DIW Berlin

EU KLEMS

Not fully completed draft

Depreciation in EU Member - States

- Empirical and Methodological Differences -

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May 2005

EU Sixth Framework Programme

Paper prepared for the Helsinki workshop of the EU KLEMS project:

Work package 3: Capital Accounts

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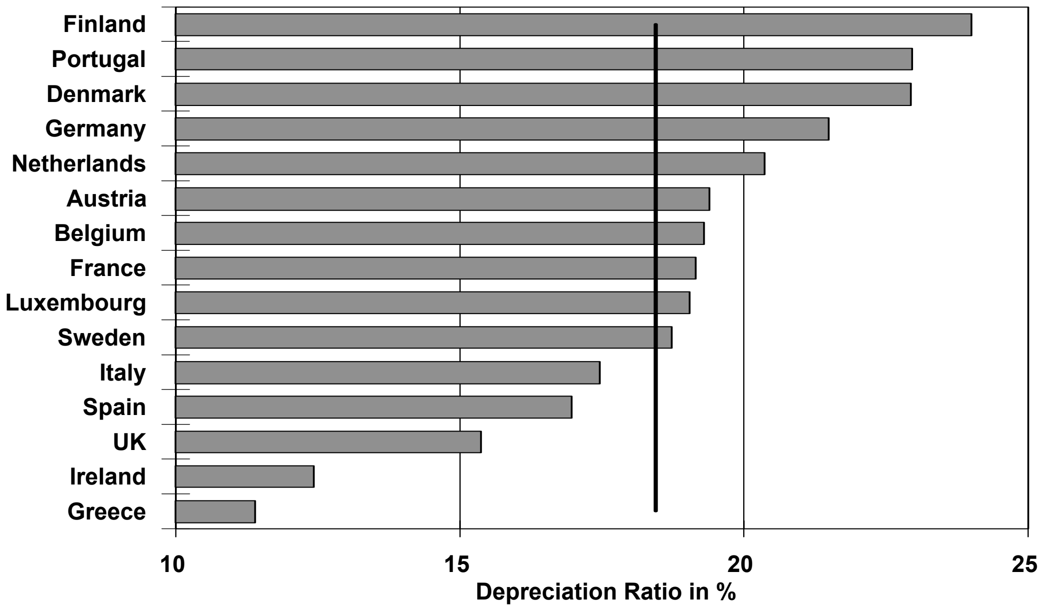
1 Overview

In common measures of TFP, depreciation is one of the most important ingredients. For measuring the input of capital services, an empirical overview on the importance of depreciation, or as it is called in ESA'95, consumption of fixed capital (CFC), in the EU member-states should help to understand the role of CFC in the European countries. Figure 1 shows that the relation between depreciation and net domestic product at factor costs varies considerably between the EU member-states. It is low with an average of 11 per cent in Greece and more than nearly double as high with 24 per cent in Finland. In most member-states, the ratio is quite stable over time. There are few exceptions as for instance the case of Finland, where the ratio performs a remarkable decrease in the nineties.

Figure 1: CFC Ratios in Net Domestic Product at Factor Costs – Average for 1994 until 2001



Two scientific disciplines can compete to explain these considerable differences in the CFC ratios:

- Economists, and
- Statisticians.

2 Economic Explanations of Varying CFC Ratios

It is not in the scope of this paper to conduct a comprehensive analysis of all the factors, which might exert an influence on the CFC ratios of the European countries. However, an admittedly very rough investigation into this subject shows that it might be difficult to find simple economic explanations for the wide span of CFC ratios.

If CFC is taken as a proxy for capital services, then the standard economic framework knows two major explanations, why CFC ratios might vary across countries. These are differences in

- Production technology, and
- Market structures.

Different production technology can have multiple causes.

Geographic factors, as:

- Mild or rough climate,
- Mountainous or flat surface,
- Kind of borders, the length of seacoasts, etc..

Demographic factors, as:

- Population density,
- Composition of the population by age, employment, etc.

Different production functions for the aggregates can also result from different degrees of *economic specialisation:*

- Heavy industries may need more capital (services) than light industries.
- Small countries may be more specialised with respect to certain production techniques than bigger ones.

In addition, under certain conditions it may also make sense to ask for the relationship between real income per capita and the CFC ratio.

Another cause for varying CFC ratios could be that *market structures* in the countries are different:

- In the case of monopolistic markets, one could expect a higher share of operating surplus in national product and the relation between CFC and profit might vary.

Given, that the need for capital services is different across countries, then also the amount of investment should be at least in a similar order. A relationship between depreciation levels and current investment levels would be expected; at least if such figures are averaged for a longer period. This relation would indicate the growth rate of investment in the past. In a stationery economy, depreciation would have equal investment. For growing economies, depreciation values would be expected to be below those of investments.

For some, certainly not at all comprehensive indicators, comparable statistical information could be found in the German Statistical Yearbook (destatis, 2003). A number of main aggregates from the National Accounts of the EU 15 have been published. They are made comparable with a unique PPP converter for all aggregates of the respective countries. The most recent publication comprises the years 1994 until 2001. In addition, a number of geographic, demographic, as well as structural indicators can be found for the EU 15, such that some correlations can be calculated.

The results are presented in table 1. Since the outliers in the CFC ratio, Greece to and Finland in some cases are influencing the results very much, coefficients of correlation are included, calculated without these outliers.

