Service lives and discard patterns of capital goods in the manufacturing industry, based on direct capital stock observations, the Netherlands

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Explanation of symbols

.	= data not available
*	= provisional figure
x	= publication prohibited (confidential figure)
–	= nil or less than half of unit concerned
–	= (between two figures) inclusive
0 (0,0)	= less than half of unit concerned
blank	= not applicable
2005-2006	= 2005 to 2006 inclusive
2005/2006	= average of 2005 up to and including 2006
2005/'06	= crop year, financial year, school year etc. beginning in 2005 and ending in 2006
2003/'04–2005/'06	= crop year, financial year, etc. 2003/'04 to 2005/'06 inclusive

Due to rounding, some totals may not correspond with the sum of the separate figures.

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Service lives and discard patterns of capital goods in the manufacturing industry, based on direct capital stock observations, the Netherlands

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Abstract

At Statistics Netherlands the development of productivity statistics is addressed as a key field of interest. The last national accounts revision at Statistics Netherlands was taken as an opportunity to improve capital stock and depreciation statistics. The Perpetual Inventory Method, as now applied at Statistics Netherlands, provides in a consistent way statistics on depreciation, the net capital stock, the productive capital stock and capital services. Much attention has been given to estimating average service lives and discard patterns of different asset types. This paper presents methods and results with regard to the estimation of service lives and discard-patterns, based on direct capital stock observations in the manufacturing industry.

Keywords: service lives, discard patterns, capital stock, SNA

1. Introduction

Most countries estimate capital stocks and consumption of fixed capital for National Accounts purposes by the Perpetual Inventory Method (PIM). The accuracy of capital stock estimates derived from a PIM highly depends on the assumed service lives i.e. on the length of time that assets are retained in the capital stock.

Ideally, what is required for accurate implementation of the PIM is a set of service lives for narrowly-defined asset groups that are used in different sectors and industries. Moreover, this set of service lives should be updated

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regularly to reflect cyclical or longer-term changes in the lengths of time that assets remain in the stock. In most countries the information that is actually available falls short of this ideal. Service life estimates are generally available only for broad asset groups, there is limited information available on differences in lives of asset groups between sectors and industries and service lives are updated at rare intervals in most countries (OECD, 2001).

Furthermore, estimates of service lives based on statistical surveys are scarce. In many countries the main sources for estimating service lives are asset lives prescribed by tax authorities (which are generally based on a variety of sources of differing reliability), company accounts, administrative records and expert advice. Most statistical offices see the high costs and respondent burden associated with obtaining and maintaining good measures of service lives by means of statistical surveys as the main obstacles in determining asset lives. However, according to the OECD manual for measuring capital (2001) there is a case for wider use of direct survey methods.

In addition, it is concluded in the OECD manual (2001) that simultaneous-exit and linear-decline discard patterns are clearly unrealistic. Survival functions with a longer tail, like the Weibull and the delayed linear are more realistic models (OECD, 2001, Meinen et al., 1998).

The Netherlands is one of the few countries where direct observations of discards and capital stock by means of statistical surveys are available. These surveys enable the estimation of discard patterns and service lives at the industry level.

In this paper estimations of discard patterns (i.e. Weibull-parameters) and service lives are presented for different divisions of the manufacturing industry in the Netherlands by utilizing directly observed capital stock data and discard surveys.[5]

2. Direct observations

For the manufacturing industry only, Statistics Netherlands is in the luxury position of having three data sources available to estimate capital stock: capital stock benchmarks, discard surveys and statistics on gross fixed capital formation. All three sources use the same classification of assets and industries.

[5] The research described in this paper took place in 2005. However, the methods and results are still valid today.

2.1 Statistics on capital stock

Up until 2003 Statistics Netherlands collected benchmarks of capital stocks by direct observation (on-site visits by enumerators). The Capital Stock Survey was collected for all enterprises within the manufacturing industry (ISIC 15-36) with 100 or more employees. It was performed on a rotational base in such a way that each division of the manufacturing industry (two-digit ISIC level) was surveyed every five years. Although estimates for the years in-between could be calculated as a result of the initial benchmark capital stock plus gross fixed capital formation, minus the retirements for the in-between years, such in-between estimates have not (yet) been used for the purpose of the present paper. Furthermore, for the purpose of the present paper only the actually observed enterprises were included in the analyses.

At least two benchmarks are available for each division (two-digit ISIC level) of the manufacturing industry. The Capital Stock Survey records all tangible fixed assets that are used by enterprises in their production processes, whether the assets are owned, rented or obtained by a leasing contract. The enquiry used by Statistics Netherlands contains information on the following types of tangible fixed assets:

1. Industrial buildings (SNA classification AN.11121), examples are factory-buildings, offices, shops, garages and sheds;

2. Civil engineering works (including site improvements) (SNA classification AN.11122), examples are roads and pipelines for oil transport;

3. External transport equipment (SNA classification AN.11131), for example excavators and dredging machines;

4. Machinery and equipment and internal means of transport (SNA classification AN.11132), for example hydraulic and pneumatic installations, communication equipment, measurement equipment, control equipment and internal means of transport such as cranes, pulleys and assembly lines;

5. Computers (SNA classification AN.11132), data processing machines that are freely programmable including peripheral devices (this excludes machinery with embedded software), examples are personal computer and printers;

6. Other tangible fixed assets (SNA classification AN.11132), examples are furniture, freight containers and silos.

2.2 Statistics on discards

The second data source available for service-life calculations is the Survey on Discards that was introduced in 1991 (Smeets and Van den Hove, 1994). Discards in a particular year comprise all fixed assets which are no longer used in the production process. These assets have either been scrapped or sold on the second-hand market. The Survey on Discards is collected annually among all enterprises within the manufacturing industry (ISIC 15-36) with 100 or more employees. The total number of enterprises that actually respond is usually lower than with the Capital Stock Survey because the Discard Survey is a mail questionnaire and the Capital Stock Survey involves on-site visits by enumerators.

2.3 Statistics on investments

The third source is the Investment Survey for fixed tangible assets. The Investment Survey provides information on all annual additions to the in-service stock comprising “off-the-shelf” capital goods directly entering the in-service stock, and transfers of completed facilities from the work-in-progress inventory. The Investment Survey is collected annually among all enterprises within the manufacturing industry[6] (ISIC 15-36) with 20 or more employees. For enterprises with less than 20 employees, a random sample is drawn yearly.

2.4 Combining the surveys

The definitions used in the surveys on capital stock, discards and investment are fairly compatible, but having compatible definitions does not necessarily imply consistent results. Obviously, the quality of each of the three sources is first of all determined by the quality of the individual enterprise response. Unfortunately the results are not always consistent. For some vintages initial gross fixed capital formation may show a mismatch in time. This inconsistency stems from work in progress that is not registered in a consistent manner. The Capital Stock Survey does not register industrial buildings and civil engineering works that are under construction as capital stock, whereas the Investment Survey does register them instantly as capital formation.

In addition, the weighting methodology that is applied to correct for non-response and not-observed enterprises differs between the different surveys. In general, for the Capital Stock Survey and Survey on Discards figures for non-response and enterprises that are not observed at all (enterprises with less than 100 employees) are calculated by multiplying the average (capital stock or discard) per employee within the industry (3-digit ISIC level) -as computed among the observed enterprises- with the number of employees within the non-response and not-observed enterprises within that industry (3-digit ISIC level). For the Investment Survey the same procedure is used but here not only the industry but also the size-classes in terms of number of employees of the enterprises were taken into account when the averages were determined. This clearly is the preferable method because evidence exists that on average

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[6] In some years the Investment Survey covers more industries than just the manufacturing industry. Furthermore, data on gross fixed capital formation from other statistical surveys is available for several industries outside the manufacturing industry.

the ratio of investments per employee gets smaller the smaller the number of employees an enterprise has. However, the Investment Survey is collected among all enterprises (for enterprises with less than 20 employees a random sample is drawn) whereas the Capital Stock Survey and Survey on Discards are only collected among enterprises with 100 or more employees. It is therefore difficult if not impossible to improve the weighting methodology of the Capital Stock Survey and Survey on Discards, because no information on small(er) enterprises is available at all. For these reasons, no weighted data were used in the present paper. Only data from enterprises that actually responded to the surveys was used.[7]

The Investment Survey could be used for service-life calculations for 'in between years' by enabling the estimation of capital stock for those years the Capital Stock Survey was not sent out to a specific industry. As already mentioned, such in-between estimates of capital stock have not been calculated for the purpose of the present paper. This may be done in future analyses though.

