construction of the database should also support the systematic production of high quality statistics on growth and productivity using the methodologies of national accounts and input-output analysis.

The EU KLEMS growth accounts include measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for European Union member states from 1970 onwards. The input measures include various categories of capital (K), labour (L), energy (E), material (M) and service inputs (S). 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. The measures will be developed for individual European Union member states, and are linked with “sister”-KLEMS databases in the U.S. and Japan. In a later stage, more countries will be added.

Below we will first outline the distinguishing features of the database. The document then proceeds as follows. Section 2 describes the coverage of the database in terms of countries, industries and variables. Section 3 lays out the general growth accounting methodology which has been used to generate growth accounts and its data requirements. In the following sections (Sections 4-6), the output and intermediate input accounts, labour accounts and capital accounts are discussed in turn. Sources for specific variables are discussed on a country-by-country basis in an accompanying document PART 2 EU KLEMS Sources. Section 7 describes the construction of the productivity accounts. In Section 8 PPPs and regional aggregation issues are discussed.

Distinguishing features of the EU KLEMS database

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. The database has been constructed on the basis of data delivered by the consortium partners with cooperation of national statistical offices, and processed according to agreed procedures which have been discussed within the consortium over the past 18 months. These procedures were developed to ensure harmonisation of the basic data, and to generate growth accounts in a consistent and uniform way. Importantly, this database is deeply rooted in statistics from the National Accounts and follows the ESA95 framework in many respects.

Harmonisation of the basic data has focused on a number of areas:

- *Industrial classifications*: although harmonisation was relatively easy to realise for the recent period for which NACE1 has been in use (with the exception of the US and Japan), older statistics were often in NACE70 or country specific classifications. Additional data had to be found to provide links across diverse classification systems.
- *Aggregation levels*: the level of industry detail in the national accounts statistics varied widely across countries, variables and periods. The EU KLEMS consortium has generated a system which allows the comparisons of statistics at various levels of aggregation by using a common industry hierarchy for all countries.
- *Reference year for volume measures*: countries differ in the reporting of volume measures, e.g. previous year prices vis-à-vis different base years. All series have been put on a 1995 reference year.
- *Price concepts*: the price concept for gross output (basic prices) and intermediate inputs (purchasers' prices) have been harmonised across countries.
- *Solving breaks*: various series had to be linked in order to bridge different vintages of the national accounts. This has been done according to standardised methodologies as discussed in the next sections
- *Labour input:* various concepts of labour input (employees, self-employed, hours worked) and harmonised measures of persons engaged and hours worked have been developed.
- *Labour services input:* labour service input has been measured in a standardised way by distinguishing a variety of labour types in terms of gender, age and educational attainment. For these series additional material has been collected, as they are not part of the system of national accounts.
- *Asset classification*: although the SNA provides a classification of capital assets, it was not always detailed enough to back out information and communication equipment from the investment series. Additional information has been collected to obtain investment series for these assets. In addition, the level of asset detail has been put on a comparable basis.
- *Capital services input:* capital service input has been measured in a standard way, using harmonised depreciation rates and common rules to deal with a variety of practical problems, such as weighting and rental rates. Importantly, capital input is measured as capital services, rather than stocks.
- *Multifactor productivity measures:* MFP has been generated on both a gross output and value added basis according to a standard methodology developed by Jorgenson, Gollop and Fraumeni (1987).
- *Intermediate input measures*: Series on intermediate inputs are broken down into energy, materials and services using a standardised classification.

2. Coverage

In this section we describe the coverage of the EU KLEMS database in terms of countries, industries and variables. In principle, the period covered is from 1970 to 2004, but due to data limitations this differs across countries, industries and variables as discussed below.

Variables and link with National Accounts

Table 2.1 provides an overview of all the series included in the EU KLEMS database. The variables covered can be split into three main groups: Basic variables, growth accounting variables and additional variables. The basic series contain all the data needed to construct single productivity measures such as output per hour worked. They include nominal, volume and price series of output and intermediate inputs, and volumes and prices of employment. All these series are part of the present European System of National Accounts (ESA 1995) and can be found in the National Accounts of all individual countries, at least for the most recent period. The main assumptions used to construct these series were needed to fill up gaps in industry detail and to link series over time, in particular in those cases where revisions were not taken back to 1970 by the national statistical institutes (NSIs). The variables in the growth accounting series are of an analytical nature and cannot be derived from published National Accounts data without additional assumptions. These include series of capital services, of labour services, and of total factor productivity which are the heart and main aim of the EU KLEMS project. The construction of these series are based on a theoretical model of production and needs additional assumptions which are spelled out in the following sections. Finally, additional series are given which have been used in generating the growth accounts and are informative by themselves. They include various measures of the relative importance of IT- and non-IT capital, and of the various labour types within the EU KLEMS classification. The last column of Table 2.1 indicates in which section the construction of a particular variable is discussed.

Table 2.1 Variables in EU KLEMS database

Basic variables		***Section***
Values		
GO	Gross output at current basic prices (in millions of local currency)	4
II	Intermediate inputs at current purchasers' prices (in millions of local currency)	4
IIE	Intermediate energy inputs at current purchasers' prices (in millions of local currency)	4
IIM	Intermediate material inputs at current purchasers' prices (in millions of local currency)	4
IIS	Intermediate service inputs at current purchasers' prices (in millions of local currency)	4
VA	Gross value added at current basic prices (in millions of local currency)	4
COMP	Compensation of employees (in millions of local currency)	4
GOS	Gross operating surplus (in millions of local currency)	4
TXSP	Taxes minus subsidies on production (in millions of local currency)	4
EMP	Number of persons engaged (thousands)	5
EMPE	Number of employees (thousands)	5
H_EMP	Total hours worked by persons engaged (millions)	5
H_EMPE	Total hours worked by employees (millions)	5
Prices		
GO_P	Gross output, price indices, 1995 = 100	4
II_P	Intermediate inputs, price indices, 1995 = 100	4
VA_P	Gross value added, price indices, 1995 = 100	4

Volumes		
GO_QI	Gross output, volume indices, 1995 = 100	4
II_QI	Intermediate inputs, volume indices, 1995 = 100	4
IIE_QI	Intermediate energy inputs, volume indices, 1995 = 100	4
IIM_QI	Intermediate material inputs, volume indices, 1995 = 100	4
IIS_QI	Intermediate service inputs, volume indices, 1995 = 100	4
VA_QI	Gross value added, volume indices, 1995 = 100	4
LP_I	Gross value added per hour worked, volume indices, 1995=100	3
Growth accounting variables		
LAB	Labour compensation (in millions of local currency)	7
CAP	Capital compensation (in millions of local currency)	7
LAB_QI	Labour services, volume indices, 1995 = 100	5
CAP_QI	Capital services, volume indices, 1995 = 100	6
VA_Q	Growth rate of value added volume (% per year)	7
VAConL	Contribution of labour services to value added growth (percentage points)	7
VAConH	Contribution of hours worked to value added growth (percentage points)	7
VAConLC	Contribution of labour composition change to value added growth (percentage points)	7
VAConKIT	Contribution of ICT capital services to output growth (percentage points)	7
VAConKNIT	Contribution of non-ICT capital services to output growth (percentage points)	7
VAConTFP	Contribution of TFP to value added growth (percentage points)	7
TFPva_I	TFP (value added based) growth, 1995=100	7
GO_Q	Growth rate of gross output volume (% per year)	7
GOConII	Contribution of intermediate inputs to output growth (percentage points)	7
GOConIIM	Contribution of intermediate energy inputs to output growth (percentage points)	7
GOConIIE	Contribution of intermediate material inputs to output growth (percentage points)	7
GOConIIS	Contribution of intermediate services inputs to output growth (percentage points)	7
GOConL	Contribution of labour services to output growth (percentage points)	7
GOConK	Contribution of capital services to output growth (percentage points)	7
GOConTFP	Contribution of TFP to output growth (percentage points)	7
TFPgo_I	TFP (gross output based) growth, 1995=100	7
Additional variables		
CAPIT	ICT capital compensation (share in total capital compensation)	6
CAPNIT	Non-ICT capital compensation (share in total capital compensation)	6
CAPIT_QI	ICT capital services, volume indices, 1995 = 100	6
CAPNIT_QI	Non-ICT capital services, volume indices, 1995 = 100	6
CAPIT_QPH	ICT capital services per hour worked, 1995 reference	6
CAPNIT_QPH	Non-ICT capital services per hour worked, 1995 reference	6
LABHS	High-skilled labour compensation (share in total labour compensation)	5
LABMS	Medium-skilled labour compensation (share in total labour compensation)	5
LABLS	Low-skilled labour compensation (share in total labour compensation)	5
LAB_QPH	Labour services per hour worked, 1995 reference	5
H_HS	Hours worked by high-skilled persons engaged (share in total hours)	5
H_MS	Hours worked by medium-skilled persons engaged (share in total hours)	5
H_LS	Hours worked by low-skilled persons engaged (share in total hours)	5
H_M	Hours worked by male persons engaged (share in total hours)	5
H_F	Hours worked by female persons engaged (share in total hours)	5
H_29	Hours worked by persons engaged aged 15-29 (share in total hours)	5
H_49	Hours worked by persons engaged aged 30-49 (share in total hours)	5
H_50+	Hours worked by persons engaged aged 50 and over (share in total hours)	5

Country coverage

Table 2.2 provides a list of countries covered in this preliminary database. It also indicates the period for which data is available. In general, data for 1970-2004 is available for the old EU-15 countries, and series from 1995 onwards are available for the new EU member states (EU-10).

Table 2.2 Countries covered

Countrycode	Countries	Period
AUT	Austria	1970-2004
BEL	Belgium	1970-2004
CYP	Cyprus	1995-2004
CZE	Czech Republic	1995-2004
DEW	West-Germany	1970-1991
DNK	Denmark	1970-2004
ESP	Spain	1970-2004
EST	Estonia	1995-2004
FIN	Finland	1970-2004
FRA	France	1970-2004
GBR	United Kingdom	1970-2004
GER	Germany	1970-2004
GRC	Greece	1970-2004
HUN	Hungary	1995-2004
IRL	Ireland	1970-2004
ITA	Italy	1970-2004
JAP	Japan	1970-2004
LVA	Latvia	1995-2004
LTU	Lithuania	1995-2004
LUX	Luxembourg	1970-2004
MLT	Malta	1995-2004
NLD	Netherlands	1970-2004
PRT	Portugal	1970-2004
POL	Poland	1995-2004
SVK	Slovakia	1995-2004
SVN	Slovenia	1995-2004
SWE	Sweden	1970-2004
USA NAICS	United States (NAICS based)	1977-2004
USA SIC	United States (SIC based)	1970-2004

Industry classification and coverage

At the lowest level of aggregation, data were collected for 71 industries, the so-called Euk industries. The industries are classified according to the European NACE revision 1 classification. This classification is very close the International Standard Industrial Classification (ISIC) revision 3. Table 2.3 provides a listing of the industries, including higher aggregates. This industry division is more detailed than the 2-digit (A60) level which is often used in European statistics. There are various reasons for this. For the recent period (1995 and after), almost all EU countries have supply-and-use tables at the A60 level. Therefore we took the 60 industries of the A60 list as our starting point and looked whether further industry detail was needed for research purposes. Industries which are interesting from an analytical point of view are those which either stand out in terms of skill and R&D intensity, or in terms of ICT investment intensity or ICT share in output. On the basis of these considerations the following 8 industries were separately identified: (1) pharmaceuticals, (2) insulated wire, (3) electronic valves, (4) telecommunication equipment, (5) scientific instruments, (6) manufacturing of ships, (7) manufacturing of aircraft and (8) legal/technical/advertising services. We also looked at the upcoming revision to ISIC and NACE in 2007, with a view to developing a database that will be both relevant and current in the years to come. Three important revisions will be: the splitting of (1) electricity from other utilities, (2) publishing from publishing and printing and (3) media services from recreational activities, etc.. This adds another 3 industries.

The level of detail in the EU KLEMS database varies across countries, industries and variables due to data limitations. In order to ensure a minimal level of industry detail for which comparisons can be made across all countries, so-called minimum lists of industries have been used. All national datasets have been constructed in such a way that these minimums are met. The minimum list is different for particular groups of variables and time-periods. Three groups of variables can be distinguished: variables needed to do labour productivity growth and unit labour cost analysis (for the period from 1995 onwards, and the period before 1995), and additional variables needed to do growth accounting (gross output, intermediate input, labour composition and capital). The industries included in each of these three groups are indicated in Table 2.3. They include respectively 62, 48 and 31 industries. The industry detail for each country conforms at least to the minimum list of industries, but often more detail is available. This information is given in Table 2.4. It indicates for each country the number of EU KLEMS industries for which data is available.

For analytical convenience, the EU KLEMS database also provides files with an alternative aggregation scheme. It includes useful aggregates such as market economy, market services and goods production. This aggregation scheme is given in Appendix Table 3. The files aggregated according to this scheme are labeled with "_alt".