Table 1: Coefficients of Correlation between Selected Indicators and CFC Ratio

Indicator	Dimension	EU 15	except	
		Total	Greece	Finland
Area	km²	0,00	-0,08	-0,06
Population	million persons	-0,05	-0,16	0,04
Population density	per km²	0,11	0,02	0,27
Unemployment	% of Employment	-0,18	0,04	-0,32
Share of manufacturing	% of GDP	-0,09	-0,35	-0,23
Share of Services	% of GDP	0,19	0,29	0,34
Investment	% of GDP	0,21	0,25	0,38
GDP per head	1000 PPP per capita	0,20	-0,01	0,25
Labour force productivity	1000 PPP / labour force	0,05	-0,11	0,12
Income distribution	Oper. Surplus / Wages	-0,73	-0,59	-0,77

Sources: German Statistical Yearbook for Foreign Countries; Calculations of DIW. -

Table 1 shows that for the selected indicators no throughout convincing relationship with the CFC ratio can be observed. In some cases, the relationship is strongly influenced by the outliers, depending whether these are included on not. There seems to a weak relationship between real income per head and the CFC ratios, but this seems to be mainly influenced by Greece. The impact of the share of manufacturing is negative, while the correlation with the share of services yields a positive value. This might have to do with the fact that services are covering most of the depreciation of the non-market producers. The relation between investment and depreciation is at least positive, as expected, however the coefficient is surprisingly low.

There is a remarkable high negative correlation between the CFC ratio and the relation between operating surplus (including mixed income) and wages. Although it is known that operating surplus as a residual is heavily influenced by a multiple number of other factors, it should be kept in mind that, taking gross income values as given, high values of CFC will reduce operating surplus and vice versa. Thus, the poor performance of most economic indicators and the comparatively high correlation between the CFC ratios and operating surplus may indicate that the wide span of observed CFC ratios has something to do with different methods in calculating CFC in the National Accounts.

3 The Political Dimension

Before the subject of known methodological differences between CFC estimates in EU countries is approached, a remark on the political aspects of CFC calculations must be made. CFC is not only an important variable for productivity analysis; it also has a direct impact on relevant political decisions. CFC is an important component in calculating value added for the institutional sector General Government and for Dwellings. Up to one-third of total CFC can be attributed to these activities. Methodological differences between countries in measuring CFC therefore have a direct influence on the level of GDP and for a number of important EU settings, such as for instance:

- Contribution to the community household,
- Fulfilment of the Maastricht criteria.

It is not known to what extent differences in CFC ratios have to be attributed to such methodological differences, neither is it known to what extent value added and GDP are influenced by the differences. However, it might be interesting to get an idea of the magnitude, such differences can result in.

Two simulations have been performed to demonstrate this. In both simulations, it has been assumed that all differences in the CFC ratio are exclusively resulting from different kinds of measurement. To compensate this, the CFC ratio for the total of the EU 15 countries has been applied to all individual countries. In a first simulation, it has been assumed that all differences in the CFC ratio between the EU 15 can be attributed to a different measurement of CFC for non-market producers. In this case, the simulated CFC has a direct impact on value added and thus GDP. It can easily be seen that GDP in some of the countries (Greece and Ireland) can be up to six per cent higher than currently calculated. Conversely, GDP for Denmark and Portugal would be three per cent lower.

Table 2: Simulation of GDP and Operating Surplus, given equal Shares of CFC in Domestic Product

Country	Simulated values as % of actual NA figures	
	GDP	Operating surplus
Greece	5	-13
Ireland	5	-17
UK	2	-9
Spain	1	-15
Italy	1	-4
Sweden	-0	6
Luxembourg	-1	-2
France	-1	7
Belgium	-1	-3
Austria	-1	-0
Netherlands	-2	-4
Germany	-2	-10
Denmark	-3	23
Portugal	-3	11
Finland	-4	10

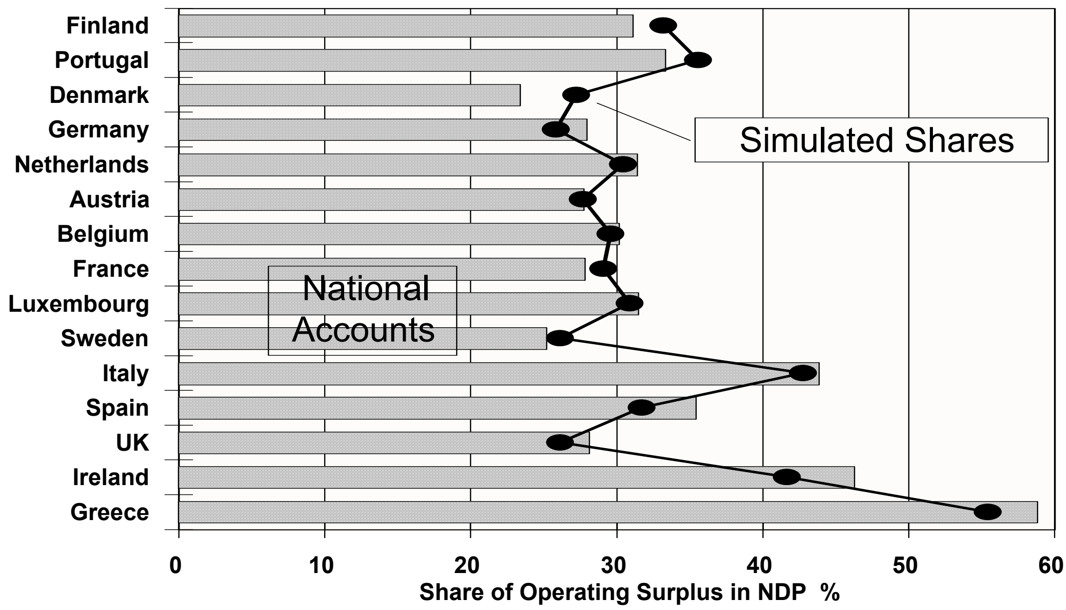
Sources: German Statistical Yearbook for Foreign Countries; Calculations of DIW. -