2.5 Applying the data

For the analyses presented in this paper data from the Capital Stock Survey in year *t-1* (stock at 31 December) were linked with data from the Discard Survey in year *t* at the enterprise level. This resulted in a database comprising capital stock and discard data for all enterprises that actually responded to the Capital Stock Survey in year *t-1* as well as to the Discard Survey in year *t*. Data from 1993 onwards were used in order to ensure two fairly recent capital stock benchmarks for every industry and to avoid difficulties with the conversion at Statistics Netherlands from the standard industrial classification-1974 to the standard industrial classification-1993.

In the Survey on Discards a distinction is made between scrap and sales on the second-hand market.[8] In the present paper a fixed asset is considered to be discarded when withdrawn from the production process of a particular industry (at approximately 2-digit ISIC level) (meso point of view). Fixed assets withdrawn from the production process by a particular enterprise, and

[7] Other data-source problems included negative capital stock figures, loss of records due to non-response on the Survey on Discards or mismatches after linking records from the Capital Stock Survey and the Survey on Discards, and higher discards than capital stock in certain industry by asset by vintage combinations. However these problems were of minor magnitude and were dealt with straightforwardly.

[8] For recent years (1999 onwards) discards are characterized as scrap, sales on the second-hand market or return to a lease-company. Analyses show that the latter category is only of substantial size for the asset type external transport equipment. The impact of lease and returns to lease-companies will therefore be discussed in section 4.3 with specific reference to external transport.

sold on the second-hand market to another enterprise within the same industry are no discards within this framework. For the capital goods ‘other machinery and other equipment (including internal means of transport)’ and ‘other tangible fixed assets’ it was assumed that all sales on the second-hand market occur between enterprises within the same industry (at approximately 2-digit ISIC level). Therefore, only discards characterized as scrap were considered a discard in the analyses of these capital goods. For all other types of capital goods it was assumed that all sales on the second-hand market occur between enterprises belonging to different industries (domestic or foreign) or between enterprises and households. Therefore, for these remaining categories of assets, scrap as well as sales on the second-hand market were considered to be discards in the analyses.

3. The model

The model described in this paper relates figures on discards with figures on tangible capital stock. Discard and capital stock data on the level of an industrial division (approximately 2-digit ISIC level) are used. Per type of asset the tangible stock of a certain vintage j, in use at the beginning of a reference year, minus the discard values of that vintage during the reference year is divided by the tangible stock of that vintage in use at the beginning of that reference year. For every vintage this ratio gives an approximation of the survival rate. In other words, the probability a capital good of a certain vintage survives until it reaches age *x* given the fact it has reached age *x-1* (where x=t-j). Given the vintage j of a capital good, its age is also determined.[9] Using the fractions mentioned above we obtain a survival rate per age.

In formulas:

$$s_j(x) \equiv \frac{GC_{j(t-1)} - R_{j(t)}}{GC_{j(t-1)}}$$

where

$GC_{j(t)}$ – gross capital stock of vintage j in use at 31 December year t.

$R_{j(t)}$ – value of retirements of vintage j during year t.

$s_j(x)$ – survival rate: the probability that a certain fraction of a population of capital goods of a certain vintage j survives until it reaches age *x* given

[9] Capital goods put into use at the beginning of a year are not distinguished from capital goods put into use at the end of the year. The vintage is determining the age. This boils down to the assumption that a capital good of vintage *j* is put into use at the beginning of that year. At the end of the year its age increases with one year.

the fact it has reached age *x-1*:

$$s_j(x) = P_t(X_j \geq x \mid X_j \geq x-1) \equiv \frac{GC_{j(t-1)} - R_{j(t)}}{GC_{j(t-1)}}.$$

It is assumed that the survival rate at a certain age is equal for all vintages, therefore:

$$s_j(x) = s(x)$$

From the survival rates, the survival function $S(x)$ can then be calculated as follows:

$$S_{(x)} = \prod_{i=1}^{x} s_{(i)} = s_{(x)} \cdot S_{(x-1)} \qquad \text{with } S(0)=1.$$

where,

$S_{(x)}$ – survival function: the probability that a certain fraction of a population of capital goods reaches the age of x year, that is, the probability a fraction of capital goods is not discarded at an age younger than x year.

For the purpose of the present paper it is assumed that the survival function can be described most accurately by a Weibull distribution. The Weibull distribution is given by:

$$S_{(x)} = e^{\left(-(\lambda x)^{\alpha}\right)} \qquad x \geq 0$$

where,

x – age of the capital good;

α – shape parameter;

λ – size parameter.

Given the Weibull distribution parameters, the expected service life equals

$$E_{(x)} = \frac{1}{\lambda} \cdot \Gamma\left(1+1/\alpha\right)$$

Here Γ is the Gamma-function and E(x) the life expectancy.

It can then be estimated which parameter values of the assumed Weibull distribution give the best approximation of the survey results. A drawback of estimating the survival function in this way, is that outliers or missing observations of in reality large discards in a certain year t have an impact on the survival rates calculated for subsequent years. For a detailed example the reader is referred to Annex A.

4. Results: estimated average service lives and discard patterns

The estimation of optimal parameter values of the assumed Weibull distribution was performed at the industry (at approximately 2-digit ISIC level) by asset type level. An adjustment for outliers, to avoid exaggerated tails[10], was made by means of an arbitrary cut off rule. The highest asset-age was determined at which at least a 1% decline in survival was observed, after which five more years were added. Up until this age data were used for analyses.

Within the 1993-2001 period, Capital Stock Survey data were available for two separate years for most industries. For those industries two separate survival functions were estimated. An overview of all results is presented in Annex B.

It then needed to be determined which results were considered reliable enough to be used as input for estimations of the capital stocks and consumption of fixed capital for National Accounts purposes. This was done by visually inspecting the fit of the estimated survival function. If the fitted survival function had an acceptable shape and the estimated service life seemed reasonable, results were considered reliable. In Annex B bold figures represent robust results that were declared reliable enough and figures not printed in bold were rejected because of low quality of the data for the purpose of the analysis conducted here. In Annex C some examples are presented to illustrate the evaluation process.

Whenever results were available for two separate years and both sets of results appeared reliable, the average of the two sets of estimated parameters was taken as the final result. When results were available for two separate years and one set of results was decided to be more reliable than the other set, the more reliable set of estimated parameters was taken as the final result. When all results within a certain industry (by asset type) were determined to be of low quality, parameters estimated within another (as closely related as possible) industry (by same asset type) were adopted (see Annex D for an overview of the results).

The Weibull distribution functions are estimated on the basis of calculated discard fractions as discussed in section 3. These discard fractions are being translated in survival rates which are by definition declining in time. These by definition declining survival rates together with the flexible properties of the Weibull distribution function lead in general to significant estimations of the average service lives and distribution patterns (i.e. the alpha's). This is also shown by the usually high R^2's in Annex B.

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[10] Exaggerated tails are expected to occur when discards are missed by the Survey on Discards.

Overall the results give the impression that the observed discard-values are rather low. In several instances it seems likely that some discards were missed by the Survey on Discards. As already mentioned, a drawback of the method used to calculate the survival function is that missing observations of in reality large discards in a certain year t have an impact on the survival function as calculated for the years after year t. Examples of cases where the data suggest that some discards were missed in the observations are shown in Annex C (e.g. Table C2, first figure, Table C3 second figure and Table C5 both figures). Data were not re-analysed on a higher aggregation level because this would not add any new information (aggregation does not solve the problem in those cases where it is suspected that discards are missing). Instead, as described above, industries with lower quality data were assigned estimates based on other industries (with higher quality data) (see Annex D for an overview of the results). The results are discussed in more detail below.