Table 2.3 Industries in EU KLEMS database and minimum sets

		GA	LP 70-95	LP 95-04
TOT	TOTAL ECONOMY	X	X	X
AtB	AGRICULTURE, HUNTING, FORESTRY AND FISHING	X	X	X
A	…AGRICULTURE, HUNTING AND FORESTRY		X	X
1	……Agriculture		X	X
2	……Forestry		X	X
B	…FISHING		X	X
C	MINING AND QUARRYING	X	X	X
10t12	…MINING AND QUARRYING OF ENERGY PRODUCING MATERIALS		X	X
10	……Mining of coal and lignite; extraction of peat			
11	……Extraction of crude petroleum and natural gas and services			
12	……Mining of uranium and thorium ores			
13t14	…MINING AND QUARRYING EXCEPT ENERGY PRODUCING MATERIALS		X	X
13	……Mining of metal ores			
14	……Other mining and quarrying			
D	TOTAL MANUFACTURING	X	X	X
15t16	…FOOD PRODUCTS, BEVERAGES AND TOBACCO	X	X	X
15	……Food products and beverages			X
16	……Tobacco products			X
17t19	…TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	X	X	X
17t18	……Textiles and textile products		X	X
17	………Textiles			X
18	………Wearing Apparel, Dressing And Dying Of Fur			X
19	……Leather, leather products and footwear		X	X
20	…WOOD AND PRODUCTS OF WOOD AND CORK	X	X	X
21t22	…PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	X	X	X
21	……Pulp, paper and paper products		X	X
22	……Printing, publishing and reproduction		X	X
221	………Publishing			X
22x	………Printing and reproduction			X
23t25	…CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	X	X	X
23	……Coke, refined petroleum products and nuclear fuel	X	X	X
24	……Chemicals and chemical products	X	X	X
244	………Pharmaceuticals			X
24x	………Chemicals excluding pharmaceuticals			X
25	……Rubber and plastics products	X	X	X
26	…OTHER NON-METALLIC MINERAL PRODUCTS	X	X	X
27t28	…BASIC METALS AND FABRICATED METAL PRODUCTS	X	X	X
27	……Basic metals		X	X
28	……Fabricated metal products		X	X
29	…MACHINERY, NEC	X	X	X
30t33	…ELECTRICAL AND OPTICAL EQUIPMENT	X	X	X
30	……Office, accounting and computing machinery		X	X
31t32	……Electrical engineering		X	X
31	………Electrical machinery and apparatus, nec		X	X
313	…………Insulated wire			X
31x	…………Other electrical machinery and apparatus nec			X
32	………Radio, television and communication equipment		X	X
321	…………Electronic valves and tubes			X
322	…………Telecommunication equipment			X
323	…………Radio and television receivers			X
33	……Medical, precision and optical instruments		X	X
331t3	………Scientific instruments			X
334t5	………Other instruments			X
34t35	…TRANSPORT EQUIPMENT	X	X	X
34	……Motor vehicles, trailers and semi-trailers		X	X

35	……Other transport equipment		X	X
351	………Building and repairing of ships and boats			
353	………Aircraft and spacecraft			
35x	………Railroad equipment and transport equipment nec			
36t37	…MANUFACTURING NEC; RECYCLING	X	X	X
36	……Manufacturing nec			
37	……Recycling			
E	ELECTRICITY, GAS AND WATER SUPPLY	X	X	X
40	…ELECTRICITY AND GAS			
40x	……Electricity supply			
402	……Gas supply			
41	…WATER SUPPLY			
F	CONSTRUCTION	X	X	X
G	WHOLESALE AND RETAIL TRADE	X	X	X
50	……Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of	X	X	X
51	……Wholesale trade and commission trade, except of motor vehicles and motorcycles	X	X	X
52	……Retail trade, except of motor vehicles and motorcycles; repair of household goods	X	X	X
H	HOTELS AND RESTAURANTS	X	X	X
I	TRANSPORT AND STORAGE AND COMMUNICATION	X	X	X
60t63	…TRANSPORT AND STORAGE	X	X	X
60	……Inland transport		X	X
61	……Water transport		X	X
62	……Air transport		X	X
63	……Supporting and auxiliary transport activities; activities of travel agencies		X	X
64	…POST AND TELECOMMUNICATIONS	X	X	X
JtK	FINANCE, INSURANCE, REAL ESTATE AND BUSINESS SERVICES	X	X	X
J	…FINANCIAL INTERMEDIATION	X	X	X
65	……Financial intermediation, except insurance and pension funding			X
66	……Insurance and pension funding, except compulsory social security			X
67	……Activities related to financial intermediation			X
K	…REAL ESTATE, RENTING AND BUSINESS ACTIVITIES	X	X	X
70	……Real estate activities	X	X	X
71t74	……Renting of m&eq and other business activities	X	X	X
71	………Renting of machinery and equipment		X	X
72	………Computer and related activities		X	X
73	………Research and development		X	X
74	………Other business activities		X	X
741t4	…………Legal, technical and advertising			X
745t8	…………Other business activities, nec			X
LtQ	COMMUNITY SOCIAL AND PERSONAL SERVICES	X	X	X
L	…PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	X	X	X
M	…EDUCATION	X	X	X
N	…HEALTH AND SOCIAL WORK	X	X	X
O	…OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	X	X	X
90	……Sewage and refuse disposal, sanitation and similar activities			X
91	……Activities of membership organizations nec			X
92	……Recreational, cultural and sporting activities			X
921t2	………Media activities			
923t7	………Other recreational activities			
93	……Other service activities			X
P	…PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	X	X	X
Q	…EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES			

Notes: GA: Growth accounting (1970-2004)

LP70-95: Labour Productivity and Unit Labour Costs (1970-1995)

LP95-04: Labour Productivity and Unit Labour Costs (1995-2004)

Table 2.4 Number of EUK industries for which variables are available

	Labour Productivity		Growth Accounting	EMS shares	Labour Composition
	1970-1995	1995-2004			
AUT	56	63	1980-2004	1988-2004	1980-2003
BEL	64	72	1986-2004	1995-2002	1986-2004
CYP	n.a.	59	n.a.	n.a.	n.a.
CZE	n.a.	63	1995-2004	1995-2004	1995-2004
DEW	52	n.a.	1970-1991	1978-1991	1970-1991
DNK	60	64	1980-2004	1970-2005	1980-2003
ESP	71	71	1980-2004	1980-2004	1980-2004
EST	n.a.	61	n.a.	2000-2002	n.a
FIN	60	67	1970-2004	1970-2004	1970-2003
FRA	65	67	1982-2004	1978-2004	1982-2004
GBR	69	69	1970-2004	1970-2004	1970-2004
GER	52	66	1970-2004	1978-2004	1970-2004
GRC	48	67	n.a.	1995-1999	n.a
HUN	n.a.	64	1995-2004	1995-2004	1995-2005
IRL	59	62	n.a.	n.a.	n.a.
ITA	48	62	1970-2004	1970-2004	1970-2004
JAP	55	61	1973-2004	1973-2004	1970-2004
LVA	n.a.	60	n.a.	n.a.	n.a.
LTU	n.a.	60	n.a.	n.a.	n.a.
LUX	40	63	1970-2004	1995-2004	n.a.
MLT	n.a.	57	n.a.	2000-2001	n.a.
NLD	48/58	63	1979-2004	1981-2004	1979-2003
POL	n.a.	62	1995-2004	1995-2004	1995-2004
PRT	48/50	65	n.a.	n.a.	n.a.
SVK	n.a.	64	n.a.	1995-2005	1995-2005
SVN	n.a.	63	1995-2004	1995-2004	1995-2004
SWE	48	62	1993-2004	1993-2003	1993-2004
USA NAICS	71	71	1977-2004	n.a.	n.a.
USA SIC	65	65	1970-2004	1970-2004	1970-2004

Notes:

EST: only nominal values for IIE, IIM and IIS

GER: 66 industry detail available from 1991 onwards, before 1991 it has 52 industries; data for GO TFP and VA TFP for 1970-1991 can be found in DEW file

HUN: Labour productivity data starts in 1991 or 1992 (WP1 in 1991, WP2 in 1992)

ITA: after 1992 some more detail (more than 48) is available, but only in 1995 are there 62 available.

JPN: National Accounts data (for WP1) starts in 1973.

LTU: no data for Q, and some problems for P, therefore it looks like it doesn't meet the minumum requirements

LVA: no data for P and Q (therefore 2 short of Min. req.)

LUX&MLT: quite some industries are zero in Luxembourg and Malta, which explains why it seems the data do not conform to the minimum requirements

NLD: 48 industries for the period 1970-1986, 58 for the period 1987-1994

PRT: for 1970-1976 48 industries

SWE: 48 industries are available for the 1970-1992 period, 62 for the post-1993 period

3. Growth and Productivity Accounts

In this section we summarize the methodology used to develop our measures of industry-level total factor 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 possibility frontiers 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, can produce a set of products indexed by *i* indicated by the production possibility set *g*. Each industry 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:

$$Y_j = g_j(Y_{ij}) = f_j(K_j, L_j, X_j, T) \qquad (1)$$

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:

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

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 profit maximizing behaviour, 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

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

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:

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

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^{Y}):

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

where the contribution of each input is defined as the product of the input's growth rate and its two-period average revenue share. This decomposition is the basis of the growth accounting results in the EU KLEMS database, as explained in Section 7.

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:

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

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).

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

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

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

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:

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

or rewriting

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

where $\overline{v}_{jt}^V$ 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)[1]

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

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[1] However, note that this is only valid as long as value added volume growth rates are derived as in equation (10). This is not always the case, see section 4 .

4. Output and Intermediate Input Accounts

4.1 Methodology

In order to provide a coherent set of industry-level productivity estimates which cover the aggregate economy, one needs a consistent set of inter-industry transaction accounts. This methodology was introduced by Jorgenson, Gollop and Fraumeni (1987). We define the quantity of output in industry j as an aggregate of M distinct outputs (using the Tornqvist index as before) :

$$\Delta \ln Y_{jt} = \sum_{i=1}^{m} \bar{v}_{ijt}^{Y} \Delta \ln Y_{jt} \quad (13)$$

$\bar{v}_{jt}$ with a bar denoting period averages and $\bar{v}$ is the two period average share of product *i* in the nominal value of output. The value share of each product is defined as follows:

$$v_{ijt}^{Y} = (\sum_{i} p_{ijt}^{Y} Y_{ijt})^{-1} p_{ijt}^{Y} Y_{ijt} \quad (14)$$

with p_{ij}^{Y} = the basic price received by industry j for selling commodity *i*. 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 quantity index for industry j is defined analogously by

$$\Delta \ln X_{jt} = \sum_{i} \bar{v}_{ijt}^{X} \Delta \ln X_{jt} \quad (15)$$

where $v_{ijt}^{X} = (\sum_{i} p_{ijt}^{X} X_{ijt})^{-1} p_{ijt}^{X} X_{ijt}$ with p_{ij}^{X} = the price paid by industry j for using product i.

There has been some confusion in the literature on the price concept to be used for intermediate inputs. It is generally acknowledged that the intermediate input weights should be seen from the user's point of view i.e. reflect the marginal cost paid by the user. Most studies maintain that purchasers' prices should be used. These prices include taxes on commodities paid by the user (non-deductible VAT included), exclude the subsidies on commodities, and importantly, also include margins on trade and transportation (see e.g. OECD 2001). However, whether trade and transportation margins should be included is crucially depended on the set of products which are included in the analysis. When trade and transportation are included as separate products, margins on other products should be allocated to them. In effect, one makes a distinction between the intermediate product as delivered by the producing industry, valued at purchasers' prices minus margins, and the trade and transportation services, valued at the margins.[2] This is the approach taken in Jorgenson, Gollop and Fraumeni (1987) and Jorgenson, Ho and Stiroh (2005) and is to be preferred. However, in practice we

[2] See Timmer (2005).

have not been able to collect the necessary data for this breakdown (see below) and use purchasers' prices to value intermediate inputs in all cases, except for the U.S. SIC data.

Intermediate inputs are divided into various groups, such as energy (E), materials (M) and services (S). This breakdown of intermediate inputs can be used for extending the growth accounting exercises, but also convey interesting information about changing patterns in intermediate consumption (see e.g. Jorgenson, Ho and Stiroh 2005, chapter 4).

4.2 Practical implementation

In this section, we describe the basic approach in deriving the following EU KLEMS variables. Table 4.1 lists the variables of the output and intermediate input accounts. The volume series are given as an index with 1995 as the base year (1995=100). However, this does not mean that the series are valued at 1995 prices. The indices are derived from annual volume growth rates based on chained Laspeyres or Tornqvist volume series, depending on the underlying data material (see below). Price indices are derived from the nominal and volume series.