Alternatively, it is assumed, that only market producers are affected by the differences in measurement. In this case, the share of operating surplus (including mixed income) in GDP would change considerably for some countries. Operating surplus would decrease at two-digit percentages in Ireland, Greece, Spain, and Germany; it would increase considerably in Denmark, Portugal, and Finland. Despite these strong influences, the simulated changes would not influence dramatically the ranking of the countries by the share of operating surplus in national product. This means, there might be an influence of differences in CFC measurement on operating surplus, but this is certainly not the main influence on this aggregate.

Apart from the political aspects, it may be asked, whether the EU KLEMS project is affected by possible measurement differences. In most of the EU 15 countries, depreciation is estimated by assuming service lives for different types of assets.

Frequently, the same type of asset is used in non-market services as well as in market services. If the assumption on service lives for these assets are one of the sources for the deviations, one would expect that this kind of measurement differences have to be attributed to both market and non-market services. Furthermore, if measurement differences affect the residual, the value of operating surplus, then depending on the methodological concept of measuring TFP, an influence might be exerted on the outcome of productivity analysis.

Figure 2: Share of Operating Surplus in Net Domestic Product – Original and Simulated



4 Methodological Differences in Calculating CFC

Apart from pure measurement errors, an assessment of the differences in the depreciation ratio may be improved by analysing the different methods applied in the EU countries to estimate CFC. Frequently, measurement errors have to do with insufficient coverage of the economy. Equally, the choice of the applied methods in many cases has the origin in insufficient coverage. The following section is mainly based on the results of UNECE survey, which has been conducted in 2003 and published in 2004 (UNECE, 2004). Since the methods applied by the countries are very different, the answers given to the questionnaire sent out are very heterogeneous. It might be possible that some of the descriptions in this paper do not really represent fully the intentions of the respondents.

According to the survey, methods applied for calculating CFC in EU member states vary considerably. It has been tried to compare these different methods by separating individual components of the method applied. However, it has to be taken into account that some of these components may depend on each other, such that it will not be easy to explain differences in depreciation ratios as a result of one of the discussed components alone.

The following aspects of the UNECE survey will be discussed.

Sources:

- Depreciation
- Capital-Stock
- Service Lives

Breakdown in service life estimates:

- Assets
- Industries

Model applied for capital stock estimates:

- Discard Function
- BEA
- BFA

Depreciation schedules:

- Linear
- Geometric

4.1 Sources of Depreciation Data

One of The most important factors to be looked for are the sources applied. In the case of depreciation, two sources have been reported:

- Direct observation,
- Estimates based on capital stock data.

Direct observation of depreciation can be based on a survey or on administrative data, as for instance tax balance sheets. Direct observed depreciation values are generally assessed to be not in line with the valuation principles of ESA'95 (OECD, 2001). In addition, in many cases, observed values of depreciation do not reflect the requirement of ESA’95 to be based on the foreseeable economic service life for the assets in question. As far as it is known from the UNECE survey, out of the EU 15 countries, only Ireland has based its depreciation figures on tax reports. It is not transparent, how non tax-paying units, mostly non-market producers, are treated.

It also seems that a majority of the transition countries among the new member-states of the EU are presently calculating depreciation figures based on direct observations. These are either survey based or in some cases, a kind of prescribed service life for governmental institutions.

4.2 Sources of Capital Stock Data

According to ESA'95, depreciation should be based on capital stock data (ESA 6.04). Sources for capital stock figures can be

- Direct observations, and
- Cumulation methods.

Direct observations should have the first priority in calculating capital stock figures for a country. However, in practice it seems that direct observations is rarely applied. From the majority of EU 15 countries, direct observation by surveys is reported for some assets by the Netherlands and France. The use of administrative records is reported by Denmark. The UK seems to be have made some experimental surveys (West 1998), but this has not reported in the UNECE survey.

Administrative data consist mostly of physical data, generally used for long living assets as dwellings and roads, which are valued at current replacement prices in order to calculate estimates for gross capital stock. For calculating net stock, additional assumptions are necessary. Major difficulties of this method, which also is called the Quantity x Price (QxP) method, are the assessment of different qualities and the choice of the adequate replacement prices. If conducted annually or periodically, the advantage of the method is that movements in capital stock from one industry to another are adequately recorded.

What is commonly called the balance of fixed assets (BFA) approach, is based on a survey in which enterprises report on capital stock at the beginning of the year, changes in capital stock due to net acquisition of new and used assets and reductions because of sales. The capital stock reported is the net capital stock. Since also cumulated depreciation is reported, gross capital stock can be calculated from these figures. Units do also report on depreciation and discards. Apart from the possibility that depreciation might be underestimated in these surveys, it also seems that reported discards are generally very low. It seems that assets, which are to be discarded or scrapped have been sold by the reporting company and are reported to be part of this item.