4.1 Industrial buildings

The final results with respect to industrial buildings are presented in Table 4.1. Only the results of those industries for which reliable estimates could be made are presented here. Capital formation is shown to give an indication of the relative significance of the industries.

Table 4.1 Expected average service lives (e.s.l.) industrial buildings

Industry	e.s.l. (years)	95% CI e.s.l	alpha	95% CI alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	42	41 - 43	2.16	2.06 - 2.26	0.022	186
Manufacture of petroleum products	36	33 - 41	1.30	1.11 - 1.50	0.025	22
Manufacture of basic chemicals, chemical products and man-made fibres	41	39 - 43	1.77	1.58 - 1.96	0.022	142
Manufacture of fabricated metal products	31	29 - 33	0.97	0.91 - 1.04	0.033	77
Manufacture of machinery and equipment n.e.c.	44	43 - 47	1.34	1.26 - 1.42	0.021	94
Manufacture of audio-, video- and telecommunication equipment	18	18 - 19	1.33	1.28 -1.39	0.050	50
Manufacture of cars and trailers	36	35 - 38	2.21	1.87 - 2.55	0.024	27

In general the predicted alpha's are relatively low which may be caused by a wide distribution of service lives over time, and therefore heterogeneity of the asset industrial buildings within the industries. This only emphasizes once more that the simultaneous exit discard pattern is an inappropriate retirement pattern.

The relatively low alpha's are not unique to the asset type industrial buildings. As will be shown below, low alpha's and therefore heterogeneity of the assets within the industries were found for all asset types.

4.2 Civil engineering works

Estimating service lives for the asset type civil engineering (non-industrial buildings, and structures) is very difficult. Data are obscured by very old vintages still found. It is questionable whether these capital goods still have the right vintage attached. Chances are that these fixed assets are already "upgraded" in such a way that at least part of the total value should have obtained a much younger vintage. As an example one can think of replacing the top layer of a parking lot. The top layer may be replaced several times while the bottom layer remains unaffected. It is questionable whether in the Survey on Discards, the replacement of the top layer is registered as a discard for the parking lot. Furthermore the replaced top layer should obtain the vintage of the year it is built, and should not be taken as part of the parking lot (with an older vintage of its own). Consequently, (too) small discard values in a certain reference period are divided by (too) large remaining capital stock values (old parking lot including old top layer plus new top layer with the parking lot vintage attached). This may result in overstated survival rates and overestimation of the expected service lives.

Our results confirm the above. Even when data were aggregated over industries hardly any discards of 'civil engineering works' were observed. This means few survival rates can be calculated in a certain reference period and the estimates are sometimes highly distorted by peak values. In addition, the G.N.I. committee, that is responsible for the harmonisation of G.N.I. estimates within the European Union, has the intention to prescribe a service life of 55 years for civil engineering works unless evidence can be provided that 55 is an incorrect age for civil engineering works in a specific country. It was therefore decided that in the case of the Netherlands an expected service life of 55 years will be used for all civil engineering works, private and public.[11] In addition, an alpha of 1.5 was selected to represent the large variation in service lives within the group of civil engineering works.

4.3 External transport equipment

Results for external transport equipment are shown in Table 4.2. For 11 of 19 industries estimates based on direct observations were considered to be reliable.

Table 4.2 Expected average service lives (e.s.l.) external transport equipment

Industry	e.s.l. (years)	95% CI e.s.l	alpha	95% CI alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	5	5 - 6	1.41	1.29 - 1.53	0.173	53
Manufacture of textile and leather products	5	4 - 6	1.13	0.92 - 1.34	0.210	5
Manufacture of paper and paper products	4	4 - 5	1.27	1.09 - 1.45	0.231	3
Publishing and printing	4	4 - 4	2.12	1.68 - 2.56	0.235	14
Manufacture of petroleum products	4	4 - 6	1.09	0.78 - 1.41	0.220	1
Manufacture of basic chemicals, chemical products and man-made fibres	6	5 - 7	1.30	1.03 - 1.56	0.154	9
Manufacture of basic metals	7	6 - 7	2.00	1.76 - 2.24	0.134	3
Manufacture of fabricated metal products	5	4 - 5	1.47	1.24 - 1.71	0.193	36
Manufacture of machinery and equipment n.e.c.	4	3 - 4	1.79	1.33 - 2.26	0.251	28
Manufacture of medical instruments and equipment	5	4 - 6	1.46	1.21 - 1.71	0.189	5
Other manufacturing	6	5 - 7	1.21	1.03 - 1.40	0.163	24

[11] The only exceptions to this rule are ISIC 10, 11, 14 (e.s.l. 35 years), ISIC 40, 41 (e.s.l. 35 years), ISIC 6301 (e.s.l. 40 years) and ISIC 64 (e.s.l. 25 years). Within these industries expert-guesses suggested there were reasons to deviate from the 55 years mentioned above.

However, the role of lease-contracts is substantial for this asset type. Information on capital goods ownership and lease[12] is available at the micro level. Information on discards with the destination 'return to lease-company' is only available for the years 1999 onwards. Before the year 1999 discards are only characterized as scrap versus sales. Analyses of data for the years 1999-2001 show that lease only plays a substantial role for the asset type external transport equipment (e.g. in 2000 75% of all discards of external transport equipment were characterized as 'return to lease-company' whereas this percentage was between 0 and 1 for the other asset types). This implies that the estimations of expected service lives for the asset type external transport equipment are to a large extent estimations of the average duration of lease-contracts. However, the assumption is that lease-companies in most cases will sell the returned cars to households in stead of hiring them out to enterprises once again. Assuming this implies that, as far as car-leasing companies are concerned, the estimation of service lives for external transport equipment is not obscured by the high percentage of lease, since sales to households are considered discards in the present paper. However, for the manufacturing industry the high percentage of lease implies that the estimated expected service lives as shown in Table 4.2 are likely to be too short since the average duration of lease-contracts is probably shorter than the average service life of the owned external transport equipment within the manufacturing industry. Therefore, for the years 1999 to 2001 the analyses were repeated excluding leased external transport equipment and excluding discards characterized as 'return to lease-company'. It turned out that such analyses were only meaningful in the industry Manufacture of food products, beverages and tobacco (data from 1999, see also Table 4.2.1). In all other industries, either the capital stock remaining after exclusion of leased external transport equipment or the amount of discards remaining after exclusion of discards characterized as 'return to lease-company' (or both) was too low to allow for meaningful analyses. Results for the industry Manufacture of food products, beverages and tobacco are summarized in Table 4.2.1. The first two lines show the original results, the average of which was taken originally (line 3) because both years were considered to give reliable results. Results after exclusion of leased capital as well as discards characterized as 'return to lease-company' are shown on line 4. As expected the estimated average service life based on data excluding lease and returns to lease-companies is higher than the average service life originally estimated for 1999. Furthermore, the newly estimated average service life for 1999 resembles the average service life estimated for 1994 much more closely. This is also in line with the expectations since the leasing of transport equipment was uncommon in 1994

[12] A distinction between financial and operational lease is not available but from analyses of data from the Investment Survey it is clear that financial lease is very small as compared to operational lease.

as compared to 1999 and no large change in average service life is anticipated to have occurred between 1994 and 1999. These results regarding the effect of lease indicate it may be valid to raise the estimated average service lives somewhat for all industries shown in Table 4.2 (e.g. by 0.712 years).

Table 4.2.1 Expected average service lives (e.s.l.) external transport equipment, with and without leased capital and discards returned to lease-company (Manufacture of food products, beverages and tobacco industry).

Data	year	e.s.l. (years)	95% CI lower b.	upper b.	alpha	95% CI lower b.	upper b.
Original data (scrap plus sales)	1994	6.1	5.8	6.5	1.39	1.27	1.50
Original data (scrap plus sales, including return to lease-company)	1999	4.6	4.2	5.1	1.43	1.21	1.65
Average of original data from 1994 and 1999	(1994+1999)/2	5.4	5.1	5.7	1.41	1.29	1.53
Original data excluding lease / return to lease-company	1999	6.0	5.8	6.3	1.48	1.37	1.60
New average of 1994 and 1999	(1994+1999)/2	6.07	5.8	6.4	1.44	1.32	1.55

4.4 Computers

Results for computers are presented in Table 4.3. For 11 of the 19 industries estimates based on direct observations were considered to be reliable. The expected service lives appear somewhat high. An explanation for this may be found in the kind of computers that are used within these industries. It should be noted that the definition of computers includes all data processing machines that are freely programmable, which may not predominantly be personal computers but larger mainframes as well within the industries under investigation here. However, the estimates are clearly too high for personal computers and should therefore not be used for the computers within for instance the industry Financial and business activities.