Table 4.1 Variables of the output and intermediate input accounts

Nominals	
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)
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)
Prices	
GO_P	Gross output, price indices, 1995 = 100
II_P	Intermediate inputs, price indices, 1995 = 100
VA_P	Gross value added, price indices, 1995 = 100
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

Basic Approach

A crucial element in KLEMS growth accounts is the consistency of inputs and outputs within and across industries. Therefore, the main building block of a KLEMS account is a series of input-output tables in which inter-industry flows are recorded in a consistent way. Until recently, the main bottleneck in productivity research for most countries was the lack of long-run series of these tables. But since the introduction and application of the European System of Accounts 1995 (ESA), this situation is changing rapidly for many European countries. In the ESA 1995, a plea was made for using SUTs as the building blocks for the construction of the National Accounts. Supply and use tables (SUTs)[3] are a particular type of input-output table. They trace the supply and use of all commodities in the economy, as well as the payments for primary factors labour and capital. The supply table indicates for each industry the composition of output by product. This is used to derive industry gross output indices. The Use table indicates for each industry the product composition of its intermediate inputs and value added components. This is used to derive the intermediate input and value added series in the national accounts. Therefore, long-series of SUTs seem to be natural starting point for KLEMS accounts for European countries.

Since 1995, many countries have started to implement the SUT approach and as a result, the availability of SUTs which are compatible with the National Accounts has increased. However, the speed of implementation differs across countries. In addition, there is variation in the timeframe under which countries carry back the revisions, if at all. Consequently, there are not many countries with official long time-series of nominal and volume SUTs. The most important reason for this lack of long-run series is the major revision of the National Accounts which took place in many European countries in 2005. This revision included among others the transfer of FISIM to using industries and a shift to annual chained Laspeyres volume indices. As a result, old SUT series needed to be revised, but this process has been slow and differs across countries.

To solve this data availability, the approach taken in the EU KLEMS project is a two-step procedure. First, we start from the most recent and revised series by industry on gross output (GO), total intermediate input (II) and value added (VA) from the NA accounts. These series are extended and broken down into more industry-detail if needed (see below on how this is done). In a second step we use available Use tables to decompose total intermediate inputs into energy (IIE), materials (IIM) and services (IIS). In this way we retain a maximum of information as also older vintage Use tables can be used to provide a breakdown of intermediate inputs (see below). Clearly, this procedure is a second-best solution and awaits further revisions of the SUTs by NSIs.

Linking National Accounts series

In some cases NA series need to be linked, for example when the recent revision of the NA has not been taken back to 1970. In that case, we link the series through splicing, i.e. apply growth rates of old

[3] We use the term supply and use tables (SUTs) here rather than IOT (Input-Output tables). In the terminology of the ESA95, supply and use tables refer to product by industry tables and input-output tables refer to industry by industry or commodity by commodity tables. IOTs are derived from SUTs through imposing various production technology assumptions which might not fit the production theoretic approach of growth accounting. In the past, IOTs were constructed without a SUT framework and provided the only available data on intermediate input categories. But with the introduction of the ESA 95, NSIs have rapidly adopted the SUT framework.

NA series to the level of new series in a particular link year. Before doing so, we check whether the old and new levels in the link year are reasonably close. If not, this procedure is not carried out, or at higher levels of aggregation. This is indicated in the country source notes.

Filling procedure for National Accounts series

In case of missing data there are basically two procedures for estimating nominal value added, employment and compensation data by industry: (1) applying shares derived from additional secondary sources to higher level national accounts aggregates or (2) applying higher-level growth rates to more detailed levels. The first is most useful when for a particular sub-sector there is no data available for any year from the national accounts. In that case, the share of the sub-sector in some higher level aggregate is derived from additional secondary data sources and applied to the aggregate in the basic source. When data is available in the basic source for some years, secondary data shares are used for missing years provided they correspond closely to the basic source. If not, growth rates from secondary data are applied to the original basic data for missing years. To maintain national accounts compatibility a normalisation procedure is used so that subsectors add to the corresponding higher-level industry aggregates provided in the national accounts. If there is a summation discrepancy, the sub-sectors absorb the residual in proportion to its weight in the parent industry. This procedure ensures that output and employment measures are national accounts compatible and, importantly, have the same economy-wide coverage.[4] The source descriptions in PART 2 provide a detailed account of the filling procedures used for each country, year and variable.

The weights provided are sometimes only for gross output but in some case, separate weights are available for various variables, e.g. gross output, intermediate inputs and labour compensation; see source description for each country. An important issue when using separate weights for a set of variables is internal consistency: e.g. weights for gross output and intermediate inputs should be consistent with the weights for value added, which in turn should be consistent with the weights for compensation, gross operating surplus and net taxes. If these weights were not consistent, our default option was to use gross output and labour compensation weights.

Weights always refer to nominal values. We use nominal weights also for the volume series, implicitly assuming identical price deflators for the sub-sectors.

Aggregation

For all aggregation (over products or industries) we use the Tornqvist quantity index, which is a discrete time approximation to a Divisia index. This aggregation approach uses annual moving weights based on averages of adjacent points in time. The advantages of the Tornqvist index are twofold. First, it belongs to the preferred class of superlative indices (Diewert 1976). More precisely, it exactly replicates a translog model which is highly flexible, that is, a model where the aggregate is a linear and quadratic function of the components and time. This is in contrast to the chained Laspeyres index which is currently employed in many European National Accounts, which is prone to substitution bias. In practice, however, when applied as an annual chain, the Laspeyres index will not

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

be far off the Tornqvist index as long as growth rates are modest.[5] Secondly, the Tornqvist is relatively easy to implement. [6]

Volume measures of value added

In this database we have chosen to report industry-level value added volume indices for each country based on the national accounts methodology of that particular country. This methodology differs across countries and will not always be equal to the implicit definitions as given in (10) and (11).[7] This choice is driven by the fact that for many countries value added volume series are often longer and have more industry detail than the gross output and intermediate inputs series. Especially in the past, value added volumes in the national accounts were not always derived using the double deflation method by separately deflating gross output and intermediate inputs. This is particularly true for some services industries, and data derived from earlier vintages of the National Accounts before the ESA 1995 revisions. Hence, redefining value added on the basis of gross output and intermediate input would have resulted in an unacceptable loss of data.

Dealing with negative value added

In some industries for some countries and years, nominal or real value added is negative. In that case, volume indices cannot be derived and the series breaks down. In those cases, the volume series is missing. But at higher levels of aggregation volume indices the negatives are included.[8] For higher level aggregates, the values are set to 0.

Value added components

To derive the factor input weights in the growth accounts the following nominal value added components are needed: compensation of employees (COMP), gross operating surplus (GOS) and net taxes on production (TXSP). Labour compensation (LAB), as discussed in section 7, is derived by applying the ratio of hours worked by total persons engaged to hours worked by employees to compensation. Capital compensation (CAP) is derived as value added minus LAB.

Energy, Materials and Services

Energy, materials and services inputs are calculated by applying shares of E, M and S from the Use-tables to total intermediate inputs from the national account series. While for many countries (nominal) SUTs are available since 1995, few countries have long-term series extending back to 1980 or earlier. Therefore, sometimes use has been made of Input-output tables, rather than SUTs to derive measures of E, M and S. This is discussed in the Source notes. Table 4.2 indicates for each country the

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[5] Significant differences can occur is fast growing industries such as electronics, or rapidly declining industries such as mining.

[6] Volume data at the lowest industry level in EU KLEMS is taken directly from the National Accounts of the countries. This will generally be chained Laspeyres volume indices are used.

[7] But differences are small, see above.

[8] To be more precise, in those cases, we sum the chained Laspeyres series instead of applying Tornqvist aggregation.

availability of intermediate input series at current and constant prices (IIE, IIE_QI, IIM, IIM_QI, IIS, IIS_QI) in the EU KLEMS database and their source (IO-tables or SUTs).

Table 4.2 Use of of SUTs and IO-tables in constructing E, M and S series

	IO	SUT
AUT		1988-2004
BEL		1995-2004
CYP		n.a.
CZE		1995-2004
DEW*	1978-1991	
DNK	1970-2005	
ESP		1980-2004
EST*		2000-2002
FIN		1975-2004
FRA*	1978-2004	
GBR		1970-2004
GER		1991-2004
GRC		1995-1999
HUN		1995-2004
IRL		n.a.
ITA		1970-2004
JAP		1973-2004
LVA		n.a.
LTU		n.a.
LUX		1995-2004
MLT*		2000-2001
NLD		1981-2004
POL		1995-2004
PRT		n.a.
SVK		1995-2005
SVN*		1995-2004
SWE		1993-2003
USA NAICS		n.a.
USA SIC		1970-2004

Notes:
DEW: only 4 IO tables are available (1978, 1986, 1988 and 1990, rest are intrapolated, 1991 extrapolated from 1990).
EST & MLT & SVN: Only nominal shares of EMS are available
FRA: Nominal EMS shares are deflated with Gross Output deflators from national accounts

Definition of EMS

Energy inputs are defined as all energy mining products (10-12), oil refining products (23) and electricity and gas products (40). All services (products from industries 50-99) are included in S. The remaining products are classified as materials. One has to keep in mind that the underlying Use-tables are valued at purchasers' prices and hence all margins are included in the value of the products and have not been reallocated to the trade and transportation products (except for the US). This will only affect the relative contributions of E, M and S to gross output growth, but not the other growth accounting variables.

4.3 Outstanding issues

Estimation procedure for SUTs

As discussed above, the available official SUT series compatible with the recent revision of the National Accounts are short. Researchers in the consortium have used various short cuts to generate long-run SUT series, e.g. for Austria, Italy and Spain (see EU KLEMS Sources for a country-by-country discussion). For other countries, data might become available from the NSIs in the near future, or similar short-cuts need to be made. A proposal for developing nominal series of SUTs, and for deflation of nominal SUTs has been made by Timmer (2005). They suggest to derive nominal series by a simple proportional correction method, and deflation by assuming a common basic price of a product independent of its use. Broersma and van Moergastel (2006) and Kratena (2006) have shown that this short-cut delivers meaningful results when compared with official series published respectively by Statistics Netherlands and Statistics Austria. It might be used for future updates of the EU KLEMS database.

5. Labour Accounts

This section provides information on the methods and sources of data measuring labour services. It begins with an overview of the theoretical method drawing from the analysis developed by Dale Jorgenson and associates. The aim of the labour accounts is to estimate total labour input so that it reflects the actual changes in the amount and quality of labour input over time. In short, in this method the labour force is subdivided into types based on various characteristics, in this case age, gender and educational attainment. In section 5.1 we outline the methodology in deriving series for labour services. Section 5.2 deals with implementation issues and 5.3 discusses outstanding issues.

5.1 Methodology

The productivity of various types of labour, such as low- versus high-skilled, will differ. Standard measures of labour input, such as numbers employed or hours worked, will not account for such differences. Hence it is important to have measures of labour input which take the heterogeneity of the labour force into account in analysing productivity and the contribution of labour to output growth. These measures are called labour services, as they allow for differences in the amount of services delivered per unit of labour. We follow the approach of Jorgenson, Gollop and Fraumeni, (JGF), 1987, Chapter 5 and assume that aggregate services are a translog function of the services of individual types. It is further assumed that the flow of labour services for each labour type is proportional to hours worked, and workers are paid their marginal productivities. Hence the corresponding index of labour services input L is a translog quantity index of individual types, indexed by l, and given by

$$(5.1) \qquad \Delta \ln L_t = \sum_l \bar{v}_{l,t} \Delta \ln H_{l,t}$$

where weights are given by the average shares of each type in the value of labour compensation $\bar{v}_{l.t} = \frac{1}{2}[v_{l,t} + v_{l,t-1}]$ and $v_{lt} = (\sum_l p_{lt}^L H_{lt})^{-1} p_{lt}^L H_{lt}$ with p_{lt}^L the price of one hour work of labour type *l*.

In this way, aggregation takes into account the changing composition of the labour force. Typically, a shift in the share of hours worked by low-skilled workers to high-skilled workers will lead to a growth of labour services (variable LAB_QI in the database*)* which is bigger than the growth in total hours worked (H_EMP in the database). We refer to this difference as the labour composition effect.[9] It is captured in the database by variable LAB_QPH. This variable indicates the labour services per hour worked. It is measured as the difference in growth of labour services and hours

[9] This difference is also known as "labour quality" in the growth accounting literature (see e.g. Jorgenson, Ho and Stiroh 2005). However, this terminology has a normative connotation which easily leads to confusion. For example, lower female wages would suggest that hours worked by males have a higher " quality" than hours worked by females. Instead we prefer to use the more positive concept of "labour composition" .

worked, taking 1995 as a reference. By comparing LAB_QPH across industries, one can see which industries have relatively high levels of highly-productive labour relative to others. Similarly, a shift of hours worked by young, unexperienced workers to older, more experienced workers will show up as a positive contribution of labour services to growth, as long as wages of the young are lower than wages of the elderly.