Table 3: Methods Applied by EU 15 Member States to Calculate Depreciation

Country	Sources			Breakdown in Service Life Estimates		Model	De-preciation Method	Comments
	De-preciation	Capital Stock	Service Lives	Assets	Indus-tries			
Austria	Net Stock	PIM		4 tan, 3 add		BEA	geo	
Belgium	Gross Stock	PIM	Tax Reg. / Other Countr.	4 tan, 3 add	< 30	Discard function	lin	
Denmark	Gross Stock	PIM / Admin. Reg.	Experts / Tax Reg. / Admin. Reg.	>400	53	Discard function	lin	
Finland	Gross Stock	PIM		5 tan, 1 add	31	Discard function	lin	
France	Gross Stock	PIM / (Benchmark survey)	Experts Advice		< 30	Discard function	lin	
Germany	Gross Stock	PIM	Experts / Tax Reg. / Admin. Reg.	>200	None	Discard function	lin	
Greece	Gross Stock	PIM		4 tan	14		lin	
Ireland	Tax Register	-	-	-	-	-	-	
Italy	Gross Stock	PIM	Experts Advice	4	< 30	Discard function	lin	
Luxembourg	Gross Stock							Not reported in ECE
Netherlands	Gross Stock	PIM / Benchmark surveys	Survey	5(11) tan 4 add	yes	Discard function	lin	
Portugal	Gross Stock							Not reported in ECE
Spain	Gross Stock	PIM	Tax Reg. / (Experts)	6 tan, 4 add	None	Discard function	lin	
Sweden	Net Stock	PIM				BEA	geo	Planned
UK	Gross Stock	PIM	Unknown	3 tan, 2 add	Some	Discard function	lin	Revising

Sources: UNECE, 2004. -

All data are reported at historical prices. In most transition countries a general revaluation of capital stock has been made after the introduction of the market economy, such that presently the capital stock data of the surveys are valued at prices of the middle of the nineties and thereafter. Although, this approach affords to re-value at current replacement prices and the assessment of depreciation depends on the institutional settings of the country's economy, as for instance the tax system, direct observation of movements in capital-stock have a number of advantages which most of the model based estimates are lacking.

Table 4: Methods Applied by New Member States to Calculate Depreciation

Country	Sources			Breakdown in Estimates		Model	De-preciation Method	Comments
	De-preciation	Capital Stock	Service Lives	Assets	Indus-tries			
Cyprus		*(PIM)*				(Discard function)		Not reported in ECE
Czech Republic		*PIM*		*4 tan, 2 add*		Discard function	*lin*	
Estonia		*Direct Obs. / Admin. Reg.*	*Admin. Reg. / Experts*				*lin*	
Hungary		PIM		*4*	*9 and more*	Discard function	*lin*	
Latvia	*Direct Obs.*	*Direct Obs. / Admin. Reg.*		*5 tan, 4 add*		*BFA*	*lin*	
Lithuania	*Direct Obs.*	*Direct Obs. / Admin. Reg.*	*Survey*	*21 tan*		*BFA*	*lin*	
Malta		*(PIM)*						Not reported in ECE
Poland		*Direct Obs. / Admin. Reg.*	*Survey*	*8 tan*				
Slovakia		*Admin. Reg.*	*Survey*				*lin*	
Slovenia		PIM / Benchmark surveys / Admin. Reg.	*Survey*	*>12 tan, 3 add*	*None*		*lin*	

Sources: UNECE, 2004.

If direct observation is not possible, ESA'95 (6.04) suggests a cumulation method, which is commonly known as PIM (Perpetual Inventory Method). It may be noted that the M in PIM stands for method, not for model. Every company is applying this approach, while making eventually a total inventory, to check for unobserved losses. According to ESA'95, cumulation is done by adding and subtracting movements in assets from a given capital stock (table 5). Given the definitions of stocks and flows of fixed assets in ESA'95, it can be argued that the survey based approach as currently applied in some of the transition countries has all features of a perpetual inventory method, but is not based on a formalised discard function.

Most countries, reporting to use PIM, obviously do apply a formalised model, which in general is based on a formalised discard function. While the cumulation method, if properly done, should yield the same results as direct observations, the main shortcoming of the discard function and similar approaches lies in the inadequate consideration of movements in stocks. This means the separate treatment and full coverage of acquisitions and sales of used assets. This might be not such a problem on the macro-economic level for bigger countries. For smaller countries, a bigger proportion of inter-industry movements of assets, especially equipments, becomes parts of imports and exports. Therefore, the comparison of big and small countries will be hindered even on the macroeconomic level.

For the EU KLEMS industry based project, movements of assets between companies might influence capital stock estimates for industries considerably.

Table 5: Stocks and Flows of Fixed Assets according to ESA'95

Definition	ESA'95 Code	German NA 2001 Mrd. €
Net stock in the closing balance (last period)	7.08	
= Net stock in the opening balance	7.08	6 385
+ Net changes of net capital stock	--	36
+ Other volume changes	3.108	0
+ Net fixed capital formation	3.101	85
+ Gross fixed capital formation (net acquisitions)	3.102	396
+ New acquisitions (purchased or self produced)	3.102	434
+ Acquisition of used assets (bought or transferred)	3.103	38
- Disposal of used assets (sold or transferred)	3.103	
- Consumption of fixed capital	6.02	311
= Net stock in the closing balance (before revaluation)		N.A.
+ Revaluations (holding gains)	7.08	9
= Net stock in the opening balance (next period)	7.08	6 479

Survey based information indicates that the acquisition of used assets might be in the magnitude of one-third of gross fixed capital formation. It is not clear from the UNECE survey, how countries, applying a formalised PIM model, are treating sales and acquisitions of used assets. It seems that this item is mostly treated to be negligible (OECD, 2001) or to be only of importance for the institutional sectors.