Table 4.3 Expected average service lives (e.s.l.) computers

Industry	e.s.l. (years)	95% CI e.s.l	alpha	95% CI alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	12	11 - 12	1.50	1.32 - 1.68	0.076	59
Manufacture of textile and leather products	14	12 - 16	1.57	1.18 - 1.96	0.066	5
Manufacture of paper and paper products	6	6 - 7	1.32	1.11 - 1.53	0.150	14
Publishing and printing	8	7 - 8	1.52	1.36 - 1.68	0.119	81
Manufacture of petroleum products	8	8 - 9	2.84	2.15 - 3.52	0.109	6
Manufacture of basic chemicals, chemical products and man-made fibres	12	11 - 13	2.03	1.68 - 2.37	0.074	42
Manufacture of fabricated metal products	8	7 - 8	2.05	1.84 - 2.26	0.115	33
Manufacture of machinery and equipment n.e.c.	12	11 - 12	1.43	1.30 - 1.56	0.077	89
Manufacture of audio-, video- and telecommunication equipment	6	6 - 7	1.55	1.44 - 1.66	0.143	16
Manufacture of cars and trailers	4	3 - 4	1.14	0.99 - 1.28	0.268	6
Other manufacturing	10	9 - 11	2.25	1.91 - 2.59	0.092	23

4.5 Machinery and equipment (including internal transport equipment)

Results for machinery and equipment are shown in Table 4.4. For 12 of the 19 industries estimates based on direct observations were considered to be reliable.

The differences between the industries are rather large, with the estimated average service lives ranging from only 12 years within the industry

Manufacture of cars and trailers to 43 years within the industry Manufacture of basis chemicals, chemical products and man-made fibres.

Table 4.4 Expected average service lives (e.s.l.) machinery and equipment

Industry	e.s.l. (years)	95% CI e.s.l	alpha	95% CI alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	27	26 - 27	1.75	1.70 - 1.80	0.033	946
Manufacture of textile and leather products	35	34 - 36	2.50	2.27 - 2.73	0.025	72
Publishing and printing	35	32 - 38	1.53	1.36 - 1.70	0.026	295
Manufacture of petroleum products	22	21 - 24	1.49	1.33 - 1.66	0.041	99
Manufacture of basic chemicals, chemical products and man-made fibres	43	48 - 52	2.18	1.65 - 1.92	0.020	957
Manufacture of building material	30	29 - 31	1.52	1.39 - 1.64	0.030	279
Manufacture of fabricated metal products	33	32 - 36	2.50	2.21 - 2.80	0.027	295
Manufacture of office machines and computers	21	20 - 22	1.83	1.62 - 2.04	0.043	30
Manufacture of audio-, video- and telecommunication equipment	18	17 - 18	1.54	1.50 - 1.58	0.054	361
Manufacture of medical instruments and equipment	15	14 - 16	1.27	1.17 - 1.37	0.062	49
Manufacture of cars and trailers	12	12 - 12	2.11	1.98 - 2.25	0.074	107
Manufacture of transport equipment (other than cars and trailers)	36	35 - 38	1.29	1.22 - 1.37	0.025	34

4.6 Other tangible fixed assets

Results for other tangible fixed assets are presented in Table 4.5. For only 7 of the 19 industries estimates based on direct observations were determined to be of an acceptable quality. Again, the differences between the industries are rather large, with the estimated average service lives ranging from 8 years within the industry Manufacture of audio-, video- and telecommunication equipment to 32 years within the industry Manufacture of building material.

Table 4.5 Expected average service lives (e.s.l.) other tangible fixed assets

Industry	e.s.l. (years)	95% CI e.s.l	alpha	95% CI alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	24	21 - 28	0.98	0.84 - 1.13	0.042	166
Manufacture of textile and leather products	30	28 - 32	2.69	2.07 - 3.32	0.030	10
Manufacture of building material	32	30 - 35	1.99	1.65 - 2.32	0.028	21
Manufacture of basic metals	30	28 - 33	1.50	1.33 - 1.66	0.030	3
Manufacture of audio-, video- and telecommunication equipment	8	8 - 9	2.63	2.29 - 2.97	0.108	35
Manufacture of medical instruments and equipment	12	12 - 13	2.50	2.12 - 2.88	0.072	14
Manufacture of transport equipment (other than cars and trailers)	11	10 - 13	1.43	1.10 - 1.76	0.081	11

4.7 Final service lives and discard patters: input for the National Accounts

After scrutinizing the results as presented in Annex D one more time, some last changes were adopted before a final table of service lives and discard patters to be used for the calculation of consumption of fixed capital and net capital stock for the National Accounts was agreed upon.

The most influential change was the adoption of a maximum service life of 12 years for ‘other tangible fixed assets’ because expert guesses indicated that service lives over 12 years were unacceptably high. In addition, the estimated service lives of ‘external transport equipment’ were raised with 0.712 years as suggested in section 4.3. Furthermore, it was decided to adopt minimum service lives for external transport equipment (5 years), computers (5 years) and industrial buildings (30 years). The adoption of these minimum service lives had only very limited impact on the estimations. Finally, for ‘machinery and equipment’ a service life of 30 years was adopted whenever the estimated service life was larger than the service life of industrial buildings in the corresponding industry. [13] Alpha's were not changed, only for alpha's smaller than 1 an alpha of 1.01 was adopted. The reason for this is the fact that when alpha is equal to or smaller than one, the derivative of the function is not equal to zero at t=0 (asset-age is zero years). In other words, with an alpha equal to or smaller than one, discards take place at t=0 which does not seem plausible.

In Annex E the final table of service lives and discard pattern parameters is presented.

5. Conclusions

This paper describes a method for estimating discard patterns for tangible fixed assets, based on direct observations. Using these discard patterns, expected service lives can be calculated. The results presented in this paper suggest that differences between industries are large, both in expected average service lives as well as in the shape of the distribution.

Although the estimations are based direct observations, the results give the impression that in general the observed discard-values are rather low and therefore the estimated average service lives are rather high.[14] In several instances it seems likely that some discards were missed by the Survey on Discards. It is probable that investments such as improvements and renovations of existing assets are not always registered as discards at the same time. This seems most likely for those asset types that have a high chance of being partially replaced during their life span, such as civil engineering works and (larger) machinery and equipment.

In addition, it should be noted that the results presented here are based on data from enterprises with 100 or more employees. Such rather large enterprises may on average have an older capital stock than small enterprises. This may have led to an overestimation of the average service lives. Since there is no data available on the average vintage of the capital stock in small(er) enterprises, we have no way of investigating this hypothesis.

It should also be noted that all the results presented in this paper are based on data from a time period of economic recovery in the Netherlands. If the higher investments in such a period coincide with a higher propensity to discard old capital goods, this would imply that total discards are overestimated in the

[13] Within the industry 'Manufacture of cars and trailers' a service life of 30 years was adopted because the originally estimated service life of 11.9 was considered too low.

[14] With the exception of the asset-type external transport equipment where estimated service lives are rather low because of the influence of lease-contracts. (see also section 4.3).

present paper. Since we have the impression that the estimated service lives are rather long, this effect seems not to be very substantial.

As described in section 4.7, the impression that the estimated average service lives are rather high has led us to adjust the service lives of ‘other tangible fixed assets’ to never exceed 12 years.

The estimated survival functions presented in this report will be applied to a long time series covering more than fifty years. Yet, it is likely that quality changes in assets and changes in rates of obsolescence may lead to changes in survival patterns over time. These dynamics are subject to future research.