5.2 Practical implementation

The following variables are part of the labour accounts in the EU KLEMS database, see Table 5.1. They include time series of numbers of all persons engaged and by employees seperately, and similarly for hours worked. The difference between the two are the self-employed and family-workers. In addition the shares of various labour types in total compensation or total hours are given. For example, by dividing LABHS by H_HS one derives the relative compensation level of high-skilled labourers compared to the industry average. LAB_QPH indicates the labour services per hour worked. It increases in case there is a shift toward labour types with higher marginal productivity.

Table 5.1 Variables of the labour accounts

EMP	Number of persons engaged (thousands)
EMPE	Number of employees (thousands)
H_EMP	Total hours worked by persons engaged (millions)
H_EMPE	Total hours worked by employees (millions)
LAB_QI	Labour services, volume indices, 1995 = 100
LABHS	High-skilled labour compensation (share in total labour compensation)
LABMS	Medium-skilled labour compensation (share in total labour compensation)
LABLS	Low-skilled labour compensation (share in total labour compensation)
LAB_QPH	Labour services per hour worked, 1995 reference
H_HS	Hours worked by high-skilled persons engaged (share in total hours)
H_MS	Hours worked by medium-skilled persons engaged (share in total hours)
H_LS	Hours worked by low-skilled persons engaged (share in total hours)
H_M	Hours worked by male persons engaged (share in total hours)
H_F	Hours worked by female persons engaged (share in total hours)
H_29	Hours worked by persons engaged aged 15-29 (share in total hours)
H_49	Hours worked by persons engaged aged 30-49 (share in total hours)
H_50+	Hours worked by persons engaged aged 50 and over (share in total hours)

5.2.1 Numbers engaged and hours worked

Comparability with National accounts

For all countries we have used National Accounts data as the major starting point for constructing series of employment and hours. However, the national accounts themselves do not provide enough information to disaggregate the data into a large number of detailed industries and, in some cases, do not separate employees and self employed. Further data is used to splice the data into finer industries and extend the series backwards. In most countries there have also been revisions of national accounts. Revised figures are not always available for the whole period and earlier numbers have then been estimated by linking or using other methods as indicated for each country in the *EU KLEMS Sources* document.

Depending on the source, employment can be measured as persons or jobs, or some measure constructed from these like "full time equivalent". A person can hold several jobs which are not necessarily even in the same industry, so the two measures are not equal. National Accounts employment is often reported in persons. When employment is reported as persons, ideally hours worked in second jobs would be somehow allocated to the industries they are actually in rather than for example to industries of the primary jobs of the jobholders. In the construction of National Accounts an attempt has often been made to reallocate hours worked in such a way.

Actual versus paid hours worked

One of the main problems with estimating hours worked is that definitions of hours vary across data sources. The most reliable data concerns contractual hours or paid hours as these data tend to come from employer payroll records or other such source. The hours measure of interest for productivity measurement, however, are hours actually worked. This also includes unpaid hours but excludes hours that are paid but not worked. National accounts often provide actual hours worked and this is the concept of hours also used in EUKLEMS. When national accoutns did not provide hours worked measures, these have been estimated from other measures. Details of these estimation methods, where used, are given in the source description for each country in the *EU KLEMS Sources* document.

Data on self-employed hours worked

The data on self employed hours tend to be less easily available and not always reported in National Accounts. In some instances these have been estimated from other figures. For example for France they have been estimated from hours worked by the employees corrected for overtime, and for the UK trends from employees were used to estimate self employed hours for early years. Further details on each individual countries methods are in their respective sections in the *EU KLEMS Sources* document.

Estimating detailed industries

National Accounts do not often provide labour statistics at the required level EU KLEMS. For most countries some disaggregation using additional measures or construction of weights was required. Industry weights are in some instances based on unpublished data or micro data that exist in a suitable classification that allows this. In the case of changes of classifications or of definitions one way of dealing with this is to assume that trends are the same even if the classification or definitions vary. Trends from closely matching industries or concepts have been applied to take series back or forwards. The details of methods used by each country are described in the *EU KLEMS Sources* document.

5.2.2 Labour composition

To calculate series on labour services input, data on hours worked and compensation by labour type are needed. In most countries, the basic data source for this type of data is the national Labour Force Surveys (but not for all, see *EU KLEMS Sources* document). However, these surveys have a limited sample size and do not allow for a very fine disaggregation of labour types by industry, especially in smaller countries. Therefore the minimum requirements within EU KLEMS were set at a rather aggregate level. It was felt that a rather aggregate analysis could capture most of the variation of labour types within the economy. Labour types were distinguished on the basis of the following characteristics: age, gender, educational attainment and industry. The list of minimum requirements is given in Table 5.2.

In incorporating educational attainment as a measure of skill, used a rigid high-medium-low skill split, which will be too restrictive for comparisons across countries, but is useful for tracking developments over time within a particular country (see discussion below). Numbers and wages are also collected on the basis of age bands. Age is used as a proxy for work-experience. 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. 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. Therefore we gave 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.

Table 5.2 Minimum requirements for labour types

Educational attainment:	High, Medium, Low
Gender:	Male, Female
Age:	15-19, 30-49, 50 and over

Hours worked by type

For almost all countries (except Austria and the U.S.), data by labour type is only available for numbers employed, not for hours. We therefore assume that hours worked by labour types in a particular industry is identical to the industry average. This might lead to biases in some cases. For example, in the case of an increasing share of female workers which work less hours than male workers, this assumption will lead to un underestimation of the growth of labour services.

Self-employed versus employees

For almost all countries, data by labour type is only available for employees, not self-employed. We assume that the labour characteristics of self-employed and employees are the same within an industry. For most industries, deviations from this assumption will have a negligible effect. However, for industries with large number of self-employed like agriculture and retailing, this assumption might be more problematic.

Compensation data

Compensation data (including wages and salaries but also all other costs of employing labour which are borne by the employer) was often available from the same source and for the same labour types. In some case the time-series for compensation was shorter than for numbers employed. In those cases, we assumed that relative compensation levels did not change over time.

Industry detail

In most cases, industry detail for labour types was restricted to 15 industries. To be able to do growth accounting at lower levels of aggregation, we assumed that labour characteristics doe not vary widely across closely related industries and imputed higher aggregates.

5.3 Outstanding issues

Employment agencies

There is a number of additional outstanding issues regarding the labour data. One such issue are employment agencies. Temporary workforce intermediated by agencies could in principle be classified either to business services (which is what employment agencies themselves are) or to the industry of the actual workplace. Preliminary questionnaires distributed to the consortium members show that for the most part these are allocated to business services. However, responses were not provided for all countries and in order to be able to correctly assess the comparability of data this issue should be further clarified. In subsequent versions of the database, the treatment of these workers needs to be clarified and addressed. One option is to treat this industry as a labour rental industry in analogy with the capital rental industry (see de Haan et al. 2005)

Self-employed income

The data on earnings of self-employed is needed. Currently the assumption that is being used in calculating labour and capital compensation is very rough (the compensation of the self employed is assumed to equal the compensation of the employees) and leads to negative capital compensation in some industries (see discussion in section 7). Preliminary analysis indicates that compensation of a self-employed person is lower in industries like agriculture and trade, but at least as high in business services.

Comparability of educational attainment across countries

The definitions of high, medium and low education are consistent over time for each country, but might differ across countries. The high-medium-low skill split is too restrictive, given the differences in educational systems throughout Europe. We therefore assume comparability only across the bachelor degrees educational level (high), but not at the other levels. Consequently, care should be taken in comparing shares of educational attainment across countries. Further research is needed into the exact definitions used. In Table 5.3 we provide a short overview of the definitions used for high-medium-low skilled for each country.

Table 5.3 Definitions of high-, medium- and low-skilled

	Definition of High-skilled	**Definition of Medium-skilled**	**Definition of Low-skilled**
AUT	College/university degree, technical/poly-technical degree, postgraduate courses	Vocational middle schools, completed upper level of Gymnasium, vocational higher schools	Primary education
BEL	University and non-university 2 cycles tertiary education	Higher/upper secondary education and non-university 1 cycle tertiary education	All people up to lower secondary education
CYP	n.a.	n.a.	n.a.
CZE	University	Higher post-secondary, Secondary with GCE, Apprenticeship and persons with unknown education	Lower secondary and primary education

DEW	16-17 years of education	vocational degree	without degree
DNK	Long cycle higher education	Medium and Short cycle higher education plus Vocational education and training	Basic School
ESP	University graduates	Upper secondary schooling	Lower secondary schooling and below
EST	n.a.	n.a.	n.a.
FIN	Tertiary schooling (or parts there of)	Upper secondary level with or without matriculation	lower secondary or unknown
FRA	University graduates	Higher education below degree, Low intermediate, vocational education	No formal qualifications
GBR	University degree	HND, HNC, BTEC, teaching qualification, nursing qualification, A level or equivalent, trade apprenticeship, O level or equivalent, BTEC, BEC, TEC GENERAL, City & guilds	No qualifications
GER	University graduates	Intermediate	No formal qualifications
GRC	n.a.	n.a.	n.a.
HUN	Tertiary education (ISCED groups 5-6)	At most upper secondary education (ISCED groups 3-4, excl. 3c programmes shorter than 3 years)	At most lower secondary education (ISCED groups 0-2 & 3c programmes shorter than 3 years)
IRL	n.a.	n.a.	n.a.
ITA	University graduates	Higher education below degree, Intermediate vocational plus advanced education, Low intermediate	No formal qualifications
JAP	University graduates	Junior College and Upper Secondary	Lower Secondary
LVA	n.a.	n.a.	n.a.
LTU	n.a.	n.a.	n.a.
LUX	n.a.	n.a.	n.a.
MLT	n.a.	n.a.	n.a.
NLD	University degree and Higher vocational	Intermediate vocational plus advanced education and Low intermediate	No formal qualifications (Basis onderwijs)
POL	Doctor and master's degree, bachelor degree or any other degree of equal status	Post secondary, vocational secondary and basic secondary levels	At most lower secondary education (ISCED groups 0-2 & 3c programmes shorter than 3 years)
PRT	n.a.	n.a.	n.a.
SVK	PhD, master's and bachelors degree	Higher professional education, secondary general, vocational and specialised education with and without matura, persons without information on educational attainment level	Basic education
SVN	University & non-university colleges	Vocational secondary school degrees 2-5, vocational school for highly skilled workers and other secondary schools	Vocational secondary school degrees 1, primary school, 1 to 7 primary school grades and no schooling
SWE	Postgraduates and Undergraduates	Higher and intermediate vocational	Intermediate education and No formal qualifications
USA NAICS	n.a.	n.a.	n.a.
USA SIC	College graduate and above	High school and some years of college (but not completed)	Less then high school and some years of high school (but not completed)

Table 5.4 Sources used for employment and wages by type

	Source used for division of employment by type	Source used for division of labour compensation by type
AUT	Microcensus data for the period 1980-2003 and individual Census of Population data for the year 1991 and 2001	Microcensus data for the period 1997. Time series are drawn from the wage and salary statistics.
BEL	Unpublished social security data for the period 1997-2004, published Ministry of Labour data and LFS data used before 1997	Unpublished social security for split by gender and age class. Micro-data from Structure of Earnings Survey and LFS for distribution by skill level
CYP	n.a.	n.a.
CZE	Eurostat Labour force survey data, 2nd quarter of each year	Structural Earnings Survey
DEW	Social security data and the German socio-economic panel, supplemented with information on employment by gender and occupation from the Statistiches Jahrbuch. Combined data with ILO occupation data.	Social security data and the German socio-economic panel, supplemented with information on employment by gender and occupation from the Statistiches Jahrbuch. Combined data with ILO occupation data.
DNK	Administrative data from 1980-2003	Administrative data from 1980-2003
ESP	Labour Force Survey	Wage Structure Survey
EST	n.a.	n.a.
FIN	Data from Statistics Finland's longitudinal census	Data from Statistics Finland's longitudinal census
FRA	Labour force surveys: 1982-1989, 1990-2002, 2003, 2004	Labour force surveys: 1982-1989, 1990-2002, 2003, 2004
GBR	Labour Force Survey 1979-2004 and General Household Survey 1974-80	Labour Force Survey 1993-2004 and General Household Survey 1972-1993/94.
GER	Income survey, social security data, and the Socio-Economic Panel Study, supplemented with micro data	Income survey, social security data, and the Socio-Economic Panel Study, supplemented with micro data
GRC	n.a.	n.a.
HUN	Eurostat Labour force survey data, 2nd quarter of each year	Structural Earnings Survey
IRL	n.a.	n.a.
ITA	Census of population of 1971, 1981, 1991, and 2001	microdata of the Bank of Italy surveys on households income, 1977-2004
JAP	Monthly Labour Survey, supplemented with General Survey on Working Conditions, Basic Survey on Wage Structure and Employment Status Survey	Monthly Labour Survey, supplemented with General Survey on Working Conditions, Basic Survey on Wage Structure and Employment Status Survey
LVA	n.a.	n.a.
LTU	n.a.	n.a.
LUX	n.a.	n.a.
MLT	n.a.	n.a.
NLD	System of Labour Accounts, Labour Force Sample Survey (LFSS) and Labour Force Survey (LFS)	Micro data for the years 1979, 1985, 1989, 1996, 1997, and 2002 from Wage Structure Inquiry, for 1992–2002 from the Inquiry of Work Conditions of the Ministry of Social Affairs and Employment.
POL	Eurostat Labour force survey data, 2nd quarter of each year	Structural Earnings Survey
PRT	n.a.	n.a.
SVK	Eurostat Labour force survey data, 2nd quarter of each year	Structural Earnings Survey
SVN	Eurostat Labour force survey data, 2nd quarter of each year	Structural Earnings Survey

SWE	Statistics Sweden, employment at A60 level with split ups for age, gender and skill levels for the period 1993-2004	Statistics Sweden, income levels for employment split-ups
USA NAICS	n.a.	n.a.
USA SIC	Census of Population, the Current Population Survey	Census of Population, the Current Population Survey

6. Capital Accounts

This section outlines details of the methods employed to estimate capital services by industry. It begins with an overview of the theoretical method drawing from the analysis developed by Dale Jorgenson and associates (as developed by Jorgenson and Griliches 1967, and outlined in Jorgenson, Gollop and Fraumeni, (JGF), 1987, Chapter 4). It then considers specific empirical issues and issues to do with data availability.