4.3 Service Lives: Sources

ESA'95 asks for depreciation, based on the probable average service life of an asset. It should include wear and tear and the foreseeable obsolescence. A variety of different sources for service lives has been reported. Most countries use several sources. These are experts' advises for instance in the case of Spain, Italy, France, Germany, and Estonia. Information from the tax register is used by Spain, Germany, Belgium, and a.o. Some countries use the results of other countries estimates, especially the US estimates. Frequently, use is made of administrative data (Germany, Denmark, Estonia, a.o.). Some countries also have surveys on service lives, as for instance the Netherlands, Finland, and some of the transition countries.

It is not always clear, what the surveys on service lives actually are reporting. In some surveys, reporting units are asked for the assumed service life, the actual service life and expected service life. In any case, a survey asking directly for the service life needs a very detailed asset breakdown. Otherwise, the reporting units would have to apply a weighting method for averaging the service lives of the assets. To cover homogeneous assets, the necessary breakdown would have to be considerably deeper then the AN classification suggested by ESA'95 (table 7.1) for gross fixed capital formation (GFCF) or the one in the delivery programme of Eurostat ( ).

Known surveys on asset service lives (Cope, 1998) are asking for more than two hundred different types of assets. The asset breakdown in the BEA estimates is about XXX. An idea of the multitude of different service lives applied in firms might also be given by the fact that for instance German tables for tax service lives cover more than 2 000 different types of assets (BMF: AfA-Tabellen).

Another method to get information on service lives is asking for the age structure of the stock, preferably the gross stock (Czech Republic, Lithuania). In this case, values, which are available in the companies' accounting system can be aggregated and reported. However, values are normally given at historic acquisition prices.

4.4 Service Lives: Degree of Differentiation

Although it is known (OECD, 2001) and easy to demonstrate that service life assumptions have a strong influence on capital stock and consumption of fixed capital, it is difficult, to measure the impact on the published data of consumption of fixed capital of the countries in question. Mostly, not comparable breakdowns of assets are made for the service life assumptions. Breakdown in the context of service life does not mean the asset and industry breakdown for which GFCF time series are available. This information has been provided for the countries in the EU KLEMS questionnaire. For an assessment of the assumptions on service lives however, it is necessary to know, how many different service life assumptions have been applied on the GFCF time-series in question. There may be an A 60 industry breakdown and a CPA 60 asset breakdown available, but only a unique service life assumption may have been applied. With respect to depreciation this would result in the same value as if the exercise had been done for the aggregated time-series.

ESA'95 does not give a specific suggestion on the necessary degree of asset breakdown. From the economic point of view, it is clear that the asset breakdown in the suggested AN classification for GFCF (ESA'95, 3.106) cannot be detailed enough. This follows from the underlying theory of depreciation. The general idea seems to be that there exists some kind of homogeneous type of capital asset, which experiences economic obsolescence. Moreover, ESA'95 also assumes that the average service life of an asset should be the regular case for all units of the economy (ESA’95, 6.04). Deviations by sectors should be treated as extraordinary changes in capital stock. Clearly, in this concept the service life has to be seen as an economic variable. The underlying idea of a unique service life for homogeneous products is the model of perfect competition.

Whether this model can be applied on the economies considered might be another question, yet in practice, only a few countries seem to adhere to this concept. The asset breakdown, according to the UNECE survey is reported to be more or less in line with the breakdown of the AN classification given in ESA'95 or below that in most EU 15 countries. Only Denmark and Germany are reporting with respect to service life assumptions an asset breakdown, which might be high enough to cover individual assets, and thus can be thought to be homogeneous. Yet, Denmark makes an additional breakdown according to industries where the assets are used.

Reasons for an additional industry breakdown can be twofold:

a) The applied asset classification is not deep enough to cover homogeneous types of asset, or

b) Different market structures in the industries will induce different economic service lives for the same kind of physical asset.

An additional industry breakdown is applied in most countries. In the EU KLEMS questionnaire, some consortium members have reported a very detailed breakdown of GFCF by industry and type of asset. Not necessarily, these industry breakdowns are made with respect to different service life assumptions. In these countries, where information on service lives has been reported by type of asset and by industry (i.e. Belgium, France, Italy), it becomes transparent, that with some exceptions, the degree of service life differentiation between industries is not very high.

4.5 Service Lives: Comparisons

The varying degree of breakdown by asset and by industry makes it difficult to compare the assumed service lives for all countries. In some cases, it might be possible to compare the assumption for a specified asset for two selected countries. However, to get an assessment of the impact of service life on the total deviation in CFC ratios, information of the aggregate impact of different service life assumptions is necessary. A way to do this comparison would be, to aggregate highly differentiated service life assumptions on the levels of higher aggregates, which have been used by all countries. For highly aggregated types of assets, information from the UNECE survey has been compared in Table 6. For most countries, only a range for the applied service life assumption can be displayed. In general, there is no knowledge about the weights, individual service life assumptions have.