Finally, it should be kept in mind that the estimated discard patterns and average service lives presented here only concern the Manufacturing industry. The total investments within the Manufacturing industry only comprise around 9 to 10 percent of total investments in the Netherlands. No directly observed data are available for most other industries. Therefore, estimations of discard patterns and service lives for those industries will have to be based on other information. For certain assets (e.g. cars, computers) it may be assumed that results for the Manufacturing industry are representative for (some) other industries.

Acknowledgement

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Annex A: Example illustrating the methodology

This annex contains an example (with imaginary figures) illustrating the methodology used for estimating survival functions and average service lives using direct observations. We assume the following data on gross capital stock and discard values are reported for reference date 31 December 1997 (all in historical prices).

Table A1: Imaginary data to illustrate the methodology.

j	x_j	$GC_j(1996)$	$R_j(1997)$	$s_j(x)$	$S(x)$
1996	1	95	1	0.989	0.989
1995	2	100	2	0.980	0.970
1994	3	80	4	0.950	0.921
1993	4	80	7	0.913	0.841
1992	5	60	20	0.667	0.560
1991	6	70	30	0.571	0.320
1990	7	50	40	0.200	0.064
1989	8	50	20	0.600	0.038
1988	9	30	20	0.333	0.013
1987	10	40	18	0.550	0.007

x_j – age of capital good with vintage *j*, for this example $x_j = 1997 - j$

$GC_j(1996)$ – gross capital stock of vintage *j* in use at 31 December year 1996.

$R_j(1997)$ – value of retirements of vintage *j* during year 1997.

$s_j(x)$ – survival rate: the probability a capital good of a certain vintage j survives until it reaches age *x* given the fact it has reached age *x-1*:

$$s_j(x) = P_{1997}(X_j \geq x \mid X_j \geq x-1) \equiv \frac{GC_j(1996) - R_j(1997)}{GC_j(1996)}.$$

$S(x)$ – survival function: the probability a capital good reaches the age of x year, that is, the probability a capital good is not discarded at an age younger than x year:

$$S(x) = \prod_{i=1}^{x} s(i) = s(x) \cdot S(x-1) \quad \text{with } S(0)=1.$$

The Weibull parameters can be estimated directly using constrained nonlinear regression, which –as linear regression- estimates parameters by minimizing the sum of the squared residuals. Unlike traditional linear regression, which is restricted to estimating linear models, nonlinear regression can estimate models with arbitrary relationships between independent and dependent variables. This is accomplished using iterative estimation algorithms.

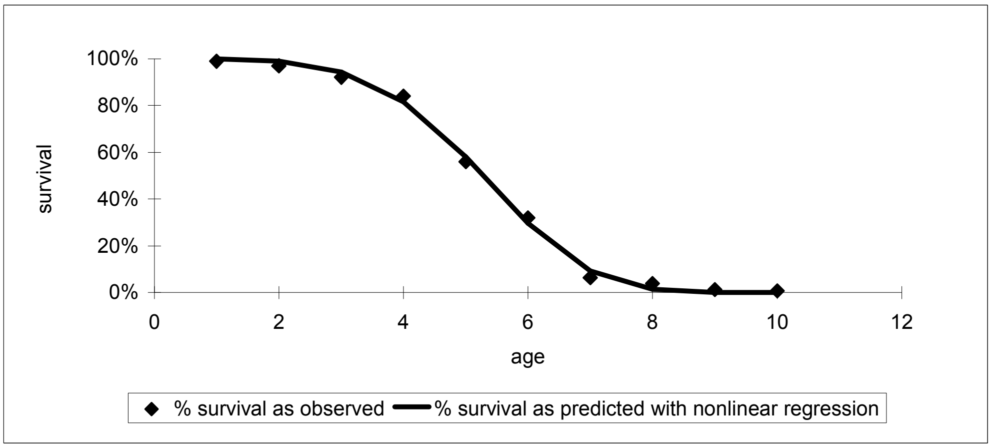
Using constrained nonlinear regression the equation $S(x) = e^{\left(-(\lambda x)^{\alpha}\right)}$ can be estimated, resulting in:

$$S(x) = e^{-(0.17412x)^{4.3897}}, R^2 = 0.997$$

From this for the expected service life it follows that:

$$E(x) = \frac{1}{\lambda} \cdot \Gamma\left(1+1/\alpha\right) = \frac{1}{0.17412} \cdot \Gamma(1 + 0.23) = \frac{0.9113}{0.17412} \approx 5.2$$

Figure A1: The Weibull distribution using the estimated parameters (nonlinear regression) confronted with the originally observed distribution.



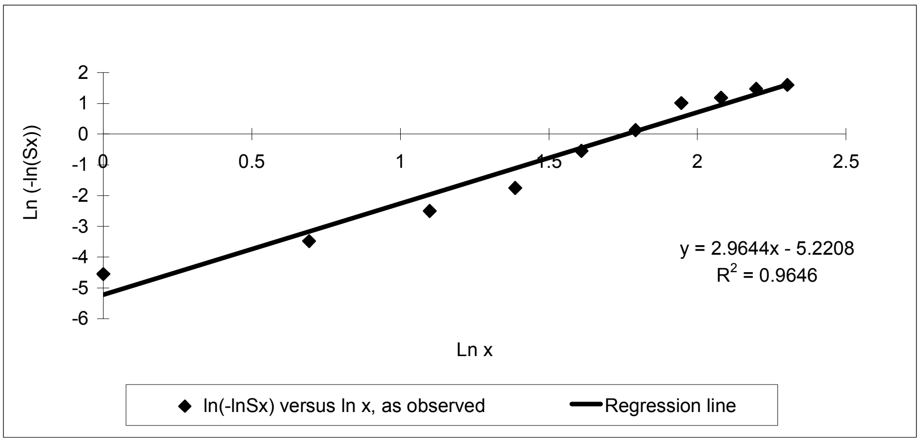
The results presented above differ from results that would be obtained using linear regression on ln-transformed data. Linear regression analysis on ln-transformed data is often used for the estimation of parameter values of the most appropriate Weibull distribution. It has in fact been used at Statistics Netherlands in the past. To illustrate the differences between the two methods, results of parameter estimation using linear regression on ln-transformed data are shown below.

Using linear regression the equation $\ln(-\ln S(x)) = \beta + \alpha \cdot \ln(x)$ can be estimated, resulting in (see also figure A2):

$$\ln(-\ln S(x)) = -5.22 + 2.96 \cdot \ln(x), \qquad R^2 = 0.96$$

This is the kind of 'hazard rate' as estimated by Meinen (1996) et al.

Figure A2: Plot of $\ln(-\ln S(x))$ versus ln *x* (regression line included).



From these parameter estimates the best estimates for the Weibull parameters are calculated as follows:

$$\alpha = a = 2.96$$

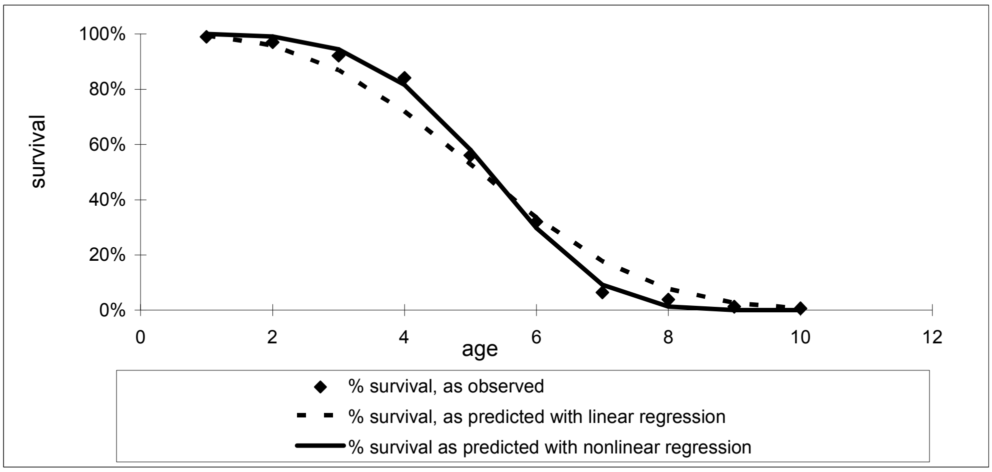
$$\lambda = e^{b/a} \approx e^{-5.22/2.96} \approx e^{-1.76} \approx 0.17$$

From this for the expected service life it follows that:

$$E(x) = \frac{1}{\lambda} \cdot \Gamma\left(1+1/\alpha\right) = \frac{1}{0.17} \cdot \Gamma(1 + 0.34) = \frac{0.89}{0.17} \approx 5.2$$

As shown in Figure A3, the estimation of the Weibull parameters using linear regression leads to a bias. This bias is introduced because of the use of ln-transformations and can be avoided by estimating the Weibull parameters directly using constrained nonlinear regression. Although the expected service life is roughly equal to that estimated with linear regression, when the Weibull parameters are estimated directly the predicted discard pattern is much closer to the original data than is the case with the estimation by linear regression (see figure A3). For this reason the direct estimation of optimal Weibull parameter values by means of nonlinear regression is used for the analyses in the present paper.