6.1 Methodology

For the measurement of capital services we need capital stock estimates for detailed assets and the shares of capital remuneration in total output value.

Construction of capital stock estimates for all asset types.

The most commonly employed approach in capital stock measurement is the Perpetual Inventory Method (PIM). In the PIM, capital stock (A) is defined as a weighted sum of past investments with weights given by the relative efficiencies of capital goods at different ages according to (industry subscripts are suppressed for convenience).

$$(1) \qquad A_{k,t} = \sum_{\tau=0}^{\infty} \theta_{k,\tau} I_{k,t-\tau}$$

with $A_{k,t}$ the capital stock for a particular asset type k at time t, $\theta_{k,\tau}$ the efficiency of a capital good of age t relative to the efficiency of a new capital good and $I_{k,t-\tau}$ the investment in period t-τ. An important implicit assumption here is that the services by assets of different vintages are perfect substitutes for each other (see JGF 1987, pp.40-49 for discussion). Implementing equation (1) requires specifying for each asset type a particular pattern of age-efficiency. On mainly practical grounds we apply the geometric pattern. The geometric pattern implies that a given vintage of investment loses a fixed percentage of its productive capacity each year. Hence with a given constant rate of depreciation δ, different for each asset type, $\theta_t = (1-\delta)^t$ and it follows that the capital stock of a particular asset k at time t, $A_{k,t}$, is given by

$$(2) \qquad A_{k,t} = \sum_{\tau=0}^{\infty} (1-\delta_k)^{\tau} I_{k,t-\tau} = (1-\delta_k) A_{k,t-1} + I_{k,t}$$

Aggregation over asset types

For the aggregation of capital services over the different asset types it is assumed that aggregate services are a translog function of the services of individual assets. It is further assumed that the flow of capital services for each asset type is proportional to its stock, independent of time. Hence the corresponding index of capital input K is a translog quantity index of individual assets in a particular industry given by

$$(3) \qquad \Delta \ln K_t = \sum_k \bar{v}_{k,t} \Delta \ln A_{k,t}$$

where weights are given by the average shares of each component in the value of capital compensation $\bar{v}_{k.t} = \frac{1}{2}[v_{k,t} + v_{k,t-1}]$ and $v_{kt} = (\sum_k p_{kt}^K A_{kt})^{-1} p_{kt}^K A_{kt}$ with p_{kt}^K the price of capital services from asset type k. In this way, aggregation takes into account the widely different marginal products from the heterogeneous stock of assets. Rental prices, or user-cost of capital, can be estimated using the standard approach grounded in the arbitrage equation derived from neo-classical theory of investment, introduced by Jorgenson (1963) and Jorgenson and Griliches (1967). In equilibrium, an investor is indifferent between two alternatives: buying a unit of capital at investment price p_{kt}^I, collecting a rental fee and then selling the depreciated asset for $(1-\delta_k)p_{k,t+1}^I$ in the next period, or earning a nominal rate of return, i_t , on a different investment opportunity. In the absence of taxation the equilibrium condition can be rearranged, yielding the familiar cost-of-capital equation:

$$(4a) \qquad p_{k,t}^K = p_{k,t-1}^I i_t + \delta_k p_{k,t}^I - [p_{k,t}^I - p_{k,t-1}^I]$$

This formula shows that the rental fee is determined by the nominal rate of return, the rate of economic depreciation and the asset specific capital gains. Or rewritten

$$(4b) \qquad p_{k,t}^K = r_{k,t} p_{k,t-1}^I + \delta_k p_{k,t}^I$$

with r the real rate of return, defined as the nominal rate of return adjusted for asset-specific capital gains. The asset revaluation term can be derived from the investment price indices. The rate of depreciation is identical to the rate used in the construction of the capital stock estimates in (2) as in the case of geometric depreciation, the age-price and age-efficiency profile follow the same geometric pattern.

Rate of return

The nominal rate of return can be estimated in two different ways.[10] The first is to use the opportunity, or ex-ante, approach, which is based on some exogenous value for the rate of return, for example interest rates on government bonds. The second approach is the residual, or ex-post approach, which estimates the internal rate of return as a residual given the value of capital compensation from the national accounts, depreciation and the capital gains. The attractive property of the latter approach is that it ensures complete consistency between income and production accounts. Hence an ex post approach is employed in this database (but see discussion below). It is assumed that the total value of capital services for each industry equals its compensation for all assets. This procedure yields an internal rate of return that exhausts capital income and is consistent with constant returns to scale. This nominal rate of return is the same for all assets in an industry, but is allowed to vary across industries. It is derived as a residual as follows:

[10] See Schreyer (2001) for a discussion of these alternatives.

$$(5) \qquad i_{j,t} = \frac{p^K_{j,t} K_{j,t} + \sum_k [p^I_{k,j,t} - p^I_{k,j,t-1}] A_{k,j,t} - \sum_k p^I_{k,j,t} \delta_k A_{k,j,t}}{\sum_k p^I_{k,j,t-1} A_{k,j,t}}$$

where the first term $p^K_{j,t} K_{j,t}$ is the capital compensation in industry j, which under constant returns to scale can be derived as value added minus the compensation of labour (see discussion below).

6.2 Practical implementation

In Table 6.1, the variables of the capital accounts in the EU KLEMS database are given. In this section we discuss three major implementation issues in the measurement of capital service inputs: the asset types which are distinguished, the rate of depreciation used and the treatment of negative capital service prices.

Table 6.1 Variables of the capital accounts

CAP_QI	Capital services, volume indices, 1995 = 100
CAPIT	ICT capital compensation (share in total capital compensation)
CAPNIT	Non-ICT capital compensation (share in total capital compensation)
CAPIT_QI	ICT capital services, volume indices, 1995 = 100
CAPNIT_QI	Non-ICT capital services, volume indices, 1995 = 100
CAPIT_QPH	ICT capital services per hour worked, 1995 reference
CAPNIT_QPH	Non-ICT capital services per hour worked, 1995 reference

Asset types

Ideally we would like to divide capital inputs into a large number of distinct asset types as is available for example in the National Income and Product Accounts produced by the US Bureau of Economic Analysis (BEA). While some European countries have detailed capital formation matrices, most provide only a limited amount of asset detail. Therefore, a minimum level of asset type detail was defined to which all country databases more or less adhere (see sources for country specificities). This minimum list includes nine asset types (see table 6.2) of which three assets are ICT assets: Computing equipment, Communications equipment and Software.

Note that we only include fixed reproducible assets. To have a complete capital accounts, however, land and inventories should also be taken into consideration, as capital compensation in the national accounts includes the user costs of these items as well. Measures of changes in land use and inventory quantities at the industry level is mostly non-existent in many European countries and hence had to be excluded. One might argue changes in inventories are short-term cycles without trends over longer periods of time, so their exclusion will not bias the growth accounting results.[11] For land, this is probably not true. Although one might argue that at the total economy level the amount of land used does not change much, at the industry level this assumption will be untenable. Moreover, exclusion of

[11] Although there is some evidence that inventories got smaller, thanks to ICT supported storage and ordering.

land might impact the estimates of rates of return (see below). However, given the current data availability at the industry level, this issue will not be resolved in the near future.

Table 6.2 List of asset types in EU KLEMS database

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

Depreciation patterns

In this database we use a harmonised approach to capital measurement and use one set of asset depreciation rates for all countries. These depreciation rates differ by asset type and industry, but not over country and also not over time. They are based on the industry by asset type depreciation rates from the BEA as described in Fraumeni (1997). The advantage of using the BEA rates is that these are based on empirical research (albeit for many assets rather outdated), rather than ad-hoc assumptions based on e.g. tax laws, see Statistical Commission and Economic Commission for Europe (2004). The BEA rates have much more asset detail than the investment series for most European countries. Therefore, we needed to aggregate the rates over BEA assets to arrive at a set of rates for the 11 euk assets. To achieve this we calculated an implicit aggregate geometric depreciation rate for each year based on capital stocks for each separate asset type available from the BEA data. Suppose within each euk asset category, k , there exist r types of assets in the BEA data set. For example BEA data are available for 23 non-residential structure types (industrial building, office buildings, electric lights and power, etc), each with separate depreciation rates. Using the geometric formula given above we calculated:

$$A^k_{r,t} = (1-\delta_r)A^k_{r,t-1} + I^k_{r,t} \qquad (6)$$

Summing across asset types gives an estimate of the aggregate capital stock at t:

$$A_t^k = \sum_r A_{r,t}^k \quad (7)$$

Define aggregate investment at t by $I_t^k = \sum_r I_{r,t}^k$. At each time period t we calculated the implied depreciation rate for aggregate asset k as:

$$\delta_{k,t} = \frac{A_{t-1}^k + I_t^k - A_t^k}{A_{t-1}^k} \quad (8)$$

The above formula was calculated for each industry j and applied to three asset subgroups: non-residential structures, non-ICT equipment and transport equipment. Note this method yields implicit depreciation rates that vary through time, even though the depreciation rate for each sub-category, r, is assumed constant. This formula captures differences in the composition of investment across industries. Since we are applying these US rates to all countries, we do not want to impose the condition that the time profile of the asset composition is the same across countries. Therefore we took the average of the depreciation rates for the period 1980-2000. Deprecation rates were those given in Fraumeni (1997), except for automobiles which was set equal to 0.272 – the geometric rate used by JHS.[12] Depreciation rates for non-ICT assets by industry are shown in Appendix Table 1.

Table 6.3 provides the minimum and maximum rates over all industries in EU KLEMS. The rates for other machinery, transport equipment and non-residential buildings differ by industry, as explained above. The rates for the other asset types are the same for all industries. The rate for residential structures is set to 0.0114, the rate for 1-to-4-unit homes from the BEA. The three ICT assets, computers, software and communications equipment were also assumed to have the same depreciation rate for all industries. These were set equal to the rates employed in JHS, i.e. 0.315 for computers and software and 0.115 for communications equipment. The rate for other immaterial assets was set equal to software, infrastructure to non-residential buildings, and products of agriculture and other products to other machinery and equipment. The depreciation rates in Appendix Table 1 were applied to all countries (see discussion below).

Table 6.3 Geometric depreciation rates used in EU KLEMS, minimum and maximum over industries

Euk asset type	Minimum over industries	Maximum over industries
Residential structures	0.011	0.011
Non-residential structures	0.023	0.069
Infrastructure	0.023	0.069
Transport equipment	0.061	0.246
Computing equipment	0.315	0.315
Communications equipment	0.115	0.115
Other machinery and equipment	0.073	0.164
Products of agriculture and forestry	0.073	0.164
Other products	0.073	0.164
Software	0.315	0.315
Other intangibles	0.315	0.315

Note: for rates by industry, see Appendix Table 1.

[12] BEA does not use a geometric rate for this asset type.

Negative capital service prices

As specified above our preference is to use an internal (ex post) rate of return. This is justified if the following assumptions hold: 1. markets are perfectly competitive, 2. the nominal rate of return is the same for all assets in an industry, 3. the sum of rental payments for all assets is equal to total property compensation. Using these assumptions and data on property compensation for each industry, in theory the rate of return in each industry can be determined according to (5). In turn, this rate is used to calculate the capital service price as in (4). In practice, the implied capital service prices can be negative. Negative rental prices are not necessarily theoretically inconsistent (see e.g. Berndt and Fuss 1986) but can also be an indication of empirical problems in the estimation of labour and capital compensation shares (see below), or in the investment deflator. Most negative rental rates are caused by large swings in investment deflators, for example in non-residential buildings. Others are due to very low, or even negative capital compensation, related to negative value added, or over-adjustment of the labour compensation of self-employed people, e.g. in agriculture.