Table 6: Applied Service Life Assumptions by Selected EU 15 Countries

Country	Dwellings	Other Buildings	Transport equipment	Other equipment
Belgium[2]	60	30-40	8-25	15-25
Denmark[2]	75	50(avg)-59	14(avg)	13(avg)
Finland[2]	50	20-70	6-25	5-27
France[2]	25-60		7-15	9-21
Germany[2]	74 (avg) 40-95	15-150	11(avg) 8-25	13(avg) 5-30
Greece[2]	66-100		4-33	10-20
Italy[2]	13-40		10-15	18-28
Netherlands[2]	75	35-60	8-25	5-45
Spain[2]	38	40-65	10	17
Sweden[3]	75	25 - 80	2 - 35	10 - 40
UK[3]	100	16 -100	10 - 30	8 - 32

[1]avg = weighted average over all assets. - [2] UNECE (2004). - [3] OECD (1993). -

Only in some cases weighted averages of the applied service lives assumptions are given. If linear depreciation has been assumed, the implicit service life assumption for aggregates by definition can be calculated in dividing gross stock by depreciation. Information to do this has not been available, but could certainly supplied by the countries.

Table 7: Selected Service Life Assumptions by Activity

Activities	NACE rev 1	Italy		Belgium		Finland		Italy	Belgium	Finland	
		Ma-chinery	Trans-port	Ma-chinery	Trans-port	Ma-chinery	Trans-port	Buildings & Structures	Buildings & Structures	Non Residential Buildings	Structures
Agriculture, Hunting, Forestry	01-02	18	10	15	12	5-12	9	51	37	35-40	30-50
Fishing; operation of fish hatcheries and fish farms; etc	05	18	10	15	25	15	10	35	39		
Mining and Quarrying	10-14					18	7			30	25
Mining and Quarrying of Energy Producing Materials	10-12	18	10					35			
Other Mining and Quarrying	13-14	18	10	20	10			35	33		
Food Products, Beverages and Tobacco	15-16	18	10	20	10	17-19	7	35	34	40	25
Textiles and Textile Products	17-18	18	10	19	10	14	7	35	38	35	40
Leather; manufacture of luggage, handbags, saddlery,etc.	19	18	10	18	10	14	7	35	38	35	40
Wood and of products of wood and cork, etc.	20	18	10	18	10	16	10	35	45	35	25
Pulp, paper and paper products, publishing, printing	21-22	18	10	19	10	15-18	6-10	35	45	40	35
Coke, refined petroleum products and nuclear fuel	23	18	10	18	10	23	10	35	38	35	40
Chemicals and chemical products	24	18	10	18	10	18	10	35	34	40	35
Rubber and plastic products	25	18	10	17	10	18	7	35	34	45	40
Other non-metallic mineral products	26	18	10	19	10	19	10	35	30	40	40
Basic metals, fabricated metal products	27-28	18	10	21	10	16-23	8-12	35	35	40	30-40
Machinery and equipment n.e.c.	29	18	10	19	10	13	8	35	35	40	30
Electrical and optical equipment	30-33	18	10	19	10	11	7	35	35	40	30
Transport equipment	34-35	18	10	18	10	15	9	35	35	45	40
Manufacturing n.e.c; recycling	36-37	18	10	18	10	14	8	35	35	35	35
Energy and water supply	40-41	18	10	25	10	24-27	8-10	40	42	45-50	35-40
Construction	45			20	10	10	10		42	40	30
Wholesale and retail trade; repairs	50-52	18	10	15	8	15	10	65	40	40	30
Hotels and restaurants	55	18	10	15	8	15	10	65	40	40	
Transport, storage and communication	60-64	18	10	15	15	5-25	7-25	80	40	20-50	20-70
Financial intermediation	65-67	18	10	15	8	10		65	40-60	40	
Real estate, renting and business activities	70-74	18	10	15	8	15	10	80	40-60	50	70
Public administration and defence; social security	75	28	15	15	8	15	10	80	60-70	50	70
Education	80	18	10	15	8	10-15	10	57	(60)	50	70
Health and social work	85	18	10	15	8	10-15	8-10	35	40	40-50	70
Other community, social and personal services	90-93			15	8	10-15	8-10		40	50	40-70
Private households with employed persons	95			15	8				40		

Sources: UNECE, 2004. - DIW Calculations. -

In the case of geometric depreciation, this method is not applicable. The service life definition in geometric depreciation schedules is not comparable with the one in the linear model.

Implicit service life assumptions of the countries can be estimated in applying an inverse PIM model, based on a standardised discard function, independently from the method applied by the country. If time series of CFC and GFCF at constant and historical (current) prices for a given period are available, it is possible to calculate this part of capital stock and accordingly of depreciation, which is the result of known investment. These calculations can be done for different service life assumptions. There will remain a gap between calculated and published figures. To fill the gap, for a given service life assumption, it can be asked, how investment growth must have been in the period before the known time series on investment have started.

This has been exercised in table 8. Time series on investment for the EU 15 countries are covering the period from 1985 until 2001. The same CFC figures, which have been used in figure 1 have been tried to simulate. The necessary time path of investment before 1985 has been calculated for a number of different service life assumptions for all countries. For some service lives, no realistic path of investment before 1985 could be found. The higher the service life assumption, the lower the resulting investment path.

Simulations of this kind have been conducted with the capital-stock model of the DIW. This model is estimating consistent values for gross and net capital stock at current (replacement) prices, acquisition prices, and constant prices. Consistent values for discards and depreciation at current, acquisition, and constant prices are estimated as well. In addition, holding gains for revaluation are quantified within the model.

The discard function is bell shaped and, similar to the Weibull function, can simulate a wide number of different discard assumptions, from one-hoss-shay to straight-line. In the simulation procedure, a constant service life assumption has been applied. For all countries, the linear depreciation schedule has been applied.