Figure A3: The Weibull distribution using the parameters estimated with linear regression and using the parameters estimated with nonlinear regression confronted with the originally observed distribution.



Annex B – Overview of estimates

Bold figures represent robust results that were declared usable. Other figures (not printed in bold) were rejected because of low quality of the data.

e.s.l. = expected average service life (in years).

Table B1: Manufacture of food products, beverages and tobacco

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1994	**34.66**	**2.00**	**0.026**	**0.95**	1999	**49.08**	**2.32**	**0.018**	**0.99**
External transport equipment	1994	**6.10**	**1.39**	**0.150**	**0.99**	1999	**4.61**	**1.43**	**0.197**	**0.98**
Machinery and equipment	1994	**26.77**	**1.75**	**0.033**	**1.00**	1999	27.66	1.53	0.033	0.98
Computers	1994	13.44	1.64	0.067	0.99	1999	**11.84**	**1.50**	**0.076**	**0.97**
Other tangible fixed assets	1994	**24.07**	**0.98**	**0.042**	**0.91**	1999	22.08	0.83	0.050	0.92

Table B2: Manufacture of textile and leather products

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	41.98	2.73	0.021	0.82	2000	38.44	8.00	0.025	0.83
External transport equipment	1995	**4.55**	**1.13**	**0.210**	**0.96**	2000	8.66	0.80	0.131	0.83
Machinery and equipment	1995	47.63	2.95	0.019	0.76	2000	**35.27**	**2.50**	**0.025**	**0.97**
Computers	1995	**13.55**	**1.57**	**0.066**	**0.91**	2000	41.31	1.33	0.022	0.87
Other tangible fixed assets	1995	73.10	1.35	0.013	0.95	2000	**29.74**	**2.69**	**0.030**	**0.88**

Table B3: Manufacture of wood and wood products

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	5005.45	0.63	0.000	0.82	2000	48.29	3.97	0.019	0.79
External transport equipment	1995	4.21	1.26	0.221	0.90	2000	16.76	0.75	0.071	0.75
Machinery and equipment	1995	67.27	1.59	0.013	0.95	2000	43.51	3.43	0.021	0.82
Computers	1995	9.76	1.68	0.092	0.88	2000	68.12	1.31	0.014	0.87
Other tangible fixed assets	1995	8951.55	3.16	0.000	-	2000	8964.49	3.26	0.000	-

Table B4: Manufacture of paper and paper products

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1996	293.02	0.55	0.006	0.84	2001	89.71	1.02	0.011	0.77
External transport equipment	1996	**3.78**	**1.08**	**0.257**	**0.97**	2001	**4.41**	**1.46**	**0.205**	**0.96**
Machinery and equipment	1996	42.16	0.92	0.025	0.92	2001	50.83	2.00	0.017	0.96
Computers	1996	**6.12**	**1.32**	**0.150**	**0.97**	2001	13.34	3.91	0.068	0.96
Other tangible fixed assets	1996	61.96	0.63	0.023	0.96	2001	66.80	2.31	0.013	0.91

Table B5: Publishing and printing[15]

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1998	40.44	0.58	0.039	0.80	2003	n.a.	n.a.	n.a.	n.a.
External transport equipment	1998	**3.76**	**2.12**	**0.235**	**0.97**	2003	n.a.	n.a.	n.a.	n.a.
Machinery and equipment	1998	**34.66**	**1.53**	**0.026**	**0.96**	2003	n.a.	n.a.	n.a.	n.a.
Computers	1998	**7.57**	**1.52**	**0.119**	**0.99**	2003	n.a.	n.a.	n.a.	n.a.
Other tangible fixed assets	1998	38.86	0.85	0.028	0.87	2003	n.a.	n.a.	n.a.	n.a.

[15] n.a. = not available

Table B6: Manufacture of petroleum products

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	**36.31**	**1.30**	**0.025**	**0.93**	2000	35.16	8.00	0.027	0.92
External transport equipment	1995	**4.40**	**1.09**	**0.220**	**0.89**	2000	6.10	0.60	0.247	0.77
Machinery and equipment	1995	64.92	2.14	0.014	0.98	2000	**22.06**	**1.49**	**0.041**	**0.96**
Computers	1995	18.49	1.55	0.049	0.79	2000	**8.14**	**2.84**	**0.109**	**0.96**
Other tangible fixed assets	1995	2403.42	0.56	0.001	0.74	2000	51.78	8.00	0.018	0.91

Table B7: Manufacture of basic chemicals, chemical products and man-made fibres[16]

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1998	**41.08**	**1.77**	**0.022**	**0.95**	2003	n.a.	n.a.	n.a.	n.a.
External transport equipment	1998	**6.00**	**1.30**	**0.154**	**0.95**	2003	n.a.	n.a.	n.a.	n.a.
Machinery and equipment	1998	**43.46**	**2.18**	**0.020**	**0.99**	2003	n.a.	n.a.	n.a.	n.a.
Computers	1998	**11.91**	**2.03**	**0.074**	**0.96**	2003	n.a.	n.a.	n.a.	n.a.
Other tangible fixed assets	1998	39.78	2.71	0.022	0.97	2003	n.a.	n.a.	n.a.	n.a.

Table B8: Manufacture of rubber and plastic products[16]

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1997	43.55	4.33	0.021	0.93	2002	n.a.	n.a.	n.a.	n.a.
External transport equipment	1997	4.81	0.99	0.209	0.84	2002	n.a.	n.a.	n.a.	n.a.
Machinery and equipment	1997	49.72	1.31	0.019	0.97	2002	n.a.	n.a.	n.a.	n.a.
Computers	1997	28.72	1.35	0.032	0.93	2002	n.a.	n.a.	n.a.	n.a.
Other tangible fixed assets	1997	71.42	0.88	0.015	0.84	2002	n.a.	n.a.	n.a.	n.a.

Table B9: Manufacture of building material[16]

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1997	78.68	1.08	0.012	0.91	2002	n.a.	n.a.	n.a.	n.a.
External transport equipment	1997	8.17	0.80	0.138	0.87	2002	n.a.	n.a.	n.a.	n.a.
Machinery and equipment	1997	**29.82**	**1.52**	**0.030**	**0.97**	2002	n.a.	n.a.	n.a.	n.a.
Computers	1997	25.63	1.15	0.037	0.95	2002	n.a.	n.a.	n.a.	n.a.
Other tangible fixed assets	1997	**31.99**	**1.99**	**0.028**	**0.93**	2002	n.a.	n.a.	n.a.	n.a.