Negative capital prices breakdown our aggregation framework and therefore need to be dealt with in an ad-hoc procedure. In the EU KLEMS database, we use a simple heuristic rule and constrain the rental price to be non-negative, setting it to zero in case where it is negative. This constraint appeared to be binding for some industries and countries, especially in the 1980s and further experimentation is needed, involving alternative deflators based on smoothing, better estimates of the capital compensation share in value added, and alternative rates of return (see below). It is to be expected that as a result the estimates of capital service growth and MFP will be changed significantly for some industries, notably industries with a large share of self-employed workers, a large share of structures in the capital stock and with small or negative value added.

Negative capital stocks

In some rare cases the capital stock became negative due to negative investments. In those cases, the capital stock was set at 0.

Inconsistent volume and nominal GFCF series

In some rare cases nominal and volume GFCF were inconsistent, that is, the differed in sign. In those cases both were set at zero.

End-of-year stock

In the current database we assume that all investment in year t takes place at the beginning of the year. Alternatively, one can assume that investment is spread throughout the year and the flow of capital services is proportional to the average of the stock available at the end of the current and the prior period, as in JHS (2005).

IT deflators

A key assumption in the capital services approach outlined above is the measurement of investment in constant-quality efficiency units. Only under this assumption, different vintages of each asset can be treated as perfect substitutes in production. This requires constant-quality price indices for each asset type, in particular those which are subject to rapid technological change and improvements in quality, such as IT assets. Generally there is support for the adoption of hedonic, or high-frequency matched model, deflators for ICT output and investment. However, there is still some discussion as to how these should be calculated (Triplett, 2004). The BEA was one of the first to adopt hedonics for computers, and recently more NSIs have adopted this approach. Others base their national deflators on the US hedonics, adjusting for international price or exchange rate movements. Only a few NSIs still use IT deflators which are clearly not adjusted for quality. We follow previous comparative studies such as Colecchia and Schreyer (2001), Timmer and van Ark (2005) and Inklaar, O'Mahony and Timmer (2005) and use the harmonisation procedure introduced by Schreyer (2002) for those countries for which IT deflators are clearly not adjusted for quality.[13] This is given for each country in Table 6.4.

CAPIT, CAPNIT, CAPIT_QPH and CAPNIT_QPH

CAPIT and CAPNIT indicate the share of ICT and non-ICT assets in total asset compensation. These shares are based on capital compensation including imputation for negative rentals, which have been discussed above. CAPIT_QPH indicates ICT capital services per hour worked. It is defined as

$$\text{CAPIT\_QPH} = \frac{\text{CAP} * \text{CAPIT} * (\text{CAPIT\_QI}/100)}{H\_EMP}$$

and similarly for non-ICT.

6.3 Outstanding issues

In this section we discuss various issues which require further attention and might improve further construction of the capital accounts.

Definition of IT, CT and software

The definition of IT and CT assets have not been completely harmonised to date. In some countries IT has been defined broadly as office and computing equipment (CPA 30), whereas others have used the more narrowly defined category CPA 3002 computers only. Similarly, CT investment in some countries is defined as investment in all products under CPA 32 (synonymous with electrical components and radio/television transmitters/receivers, product numbers 3210, 3220 and 3230) while others also included 3130 Insulated wire and cable, 3312 Instruments and appliances for measuring, checking testing, navigating a other purposes, except industrial process equipment and 3313 Industrial process control equipment, as this is the broader definition of CT assets as suggested by OECD (2001c). However, although further harmonisation is needed, this seems hard to achieve without detailed investment by product data.

More importantly, it is also clear that there remains much to be done before software statistics can said to be truly comparable. Much has been achieved in the last years, but serious differences in

[13] NB We only harmonise the investment series for IT, but not the IT output series as the composition of IT output varies highly across countries, and this cannot be taken into account.

definitions still remain (Aspden 2004). An important issue is the estimation of own-account software and improving this should have a high priority.

Estimates of gross fixed capital formation in IT and CT

For some countries, IT and CT GFCF by industry are available from the National Accounts. However, for many other countries, IT and CT had to be estimated and split off from Machinery in general. The methods used to do this, vary considerably across countries. While some are based on survey evidence, others use proportions from recent years, from the BEA or from other countries. In Table 6.4 a brief overview is given. For full details, see PART 2 Sources by country.

Definition of gross fixed capital formation (GFCF)

According to the ESA 95, GFCF consists of new investments and net sales of second-hand assets. As such, GFCF can be negative. In some countries, such as Germany, GFCF also includes *other volume changes*. These include cases of premature scrapping and industry changes of companies. The treatment of other volume changes is unclear for most other countries.

Benchmark capital stock

Ideally one needs investment series going back in time infinitely. In practice one can truncate after a certain period since declining efficiency older vintages will only marginally add to the capital service flow. Alternatively, one might apply the PIM to a benchmark estimate of the productive capital stock. For some countries, investment series go back to the 1940s or earlier. For other countries we had a benchmark stock to start with, e.g. in the 1950s, 1970s or 1990s. Ideally, these stocks should be estimates of the productive capital stock, estimated in the same way as outlined above. This is not always met in practice, as the reported stock might be based on a wealth survey, or short-cut investment series. In addition, the stock estimate might be based on the gross concept, or net concept, using some different depreciation functions than the geometric one used in EU KLEMS. This is described in column 1 of Table 6.4. Further research into the assumptions underlying the benchmark stocks are needed and sensitivity of the results to alternative estimates checked.

Depreciation rates

The geometric depreciation rates in Table 6.3 and Appendix Table 1 were applied to all countries. The method assumes both that depreciation rates for specific assets are constant across countries, equal to those in the US, and that the asset capital composition within industries, averaged across time, also does not vary across countries. Both assumptions are unlikely to be met in practice. However it is difficult to devise a workable alternative since there is very little reliable information on industry depreciation rates outside the US. A notable exception are the depreciation rates provided by Statistics Netherlands which are based on capital discard surveys (see Van den Bergen et al., 2005). This might be experimented with.

Also, one can argue that the harmonised depreciation rates do not take into account country specific events such as premature scrapping and changes of industry ownership. For some industries (e.g. mining, utilities, communication) and countries (especially those with rapid structural changes such as in Eastern Europe) these shifts can be sizeable and will not be picked up by the harmonised depreciation rates. One might attempt to use information on consumption of fixed capital from the national accounts to derive a rough estimate of the size of these industry movements and scrapping.

Table 6.4 Sources used for capital stock estimation

	Benchmark stock year	IT and CT investment	ICT deflator	Remarks
AUT	1976 Net stock	Before 1994 using BEA asset proportions	Harmonised BEA for IT/CT	
BEL	GFCF back to 1853	Before 1995 asset shares constant	Harmonised BEA for IT/CT	Software before 1994 based on 1995 industry shares
CYP	n.a.	n.a.	n.a.	n.a.
CZE	1995 net stock	Estimated on rough GFCF	Harmonised BEA for IT	
DEW	1970 net stock	Estimated based on survey	National	
DNK	1970 net stock	Available from Nat Acc	Harmonised BEA for IT	
ESP	1964 stock	CT and soft estimated by commodity-flow	Harmonised BEA for IT/CT	Industries 50-52/K/60-64 estimated by higher aggregates
EST	n.a.	n.a.	n.a.	n.a.
FIN	1970 stock broken down using GFCF	using BEA asset proportions	Harmonised BEA for IT/CT	
FRA	GFCF back to 1846	Available from Nat Acc	National	
GBR	1948 stock	IT/CT based on survey	National	Industries 50-52/K/60-64 estimated by higher aggregates
GER	1991 net stock	IT/CT based on survey	National	
GRC	n.a.	n.a.	n.a.	n.a.
HUN	2000 net stock	Based on NA stock estimates	Harmonised BEA for IT	CT ratio based on other countries
IRL				
ITA	1952 stock	Available from Nat Acc	Harmonised BEA for IT	Industries 50-52/K/60-64 estimated by higher aggregates
JAP	1955 wealth stock	Available from IO-tables, intrapolated inbetween	National	
LVA	n.a.	n.a.	n.a.	n.a.
LTU	n.a.	n.a.	n.a.	n.a.
LUX	GFCF start in 1948	Available from Nat Acc	National	
MLT	n.a.	n.a.	n.a.	n.a.
NLD	1952 net stock	CT estimated	National	
POL	1995 gross stock	n.a.	n.a.	
PRT	n.a.	n.a.	n.a.	n.a.
SVK	n.a.	n.a.	n.a.	n.a.
SVN	1999 gross stock	Available from Nat Acc	National	Before 1999 industry investment shares used
SWE	1993 net stock	Available from Nat Acc	National	
USA NAICS	GFCF start in 1901	Available from Nat Acc	National	
USA SIC	GFCF start in 1901	Available from Nat Acc	National	After 2000 growth rates based on NAICS

Source: see Sources document for detailed descriptions of methodologies used

Capital taxes

Ideally taxes should be included to account for differences in tax treatment of the different asset types and different legal forms (household, corporate and non-corporate). The capital service price formulas above should then be adjusted to take these tax rates into account (see Jorgenson and Yun 1991). However this refinement would require data on capital tax allowances and rates by country, industry and year which is beyond the scope of this database. Available evidence for major European countries shows that the inclusion of tax rates has only a very minor effect on growth rates of capital services and MFP (Erumban 2005).

Capital compensation by industry

Labour compensation of self-employed is not registered in the National Accounts. We make an imputation by assuming that the compensation per hour of self-employed is equal to the compensation per hour of employees. This assumption is made at the industry level and can be crude for some industries if earnings of self-employed and employees vary widely. As a result, labour compensation is sometimes higher than value added, such that capital compensation, which is defined as the residual, becomes negative. Alternatively, the capital part of mixed income can also be estimated independently if one is able to compile capital services cross-classified by industry branches and institutional sectors. Results for the Netherlands show that in several cases these independent estimates for labour and capital income together are substantially larger than mixed income, even when the lowest rates of return are assumed, and for longer ranges of years. These outcomes seem therefore implausible (de Haan et al. 2005, see also Bonde and Sjerbo for an attempt for Denmark). Alternatively, one might constrain the imputation for self-employed to a maximum, given by mixed income. This was only feasible for Belgium as mixed income by industry is not available for other countries.

Alternative rate of return estimates

Recently, the discussion about the measurement of capital service prices has been revived by the proposal to include capital services into the next revision of the National Accounts (Schreyer, Diewert and Harrison 2005). We follow the ex-post approach as advocated by Jorgenson and associates. However, there are reasons to opt for an ex-ante measure instead (Schreyer 2004). All agree on the fact that the ex post measure is the preferred measure *in principle*, and also agree on the fact that the ex post measure *in practice* (which is based on the gross operating surplus from the national accounts) is a rough proxy of the true measure. But whereas the former group argues that it is the best there is, the latter maintain that a different proxy is needed. It needs to be stressed that both alternatives are proxies for the true expost measure.

The main weaknesses of the measures based on GOS (called ex post) are the following:

1. GOS includes compensation for all assets, including ones not covered in the SNA. Therefore the ex post rate will be overestimated,
2. it is based on strong assumptions, such as equalisation of rates of return across all assets,
3. endogenous rates of return are volatile and can lead to negative rental prices.

In contrast, the measure based on exogenous information (called ex ante) is much less volatile and does not need identifying assumptions. Main problem however is what to take as the exogenous rate of return, for which one needs to find information outside the SNA. The discussion is largely methodological, as studies show that in practice, the choice for the ex ante or ex post measure does not make a big difference: growth rates of capital services appear to be almost similar for both methods, both at the aggregate economy and the industry level (Baldwin et al 2005, Schreyer 2004, Erumban 2004, Oulton 2005). However, this is not necessarily the case when calculating the contribution of capital to output growth. Most studies show that in contrast to capital service input growth, estimates for MFP growth can be rather different, depending on whether expost or ex ante measures are used. Baldwin et al. (2005) show growth rates of MFP for Canada, 1961-1981 annually 1.0% for ex post while 1.5% for exante (Table 3), see also Schreyer (2004).

Most authors suggest that the choice for the ex ante or expost measure in the calculation of capital service input already determines the measure to be taken in the calculation of contributions of capital input to output growth. However, Oulton (2005) argues that favouring ex ante in the capital service input measures does not automatically imply ex ante measures in output growth accounting. The reasons to favour one measure above the other might be different. In particular, two of the disadvantages of the ex post measure in the aggregation of capital assets into capital service flow do not hold any more when trying to find suitable weights for aggregate capital service input in the growth process (2. and 3.). The weight (GOS by industry) can be readily observed from the SNA. This hybrid methodology suggests that ex ante measures are used to construct the index of capital services, while the growth of this index should be weighted by the actual (ex post) share in compensation as measured by the observed share of profits in output, when the contribution of capital to output is being measured. This has also been the approach used by Erumban (2004). In the next phase of this project, experimentation will take place with different rate of return measures to investigate the sensitivity of the results.