These calculations can be abbreviated by asking for the combination of service life assumption and investment growth in the past, which will give the best adaptation to present time-series of depreciation. The results show a wide range of implicit service life assumptions. Most of them are between 20 and 30 years. The highest assumed service life could be found in Austria and France. For Finland and Greece, the outlier countries with respect to the CFC ratio, implicit service lives just below the average seem to be applied. Ireland has a CFC ratio nearly as low as that of Greece, but its implicit service life is one of the lowest of the EU 15.

No satisfactory solutions could be found for Sweden and Denmark. Country specific knowledge may help to explain this. For Germany, for example, other sources suggest an implicit service life for the capital stock of the total economy of 32 years. However, in the data used, the treatment of investment before German unification has not been solved satisfactorily.

No correlation (-0.06) between the CFC ratio and the estimated implicit service life assumption could be found. It seems that differences in the service life assumptions cannot explain the huge differences in CFC ratios between the countries. However, results of the calculations could change if the data input can be improved, especially if longer time series of investment can be used.

Table 8: Evaluation of Implicit Service Life Assumptions for Published Depreciation Values

Country	Years of assumed average Service Life							Optimal	
	20	25	30	35	40	45	60		
	Simulated growth rate of Investment before 1985 %								Service Life
Austria	.	.	5	5	2	2	1	2	67
Belgium	.	6	0	0	-0	-0	-0	2	24
Denmark	7	3	1	1	0	0	0	.	13
Finland	.	9	3	3	2	1	1	6	24
France	.	13	3	3	1	1	0	9	57
Germany	.	.	18	18	5	3	1	0	33
Greece	.	.	12	12	5	4	2	6	29
Ireland	.	9	1	-0	0	-0	-0	8	18
Italy	.	16	4	4	2	1	1	3	32
Luxembourg	-7	-7	-5	-5	-4	-3	-2	4	19
Netherlands	.	.	2	2	1	1	0	8	20
Portugal	-5	-5	-4	-4	-3	-2	-2	-2	14
Spain	.	.	2	2	0	0	-0	4	25
Sweden	.	11	3	3	1	1	1	.	18
UK	.	7	1	1	0	0	0	2	25

Source: DIW Calculations. - "." No solution found.

4.6 Models

Three kinds of models are reported. The traditional PIM-Model, applying a discard function is used by a majority of the EU 15 countries. The chosen discard function by most countries is bell shaped, except in Spain, where a delayed linear function is used. While it can be shown, that the exact shape of the discard function does not have so much impact on the outcome, it should be noted that in such cases, where countries are applying the discard function for highly aggregated assets, this function does not only reflect accidental discards, which can be insured against, as asked by a ESA'95 (6.04). The shape of the discard function in such cases must also reflect the fact that in an aggregated discard function, assets with different service lives are included. In this case, one would expect a left steep discard function.

Austria applies the BEA method; Sweden reported in 2003 that it intends to apply the BEA method in future. There is no description on the presently applied method. Some of the new member-states are applying the BFA method, but most of them are expected to install a discard model based approach in future.

4.7 Depreciation Schedules

Most countries apply the linear depreciation method, which is in line with the suggestions of ESA'95 (6.04). From the reporting EU 15 countries, Austria is applying a geometric depreciation method and Sweden intends to do this.

ESA'95 suggests linear depreciation, but allows for geometric depreciation if necessary. There are a number of reasons, which suggest that geometric depreciation may be a more adequate depreciation schedule. It is argued for instance, based on empirical and theoretical evidence that depreciation, e.g. the loss of value over time, is higher in the beginning than at the end of the service life of an asset. This may especially be true for assets, which are exposed to high competition and rapid change of technology and/or taste.

On the other hand, for other types of assets the opposite can be argued. Mainly for assets with a high service life, investors frequently are not motivated by an expected short-term high return on capital, but by the expected value increase of the asset. Investments in dwellings are a typical example where this kind of investment behaviour can be observed and explained theoretically (Görzig, 1998). From this, investments into dwellings do not seem to be a good candidate for applying geometric depreciation.

In geometric depreciation schedules, the service life assumption is not comparable with the definition taken from population statistics. It is mainly a denominator for calculating the depreciation rate. The depreciation values depend equally on the *declining balance rate* (R).

Equation 1:

$$d = R / T$$

d = *depreciation rate*
R = *declining balance rate*
T = *service life*

In commercial uses of geometric depreciation, this factor frequently is assumed to be 2. This is for instance the standard value, which is used in spreadsheet applications like Excel. The US Bureau for Economic Analysis (BEA), which applies geometric depreciation, assumes in most cases a factor of 1.65. A similar magnitude (1.6) is suggested by Katz (2002) to be applied for dwellings. The BEA applies for all components of dwellings a factor of only 0.91 (BEA 1997, p. 29).

The assumption on the declining balance rate (R) together with the service life assumption (T) determines the depreciation rate (d), which in turn lastly is relevant for the size of the calculated net capital stock and the level of consumption of fixed capital. Obviously, there is a trade-off between these two parameters. High values for the declining balance rate and high values for the service life may yield the same depreciation rate and finally so same amount of depreciation as lower values for both.

The BEA assumptions on the declining balance rate in dwellings for instance of 0.91 is accompanied by an assumption on service life of 80 years for new 1 to 4 unit structures. These two assumptions yield an annual depreciation rate of 1.14 per cent. Using a declining balance rate of 1.6 instead, combined with a service life assumption of about 140 years, one would arrive at the same depreciation rate. Given an average service life of 80 years in dwellings, Katz however, would calculate with a suggested declining balance rate of 1.6 a depreciation rate of 2 per cent per annum.