Table B10: Manufacture of basic metals

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	63.24	2.22	0.014	0.91	2000	131.12	0.74	0.009	0.92
External transport equipment	1995	**6.63**	**2.00**	**0.134**	**0.99**	2000	9.70	1.08	0.100	0.94
Machinery and equipment	1995	47.37	2.14	0.019	0.97	2000	138.76	1.84	0.006	0.97
Computers	1995	17.38	3.13	0.051	0.98	2000	151.55	0.83	0.007	0.91
Other tangible fixed assets	1995	**30.21**	**1.50**	**0.030**	**0.97**	2000	170.66	0.80	0.007	0.96

Table B11: Manufacture of fabricated metal products

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1996	317.41	0.79	0.004	0.87	2001	**30.78**	**0.97**	**0.033**	**0.83**
External transport equipment	1996	**4.69**	**1.47**	**0.193**	**0.98**	2001	9.56	0.90	0.110	0.86
Machinery and equipment	1996	**32.78**	**2.50**	**0.027**	**0.95**	2001	71.25	1.42	0.013	0.88
Computers	1996	**7.67**	**2.05**	**0.115**	**0.99**	2001	40.73	0.93	0.025	0.92
Other tangible fixed assets	1996	50.33	1.41	0.018	0.96	2001	98.55	1.71	0.009	0.93

[16] n.a. = not available

Table B12: Manufacture of machinery and equipment n.e.c.[16]

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1997	**44.41**	**1.34**	**0.021**	**0.99**	2002	n.a.	n.a.	n.a.	n.a.
External transport equipment	1997	**3.54**	**1.79**	**0.251**	**0.96**	2002	n.a.	n.a.	n.a.	n.a.
Machinery and equipment	1997	63.03	1.03	0.016	0.88	2002	n.a.	n.a.	n.a.	n.a.
Computers	1997	**11.78**	**1.43**	**0.077**	**0.99**	2002	n.a.	n.a.	n.a.	n.a.
Other tangible fixed assets	1997	37.48	1.28	0.025	0.94	2002	n.a.	n.a.	n.a.	n.a.

Table B13: Manufacture of office machines and computers

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	48.29	2.97	0.018	0.85	2000	580.04	0.89	0.002	0.74
External transport equipment	1995	6.32	1.04	0.156	0.77	2000	2.99	3.61	0.302	0.96
Machinery and equipment	1995	**20.80**	**1.83**	**0.043**	**0.97**	2000	8917.72	2.91	0.000	-
Computers	1995	26.49	0.61	0.055	0.87	2000	11.01	1.78	0.081	0.92
Other tangible fixed assets	1995	49.82	1.86	0.018	0.93	2000	39.56	6.42	0.024	0.86

Table B14: Manufacture of (other) electronic machinery and equipment

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	58.76	8.00	0.016	0.78	2000	5.59	6.24	0.166	0.95
External transport equipment	1995	3.54	1.57	0.253	0.97	2000	3.46	0.78	0.333	0.67
Machinery and equipment	1995	50.04	1.49	0.018	0.74	2000	66.92	1.06	0.015	0.96
Computers	1995	26.69	1.12	0.036	0.95	2000	49.89	1.06	0.020	0.91
Other tangible fixed assets	1995	43.12	0.98	0.023	0.91	2000	9696.20	1.08	0.000	0.13

Table B15: Manufacture of audio-, video- and telecommunication equipment

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	**18.37**	**1.33**	**0.050**	**0.99**	2000	10.67	0.99	0.094	0.86
External transport equipment	1995	2.76	3.32	0.325	0.99	2000	2.07	2.28	0.427	1.00
Machinery and equipment	1995	**13.37**	**1.47**	**0.068**	**1.00**	2000	**21.73**	**1.61**	**0.041**	**1.00**
Computers	1995	**6.45**	**1.67**	**0.138**	**0.99**	2000	**6.17**	**1.43**	**0.147**	**0.98**
Other tangible fixed assets	1995	**8.23**	**2.63**	**0.108**	**0.99**	2000	6.05	1.12	0.159	0.96

Table B16: Manufacture of medical instruments and equipment

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	50.65	1.17	0.019	0.91	2000	30.13	2.33	0.029	0.83
External transport equipment	1995	**5.55**	**1.07**	**0.176**	**0.88**	2000	**4.41**	**1.85**	**0.202**	**0.99**
Machinery and equipment	1995	**15.01**	**1.27**	**0.062**	**0.98**	2000	5.70	1.48	0.159	0.97
Computers	1995	8.63	4.86	0.106	0.96	2000	3.65	8.00	0.258	0.99
Other tangible fixed assets	1995	**12.34**	**2.50**	**0.072**	**0.98**	2000	5.27	1.39	0.173	0.96

Table B17: Manufacture of cars and trailers

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1996	**36.29**	**2.21**	**0.024**	**0.93**	2001	106.41	1.21	0.009	0.91
External transport equipment	1996	4.93	4.93	0.186	0.96	2001	7.98	2.68	0.111	0.82
Machinery and equipment	1996	22.71	2.18	0.039	0.96	2001	**11.90**	**2.11**	**0.074**	**0.99**
Computers	1996	9.07	2.62	0.098	0.98	2001	**3.56**	**1.14**	**0.268**	**0.99**
Other tangible fixed assets	1996	105.96	1.64	0.008	0.71	2001	799.46	0.60	0.002	0.75

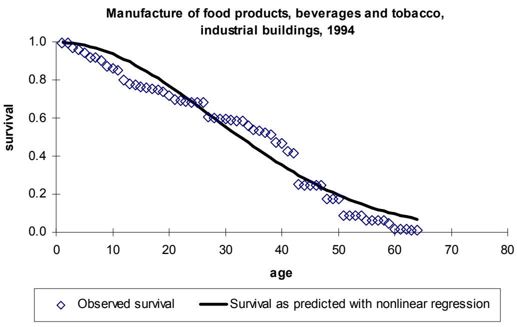
Table B18: Manufacture of transport equipment (other than cars and trailers)

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1996	29.23	8.00	0.032	0.82	2001	42.88	8.00	0.022	0.80
External transport equipment	1996	31.50	0.49	0.065	0.71	2001	5.58	1.22	0.168	0.81
Machinery and equipment	1996	40.23	1.11	0.024	0.92	2001	**36.47**	**1.29**	**0.025**	**0.98**
Computers	1996	15.01	2.31	0.059	0.85	2001	12.26	1.57	0.073	0.96
Other tangible fixed assets	1996	11.54	1.90	0.077	0.80	2001	**11.16**	**1.43**	**0.081**	**0.94**

Table B19: Other manufacturing

Asset type	year	e.s.l.	alpha	lambda	R^2	year	e.s.l.	alpha	lambda	R^2
Industrial buildings	1995	22924.79	0.47	0.000	0.69	2000	21462.34	0.48	0.000	-
External transport equipment	1995	**5.28**	**1.19**	**0.178**	**0.94**	2000	**6.34**	**1.23**	**0.147**	**0.96**
Machinery and equipment	1995	50.64	3.57	0.018	0.82	2000	134.94	1.39	0.007	0.93
Computers	1995	**8.49**	**1.76**	**0.105**	**0.90**	2000	**11.32**	**2.75**	**0.079**	**0.98**
Other tangible fixed assets	1995	27.57	1.82	0.032	0.92	2000	119.79	1.84	0.007	0.95

Annex C – Examples to illustrate how results were evaluated



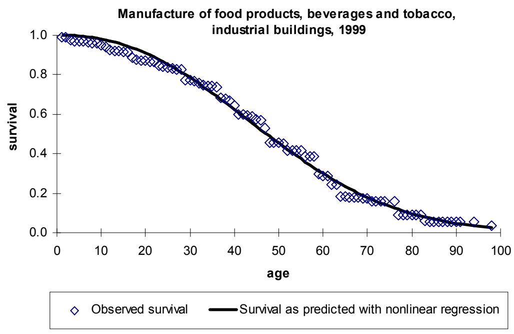
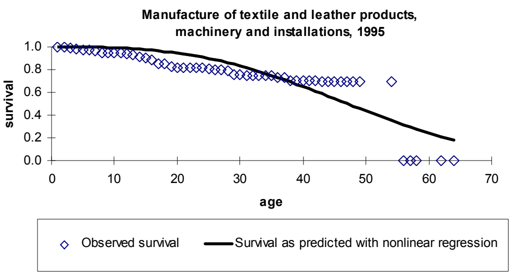


Table C1: Manufacture of food products, beverages and tobacco; industrial buildings

	Industry	Year	e.s.l. (years)	alpha	lambda
Results:					
	Manufacture of food products, beverages. & tobacco	1994	34.66	2.00	0.026
	Manufacture of food products, beverages. & tobacco	1999	49.08	2.32	0.018
Selected:					
	Manufacture of food products, beverages. & tobacco	Average of results 1994 and 1999	41.87	2.16	0.022