Ownership vs. use

A widely acknowledged problem is the recording of operational leases of assets. The SNA accounts for assets on the basis of ownership. As a result, capital services from assets under operational lease are recorded as intermediate consumption by the using industry. From a productivity perspective, it might be more informative to classify assets by industry of use, rather than ownership. It is unclear how countries deal with this distinction and more information is needed.

An interesting new alternative is proposed by de Haan et al (2005), who suggest to treat leasing companies like distributive traders. The production value of lease companies should with regard to operational leases only include the margin and not the full capital service provided. This margin reflects a reward for providing capital services under certain, usually more pleasant or flexible conditions from the perspective of the user, compared to owning these assets. This would require changes in both the SUTs and capital accounts.

Deflation of CT and software

In addition to IT, there is also good reason to search for alternative deflators for other ICT products such as CT and software. Various studies have shown that the deflators for communication equipment and software do not adequately capture quality improvements (Doms 2005, Abel, Berndt and White 2003) and further research is needed.

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.

7. Productivity Accounts

7.1 Methodology

In Table 7.1, the variables resulting from the growth accounting exercises are given. Growth accounts following the methodology outlined in section 3 have been performed for gross value added and for gross output. In the case of gross output, growth is decomposed into the contribution of intermediate inputs, labour and capital services as follows

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

with $\bar{v}_{jt}^{X}$ indicating the share of intermediate inputs in total gross output, averaged over two years and $\Delta \ln X_{jt}$ the growth rate of intermediate inputs. Similarly for labour and capital. In addition, the contribution of intermediate inputs is split into the contributions

$$GOconIIE = \bar{v}_{jt}^{XE} \Delta \ln X_{jt}^{E}$$
$$GOconIIM = \bar{v}_{jt}^{XM} \Delta \ln X_{jt}^{M}$$
$$GOconIIS = \bar{v}_{jt}^{XS} \Delta \ln X_{jt}^{S}$$

$\bar{v}_{jt}^{XE}$ the share of energy in gross output and $\Delta \ln X_{jt}^{E}$ its growth rate, similarly for services and materials.

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

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

with $\overline{w}_{jt}^{K}$ indicating the share of capital in value added, and similarly for labour. In the case of value added, the contribution of capital services to value added growth have been split into the contribution of ICT-capital and non-ICT capital. The contribution of labour services was split into the contribution of hours worked, and the contribution of changes in the labour composition.

$$VAconKIT = \overline{w}_{jt}^{KIT} \Delta \ln KIT_{jt}$$

$$VAconKNIT = \overline{w}_{jt}^{KNIT} \Delta \ln KNIT_{jt}$$

$$VAconH = \overline{w}_{jt}^{L} \Delta \ln H_{jt}$$

$$VAconLC = \overline{w}_{jt}^{L} (\Delta \ln L_{jt} - \Delta \ln H_{jt})$$

with $\overline{w}_{jt}^{KIT}$ indicating the share of ICT-capital in value added, and similarly for non-ICT.

Table 7.1 Variables resulting from growth accounting

VA_Q	Growth rate of value added volume (% per year)
VAConL	Contribution of labour services to value added growth (percentage points)
VAConH	Contribution of hours worked to value added growth (percentage points)
VAConLC	Contribution of labour composition change to value added growth (percentage points)
VAConKIT	Contribution of ICT capital services to output growth (percentage points)
VAConKNIT	Contribution of non-ICT capital services to output 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)
GOConIIM	Contribution of intermediate energy inputs to output growth (percentage points)
GOConIIE	Contribution of intermediate material inputs to output growth (percentage points)
GOConIIS	Contribution of intermediate services inputs to output growth (percentage points)
GOConL	Contribution of labour services 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

7.2 Practical implementation

Growth accounting decompositions and levels of aggregation

Gross output decompositions are most meaningful at the lowest level of aggregation, viz. firms. As soon as gross output of aggregates are decomposed, one runs into problems of comparability over time and across countries, depending on differences in vertical integration of firms. Ideally, decomposing gross output should be done on a sectoral output measure which excludes intra-sectoral deliveries of intermediates (see e.g. Gullickson and Harper 1999 and more recently Corrado et al., 2006). Measures of sectoral output require detailed symmetric domestic input-output tables, which are not available on a sufficiently large scale for all European countries. Therefore, we present gross output decompositions only at the lowest possible industry level, depending on the level of detail of output and inputs, and do not show any higher aggregates. This issue needs to be readdressed in experimental extensions of the current database, exploiting the availability of these tables for a limited set of countries and years.

Instead, we also present the decomposition of value added growth, which is insensitive to the intra-industry delivery problem. These decomposition results are shown for all aggregation levels, up to total economy. For all of our aggregations of outputs and inputs over industries we use the Tornqvist quantity index, which is a discrete time approximation to a Divisia index. This is akin to the "direct aggregation across industries" approach as developed by Jorgenson, Gollop and Fraumeni (1987, chapter 2) and is based on the assumption of existing value added functions for each industry, but does not impose cross-industry restrictions on either value-added or inputs. Other aggregation procedures might be tried in experimental extensions of the current database, see e.g. Aulin-Ahmavaara, Pirkko, and Perttu Pakarinen (2005).

Negative capital compensation and missing TFP

In case total capital compensation is negative, the weights given to capital growth will be negative. In some of these cases (e.g. negative compensation in first year of the series, or the base year 1995) MFP growth cannot be calculated.

Logarithmic growth rates

All growth rates are measured in natural logarithms.

7.3 Outstanding issues

Input shares

The input weights for production factors labour and capital should reflect the marginal cost of labour and capital usage respectively. 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 of employees (variable COMP in the database) plus operating surplus/mixed income (variable GOS) plus other taxes on production (variable TXSP): $P_j^V V_j = LC_j^E + OS_j + T_j^O$. Operating surplus should be divided into compensation for self-employed (LC_j^S), which is part of labour compensation, and the rest which should be allocated to capital compensation. Similarly other taxes on production should be allocated to capital and labour inputs: ($T_j^O = T_j^K + T_j^L$). So, total labour costs (variable LAB in the database) and capital costs (CAP) are defined as follows:

$$LAB = P_j^L L_j = T_j^L + LC_j^E + LC_j^S \qquad (13)$$
$$CAP = P_j^K K_j = T_j^K + OS_j - LC_j^S$$

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, that is $T_j^O = T_j^K$

Labour compensation of self-employed is not registered in the National Accounts. We make an imputation by assuming that the compensation per hour of self-employed is equal to the compensation per hour of employees. This assumption is made at the industry level and can be crude for some industries where characteristics of self-employed and employees vary widely. Preliminary research on the basis of data for the U.S. indicates that the hourly compensation for self-employed in industries like agriculture should be less than one and closer to 0.8, but in industries like trade 1.0 seems to be reasonable. In contrast, self-employed in business services seem to earn even more than employees, and a higher ratio is suggested. Further research for European countries should establish how plausible this assumption is in practice by using of survey estimates of the earnings for self-employed. Ideally, one should constrain the imputation for self-employed to the mixed income component of the gross operating surplus. However, data limitations did not allow us to do so.[14]

Non-constant returns to scale

The assumption of constant returns to scale 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, Schreyer 2004, Balk 1998). These alternative might be tried in experimental extensions of the current database.

Health warnings for some productivity measures at industry level

In the EU KLEMS database multi-factor productivity measures are given for all industries covering the total economy. However, the user should be aware of particular limitations concerning the interpretation of the results of some industries. In particular one should keep in mind the following:

- Land and natural resources assets are not taken into account. MFP measures for industries like agriculture (AtB) and mining (C) should be interpreted from this perspective. In addition, capital compensation in these industries is frequently negative, indicating that capital assets do not contribute to growth which is unlikely over long periods of time.
- Public infrastructure is not allocated to the using industries. This is an important asset in the transport industries (60-63) and hence MFP growth in this industry includes the contribution of infrastructure to output growth.
- Countries differ in the measurement of government output. In some countries this is measured by wages only. Others also impute capital compensation, either with or without a net rate of

[14] Only in the case of Belgium this restriction has been applied.

return. Still others employ quantity indicators to measure volume of output. Some countries make assumptions on improvements in labour productivity in the public sector, and hence the derived productivity measures in the database will simply be uncovering the assumptions made. Mas (2004) provides a discussion for the effects on growth accounting of these differences.[15] MFP measures for these industries (L, M and N) should be interpreted with care, if at all.

- A special item in the SNA is the imputation for owner occupied housing. This imputation is normally added to the output of renting activities of the real estate industry. From a productivity perspective, this is unfortunate. First, it introduces problems for international comparisons, because methods by which rents are imputed vary across countries. Second, this output is measured as input (services from owner occupied residential buildings) and hence productivity growth is zero by definition. Third, it is unclear to what extent the investment series in residential housing make a distinction between owner occupied and letting, and how these flows are recorded across industries and private households. Preferably, we would like to have a separate industry called "owner-occupied housing" whose output consists of the imputed rents and whose input consists solely of the services of owner occupied buildings. This requires a breakdown of residential building investment by sector (household sector vs. other). Unfortunately, very few countries were able to make a proper distinction and consequently imputed rents have been included in the real estate industry. Therefore, productivity comparisons of this industry (70), and aggregates including this industry, should be interpreted with caution.
- Output in industry Employed persons by households (P) should consist solely of labour compensation. Hence, productivity measures are meaningless. In practice, employment and output figures for this industry appear often to be constructed independently and measured productivity can differ significantly from 0.

[15] Labour productivity growth should be zero when wages are used as output measure, and MFP should be zero in case imputations are made for capital consumption (and these imputations are equal to the ones made in EU KLEMS).

8. Country aggregations

8.1 Methodology

Country groupings

Aggregate tables are provided for 4 institutional country groupings: EU-25 (all member states of the EU as of 1 May 2004), EU-15 (all member states of the EU as of 1 January 1995), EU-10 (all states which joined the EU on 1 May 2004) and Euro (all countries in the euro zone as of 1 January 2001). We also provide an aggregation for those countries for which there is long-run capital and labour composition data. This group is called EU-15ex. The members of each group are given in Table 8.1.

Table 8.1 Country aggregates

EU-25	EU-15	EU-10	Euro	EU-15ex
AUT	AUT	CYP	AUT	AUT
BEL	BEL	CZE	BEL	BEL
CYP	DNK	EST	ESP	DNK
CZE	ESP	HUN	FIN	ESP
DNK	FIN	LTU	FRA	FIN
ESP	FRA	LVA	GER	FRA
EST	GBR	MLT	GRC	GBR
FIN	GER	POL	IRL	GER
FRA	GRC	SVK	ITA	ITA
GBR	IRL	SVN	LUX	NLD
GER	ITA		NLD	
GRC	LUX		PRT	
HUN	NLD			
IRL	PRT			
ITA	SWE			
LTU				
LUX				
LVA				
MLT				
NLD				
POL				
PRT				
SVK				
SVN				
SWE				

Deflation

For each country in the database, nominal values are given in local currency, see Appendix Table 2. As some countries switched currency to the euro, fixed Euro conversion rates are used. This is also indicated in the table. To aggregate across countries use is made of so-called Purchasing Power Parities (PPPs). A PPP is defined as the ratio of the price of a product or a bundle of products between two countries, with prices expressed in each country's own currency. The relative price level is defined as the (average) price of one country relative to the (average) price of the other country, with prices expressed in a common currency. When countries have different currencies, the relative price level is obtained as the ratio of the PPP to the currency exchange rate. So the relative price level of a haircut in Poland compared to Germany is obtained by comparing the PPP of the haircut (for example, 30 Złoty in Poland to 15 euro in Germany) to the currency exchange rate (for example, 4 Złoty to one euro). The relative price level of Poland relative to Germany is then (30/15) / 4 = 50 per cent. When two countries have the same currency, for example, the euro, the relative price level can be directly derived from the PPP. For example, when the ex-factory price of a ton of flat steel of identical quality is 2,000 euro in Portugal against 2,500 euro in Germany, the Portuguese price level is 80 per cent of that in Germany. The PPPs used for regional aggregation in EU KLEMS are industry-specific and reflect differences in price levels across countries at a detailed industry level (see Timmer, Ypma and van Ark, 2006, for an extensive discussion). The PPPs are given for the benchmark year 1997 for all 25 countries and industry levels in a separate file on the EU KLEMS website, named 1997-PPPs_07I. The PPPs are only used for country aggregations as described below.

8.2 Practical implementation

Country aggregation of hours worked and number of workers is done by straightforward summation and does not need PPP conversion. However, all other country aggregates of nominals and volume measures are based on PPP converted values. Aggregation takes place first over countries at the detailed industry level as defined by the minimum lists, and only then aggregated over industries. Finally, all analytical manipulations such as labour productivity and growth accounting are done on the country-aggregated data.