These differences make clear, that in the case of geometric depreciation, the outcome of the calculations depends heavily on both: the average service life and the applied declining balance rate. Service life assumptions applied in geometric depreciation schedules therefore are not necessarily comparable with those used in linear depreciation schedules. The service life assumption in the BEA calculations is mainly a denominator, needed for calculating the depreciation rate (BEA 1997, p. 32).

Another differences in the results can occur depending on the treatment of the residual value. Calculating depreciation by multiplying a given net capital stock with a fixed depreciation rate every year, can be done for an infinite number of years. Since assets have a finite service life, every asset to be scrapped will have a positive net value at the end of its service life, the residual value. The magnitude of this residual value is in most cases far above the regular depreciation value. The residual value converges to 16 per cent of the original investment in the case of a declining balance rate of 2. It goes up to 20 per cent of the original investment, if the declining balance rate is 1.6. If the declining balance rate is only 0.91, as in the case of dwellings in the US, then the residual value will amount to 40 per cent of the original investment value.

Equation 2:

$$\textbf{Residual value} = (1 - R / T)^{T}$$

In commercial uses, this residual value has to be treated as depreciation, once the asset is scrapped. In the BEA estimates, it is assumed to be distributed over an infinite number of years.

Given these two important differences between linear and applied geometric depreciation schedules a comparison of the assumed respective service lives does not make sense. It would certainly be more informative to compare the average depreciation rates applied.

5 Conclusions and Questions for the EU KLEMS Project

Depreciation levels in the EU 15 countries vary considerably. However, there seems to be no unique factor to explain this. Economic explanations are not satisfactory. Methodological differences exist, but the causality is not clear-cut.

To improve the possibilities of explanation, more standardised methods could be helpful. The most important candidate for standardisation in the EU KLEMS project is the asset and industry breakdown. If for all countries the same breakdown can be applied then it will be better possible to separate structural influences from these of service life assumptions.

Before the background of the political dimension, it should be asked to what extent, alternative depreciation levels could be assumed in the EU KLEMS project, if diverting methods are applied.

Annex 1: Comparing linear depreciation with selected geometric depreciation schedules

Table 9 shows the differences in depreciation, which can develop due to different depreciation schedules. For a given gross capital stock, linear depreciation is compared with geometric depreciation as it is applied in companies and geometric depreciation as it is practised by the BEA.

Geometric depreciation practised by companies does not yield very different results from the linear case. Differences between the results of geometric or linear depreciation schedules arise from changes in investment growth, such that the age structure of gross capital stock deviates from the "normalised" age structure given by constant investment figures. Therefore, since the factual distribution of the age groups may be different from the exemplary distribution applied here, the degree of deviation from the linear case may change if the age structure of gross capital stock of a given country is inserted into the table.

The assumptions made by the BEA for the US with respect to the residual value however differ from those applied by commercial bookkeeping systems. As no explicit scrapping function is assumed, calculations are based on the implicit assumption that depreciation for a given asset can be done infinitely (BEA 1997, p. 32).

In the table, the coefficients for an assumed average expected service life of 60 years have been compared with the results of linear depreciation in the chosen age groups. In addition, in the table, coefficients are calculated according to the formulas suggested by Katz. These coefficients will give a lower value for consumption of fixed capital due to generally lower net to gross coefficients, especially in the open class for assets with an age above 60 years. These deviations have to be considered in comparing the results for consumption of fixed capital calculated by different methods.

Table 9: Impact of Alternative Depreciation Methods

Example with Average Expected Service Life = 60 years								
	All	Age groups						
Depreciation method	ages [6]	Over 60	51-60	41-50	31-40	21-30	11-20	1-10
		Years of age						
Gross capital stock	67 615	6 514	3 973	7 505	7 980	11 168	12 804	17 672
	Ratio of net to gross capital stock							
Linear [1]	0,584	0,143	0,247	0,327	0,427	0,558	0,728	0,915
Geometric commercial [1, 2, 4]	0,565	0,253	0,302	0,346	0,408	0,504	0,654	0,876
Geometric [4]	0,540	0,078	0,229	0,299	0,391	0,512	0,669	0,875
	Depreciation rate [3]							
Linear [1]	0,029	0,085	0,056	0,047	0,039	0,032	0,026	0,021
Geometric commercial [1, 2, 4]	0,032	0,065	0,040	0,035	0,031	0,029	0,028	0,030
Geometric [4]	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026
	Net capital stock							
Linear [1]	39 490	929	980	2 453	3 406	6 236	9 316	16 171
Geometric commercial [1, 2, 4]	38 186	1 649	1 198	2 593	3 257	5 628	8 378	15 482
Geometric [4]	36 525	511	910	2 247	3 123	5 714	8 565	15 456
	Consumption of fixed capital							
Linear [1]	1 158	79	55	114	133	202	241	334
Geometric commercial [1, 2, 4]	1 204	108	48	90	102	163	237	457
Geometric [4]	966	14	24	59	83	151	227	409

[1] Calculated with a PIM - model, using a symmetric discard function and constant investment in each cohort - [2] Full depreciation of residual net stock in the last year of use. - [3] Ratio of depreciation to net capital stock. - [4] Declining balance rate (R)

Annex 3: Data Used

Annex 2: The DIW Model

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