Below we give an example of how nominal gross output for an industry is aggregated across a set of countries, followed by an example of aggregation of gross output volumes. The procedure for other nominals and volume measures such as value added, labour services and capital services is similar.

Aggregation of nominals

Industry-specific PPPs for gross output are available for all countries c and industries j for 1997 ($PPP_{c,j,1997}$). The base country for the PPPs is Germany.[16] PPPs have been back- and updated to cover the period 1970-2004, using gross output deflators (P^Y) for each country c relative to Germany (G) at a detailed industry level (as defined by the minimum list) as follows

$$PPP_{c,j,t} = \frac{P^Y_{c,j,t} / P^Y_{c,j,1997}}{P^Y_{G,j,t} / P^Y_{G,j,1997}} * PPP_{c,j,1997} \qquad (8.1)$$

[16] As the PPPs are based on a multilateral methodology, country aggregates will be insensitive to the choice of the benchmark country.

For aggregation of nominal gross output across a set of countries *c* (c ε EU), we convert gross output from national prices to German prices using the industry output PPPs derived in (8.1) and summed across all countries:

$$P^Y_{EU,j,t}Y_{EU,j,t} = \sum_c \frac{P^Y_{c,j,t}Y_{c,j,t}}{PPP_{c,j,t}} \qquad (8.2)$$

Industry aggregations of EU nominals are derived by simply summing the results from (8.2) across industries *j*

$$P^Y_{EU,t}Y_{EU,t} = \sum_j P^Y_{EU,j,t}Y_{EU,j,t} \qquad (8.3)$$

Aggregation of volumes

To derive volume measures for country aggregates, a Tornqvist procedure is used, analogous to aggregation across industries for individual countries as described in previous sections. The EU aggregated nominal values as derived in (8.2) are used to weight growth rates of gross output volumes in each country. First, shares of each country in EU nominal gross output are calculated for each industry *j* as:

$$v^Y_{c,j,t} = \frac{\left[\dfrac{P^Y_{c,j,t}Y_{c,j,t}}{PPP_{c,j,t}}\right]}{P^Y_{EU,j,t}Y_{EU,j,t}} \qquad (8.4)$$

Next, two-year average shares are calculated as:

$$\bar{v}^Y_{c,j,t} = \frac{1}{2}\left(v^Y_{c,j,t} + v^Y_{c,j,t-1}\right) \qquad (8.5)$$

The growth rate of the EU aggregate ($\Delta \ln Y_{EU,j,t}$) is calculated as a weighted average of country growth rates ($\Delta \ln Y_{c,j,t}$) as:

$$\Delta \ln Y_{EU,j,t} = \sum_c \bar{v}^Y_{c,j,t}\Delta \ln Y_{c,j,t} \qquad (8.6)$$

where country volume growth rates are in local currencies, which can be directly derived from the country files in the EU KLEMS database (variable *GO_Q*). Finally, industry aggregations of EU growth rates are derived as usual by

$$\Delta \ln Y_{EU,t} = \sum_j \bar{v}^Y_{EU,j,t}\Delta \ln Y_{EU,j,t} \qquad (8.7)$$

with $\bar{v}^Y_{EU,j,t}$ the two-period average share of industry j in aggregate EU nominal gross output.

8.3 Outstanding issues

PPPs for inputs

All nominal values are converted using PPPs for gross output. Ideally, separate PPPs for inputs (intermediate, capital and labour) should be used for inputs. These can be derived using input-output tables and information on relative wages and rental costs (see Inklaar and Timmer 2006). These measures will be available on an experimental basis in the second version of the database.

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Appendix tables

Appendix Table 1 Depreciation rates by industry

	OMach	TraEq	NRStruc		OMach	TraEq	NRStruc
TOT	0.126	0.189	0.031	**35**	0.106	0.167	0.033
AtB	0.129	0.170	0.024	**351**	0.106	0.167	0.033
A	0.129	0.170	0.024	**353**	0.106	0.167	0.033
1	0.129	0.170	0.024	**35x**	0.106	0.167	0.033
2	0.129	0.170	0.024	**36t37**	0.113	0.193	0.033
B	0.129	0.170	0.024	**36**	0.115	0.184	0.033
C	0.129	0.170	0.024	**37**	0.110	0.202	0.033
10t12	0.133	0.148	0.049	**E**	0.094	0.191	0.023
10	0.141	0.155	0.041	**40**	0.094	0.191	0.023
11	0.129	0.096	0.069	**40x**	0.073	0.194	0.023
12	0.130	0.192	0.039	**402**	0.115	0.189	0.024
13t14	0.130	0.192	0.039	**41**	0.115	0.201	0.024
13	0.130	0.192	0.039	**F**	0.139	0.195	0.034
14	0.130	0.192	0.039	**G**	0.133	0.216	0.030
D	0.108	0.172	0.033	**50**	0.121	0.229	0.031
15t16	0.109	0.168	0.033	**51**	0.143	0.204	0.031
15	0.108	0.192	0.033	**52**	0.137	0.215	0.027
16	0.109	0.144	0.032	**H**	0.140	0.203	0.028
17t19	0.109	0.184	0.033	**I**	0.107	0.146	0.027
17t18	0.109	0.184	0.033	**60t63**	0.118	0.092	0.028
17	0.105	0.165	0.033	**60**	0.116	0.129	0.025
18	0.114	0.183	0.034	**61**	0.125	0.061	0.026
19	0.108	0.205	0.032	**62**	0.133	0.111	0.025
20	0.109	0.183	0.032	**63**	0.096	0.066	0.036
21t22	0.106	0.173	0.033	**64**	0.096	0.201	0.027
21	0.099	0.153	0.033	**JtK**	0.147	0.189	0.040
22	0.113	0.192	0.034	**J**	0.149	0.187	0.044
221	0.113	0.192	0.034	**65**	0.138	0.138	0.037
22x	0.113	0.192	0.034	**66**	0.144	0.178	0.045
23t25	0.102	0.196	0.033	**67**	0.164	0.246	0.050
23	0.110	0.154	0.032	**K**	0.145	0.191	0.036
24	0.104	0.181	0.033	**70**	0.147	0.227	0.027
244	0.104	0.181	0.033	**70imp**	0.147	0.227	0.027
24x	0.104	0.181	0.033	**70x**	0.147	0.227	0.027
25	0.113	0.202	0.033	**71t74**	0.144	0.155	0.044
26	0.112	0.191	0.033	**71**	0.144	0.155	0.044
27t28	0.106	0.169	0.033	**72**	0.144	0.155	0.044
27	0.099	0.155	0.032	**73**	0.144	0.155	0.044
28	0.113	0.183	0.033	**74**	0.144	0.155	0.044
29	0.107	0.170	0.033	**741t4**	0.144	0.155	0.044
30t33	0.108	0.166	0.033	**745t8**	0.144	0.155	0.044
30	0.107	0.170	0.033	**LtQ**	0.140	0.198	0.032
31t32	0.101	0.164	0.033	**L**	0.138	0.173	0.025
31	0.101	0.164	0.033	**M**	0.138	0.173	0.025
313	0.101	0.164	0.033	**N**	0.149	0.225	0.027
31x	0.101	0.164	0.033	**O**	0.136	0.223	0.051
32	0.101	0.164	0.033	**90**	0.136	0.223	0.051
321	0.101	0.164	0.033	**91**	0.136	0.223	0.051
322	0.101	0.164	0.033	**92**	0.139	0.145	0.029
323	0.101	0.164	0.033	**921t2**	0.131	0.203	0.030
33	0.117	0.164	0.033	**923t7**	0.148	0.088	0.029
331t3	0.117	0.164	0.033	**93**	0.156	0.199	0.028
334t5	0.117	0.164	0.033	**P**	0.140	0.198	0.032
34t35	0.109	0.167	0.033	**Q**	0.140	0.198	0.032
34	0.112	0.167	0.033				

Omach = Machinery, excl. transport, IT and CT; TraEq= transport equipment; NRStruc=non-residential structures

Appendix Table 2 Currency units used in EU KLEMS

Country	Currency	Comment
Austria	Euro	In Euros from 1999 onwards. Before 1999, Austrian Schilling converted to Euro with the 1999 official fixed Euro conversion rate (13.7603 ATS/EUR).
Belgium	Euro	In Euros from 1999 onwards. Before 1999, Belgian Francs converted to Euro with the 1999 official fixed Euro conversion rate (40.3399 BEF/EUR).
Cyprus	Cypriot Pound	
Czech Republic	Czech Koruna	
Denmark	Danish Krone	
Estonia	Estonian Kroon	
Finland	Euro	In Euros from 1999 onwards. Before 1999, Finnish Marks converted to Euro with the 1999 official fixed Euro conversion rate (5.94573 FIM/EUR).
France	Euro	In Euros from 1999 onwards. Before 1999, French Francs converted to Euro with the 1999 official fixed Euro conversion rate (6.55957 FRF/EUR).
Germany	Euro	In Euros from 1999 onwards. Before 1999, Deutsche Marks converted to Euro with the 1999 official fixed Euro conversion rate (1.95583 DEM/EUR)
Great Britain	British Pound Sterling	
Greece	Euro	In Euros from 2001 onwards. Before 2001, Greek Drachmas converted to Euro with the 2001 official fixed Euro conversion rate (340.750 GRD/EUR).
Hungary	Hungarian forint	
Ireland	Euro	In Euros from 1999 onwards. Before 1999, Irish Pounds converted to Euro with the 1999 official fixed Euro conversion rate (0.787564 IEP/EUR).
Italy	Euro	In Euros from 1999 onwards. Before 1999, Italian Liras converted to Euro with the 1999 official fixed Euro conversion rate (1936.27 ITL/EUR).
Latvia	Latvian Lats	
Lithuania	Lithuanian Litas	
Luxembourg	Euro	In Euros from 1999 onwards. Before 1999, Lux Francs converted to Euro with the 1999 official fixed Euro conversion rate (40.3399 LUF/EUR).
Malta	Maltese lira	
Netherlands	Euro	In Euros from 1999 onwards. Before 1999, Dutch Guilders converted to Euro with the 1999 official fixed Euro conversion rate (2.20371 NLG/EUR).
Poland	New Polish Zloty	
Portugal	Euro	In Euros from 1999 onwards. Before 1999, Portuguese Escudos converted to Euro with the 1999 official fixed Euro conversion rate (200.482 PTE/EUR).
Slovak Republic	Slovak Koruna	
Slovenia	Slovenian Tolar	
Spain	Euro	In Euros from 1999 onwards. Before 1999, Spanish Pesetas converted to Euro with the 1999 official fixed Euro conversion rate (166.386 ESP/EUR).
Sweden	Swedish Krona	
United States-NAICS based	United States Dollar	
West Germany	Deutsche Mark	

Appendix Table 3 Alternative aggregation scheme in EU KLEMS

description	code
TOTAL INDUSTRIES	**TOT**
MARKET ECONOMY	**MARKT**
ELECTRICAL MACHINERY, POST AND COMMUNICATION SERVICES	**ELECOM**
Electrical and optical equipment	30t33
Post and telecommunications	64
GOODS PRODUCING, EXCLUDING ELECTRICAL MACHINERY	**GOODS**
TOTAL MANUFACTURING, EXCLUDING ELECTRICAL	**MexElec**
Consumer manufacturing	Mcons
Food products, beverages and tobacco	*15t16*
Textiles, textile products, leather and footwear	*17t19*
Manufacturing nec; recycling	*36t37*
Intermediate manufacturing	Minter
Wood and products of wood and cork	*20*
Pulp, paper, paper products, printing and publishing	*21t22*
Coke, refined petroleum products and nuclear fuel	*23*
Chemicals and chemical products	*24*
Rubber and plastics products	*25*
Other non-metallic mineral products	*26*
Basic metals and fabricated metal products	*27t28*
Investment goods, excluding high tech	Minves
Machinery, nec	*29*
Transport equipment	*34t35*
OTHER PRODUCTION	**OtherG**
Mining and quarrying	C
Electricity, gas and water supply	E
Construction	F
Agriculture, hunting, forestry and fishing	AtB
MARKET SERVICES, EXCLUDING POST AND TELECOMMUNICATIONS	**MSERV**
DISTRIBUTION	**DISTR**
Trade	50t52
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	*50*
Wholesale trade and commission trade, except of motor vehicles and motorcycles	*51*
Retail trade, except of motor vehicles and motorcycles; repair of household goods	*52*
Transport and storage	60t63
FINANCE AND BUSINESS, EXCEPT REAL ESTATE	**FINBU**
Financial intermediation	J
Renting of m&eq and other business activities	71t74
PERSONAL SERVICES	**PERS**
Hotels and restaurants	H
Other community, social and personal services	O
Private households with employed persons	P
NON-MARKET SERVICES	**NONMAR**
Public admin, education and health	LtN
Public admin and defense; compulsory social security	*L*
Education	*M*
Health and social work	*N*
Real estate activities	70