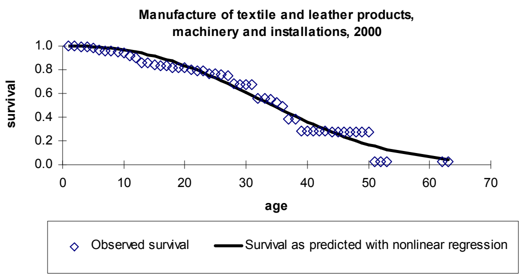
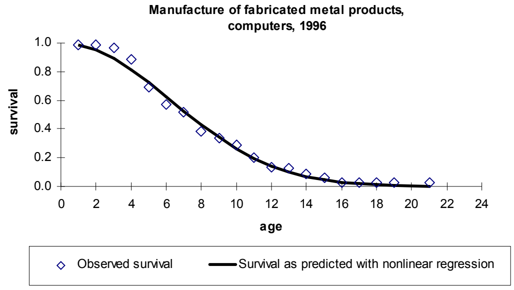


Table C2: Manufacture of textile and leather products; machinery and equipment

	Industry	Year	e.s.l. (years)	alpha	lambda
Results:					
	Manufacture of textile & leather products	1995	47.63	2.95	0.019
	Manufacture of textile & leather products	2000	35.27	2.50	0.025
Selected:					
	Manufacture of textile & leather products	2000	35.27	2.50	0.025



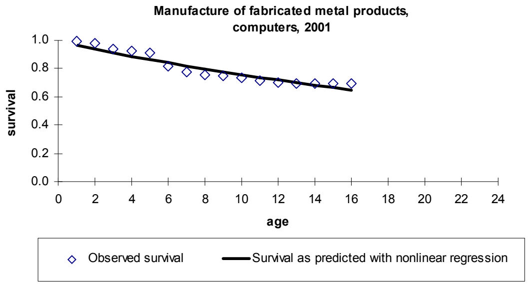
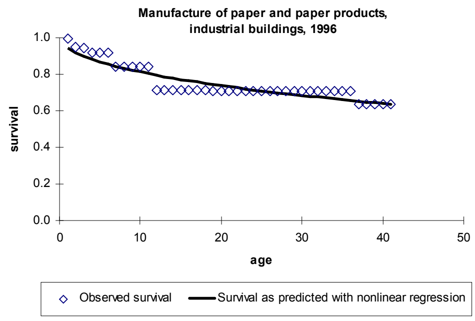


Table C3: Manufacture of fabricated metal products; computers

	Industry	Year	e.s.l. (years)	alpha	lambda
Results:					
	Manufacture of fabricated metal products	1996	7.67	2.05	0.115
	Manufacture of fabricated metal products	2001	40.73	0.93	0.025
Selected:					
	Manufacture of fabricated metal products	1996	7.67	2.05	0.115



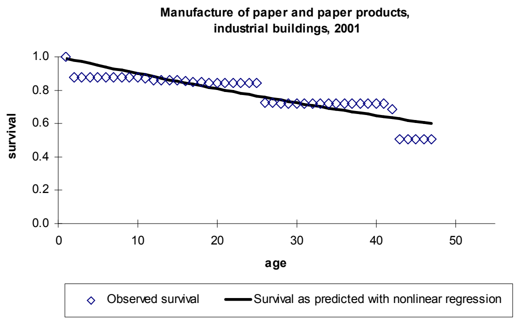
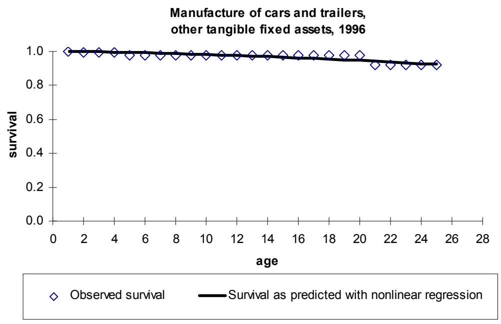


Table C4: Manufacture of paper and paper products; industrial buildings

	Industry	Year	e.s.l. (years)	alpha	lambda
Results:					
	Manufacture of paper and paper products	1996	293.02	0.55	0.006
	Manufacture of paper and paper products	2001	89.71	1.02	0.011
Selected:					
	Manufacture of food products, beverages. & tobacco	Average of results 1994 and 1999	41.87	2.16	0.022



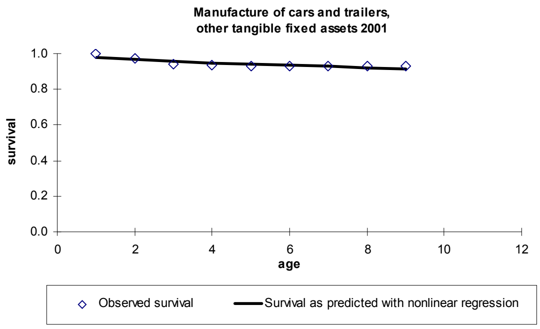


Table C5: Manufacture of cars and trailers; other tangible fixed assets

	Industry	Year	e.s.l. (years)	alpha	lambda
Results:					
	Manufacture of cars and trailers	1996	105.96	1.64	0.008
	Manufacture of cars and trailers	2001	799.46	0.60	0.002
Selected:					
	Manufacture of other transport equipment	2001	11.16	1.43	0.081

Annex D – Table of service lives and discard patterns.

Figures printed in bold represent real estimates (at the industry by asset level). Figures that are not printed in bold are estimates borrowed from another industry because of the low quality of data in the own industry. Capital formation in 2001 is added to give an indication of the relative significance of the industries.

NB for external transport equipment the estimated service lives were later raised with 0.712 years (see also section 4.3).

Table D1: Industrial buildings

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**41.87**	**2.16**	**0.022**	186
Manufacture of textile and leather products	41.87	2.16	0.022	8
Manufacture of wood and wood products	41.87	2.16	0.022	27
Manufacture of paper and paper products	41.87	2.16	0.022	34
Publishing and printing	41.87	2.16	0.022	59
Manufacture of petroleum products	**36.31**	**1.30**	**0.025**	22
Manufacture of basic chemicals, chemical products and man-made fibres	**41.08**	**1.77**	**0.022**	142
Manufacture of rubber and plastic products	41.08	1.77	0.022	43
Manufacture of building material	41.87	2.16	0.022	57
Manufacture of basic metals	30.78	0.97	0.033	22
Manufacture of fabricated metal products	**30.78**	**0.97**	**0.033**	77
Manufacture of machinery and equipment n.e.c.	**44.41**	**1.34**	**0.021**	94
Manufacture of office machines and computers	18.37	1.33	0.050	15
Manufacture of (other) electronic machinery and equipment	18.37	1.33	0.050	20
Manufacture of audio-, video- and telecommunication equipment	**18.37**	**1.33**	**0.050**	50
Manufacture of medical instruments and equipment	18.37	1.33	0.050	14
Manufacture of cars and trailers	**36.29**	**2.21**	**0.024**	27
Manufacture of transport equipment (other than cars and trailers)	36.29	2.21	0.024	26
Other manufacturing	41.87	2.16	0.022	86

Table D2: External transport equipment

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**5.36**	**1.41**	**0.173**	53
Manufacture of textile and leather products	**4.55**	**1.13**	**0.210**	5
Manufacture of wood and wood products	4.69	1.47	0.193	10
Manufacture of paper and paper products	**4.10**	**1.27**	**0.231**	3
Publishing and printing	**3.76**	**2.12**	**0.235**	14
Manufacture of petroleum products	**4.40**	**1.09**	**0.220**	1
Manufacture of basic chemicals, chemical products and man-made fibres	**6.00**	**1.30**	**0.154**	9
Manufacture of rubber and plastic products	4.69	1.47	0.193	7
Manufacture of building material	4.69	1.47	0.193	21
Manufacture of basic metals	**6.63**	**2.00**	**0.134**	3
Manufacture of fabricated metal products	**4.69**	**1.47**	**0.193**	36
Manufacture of machinery and equipment n.e.c.	**3.54**	**1.79**	**0.251**	28
Manufacture of office machines and computers	4.69	1.47	0.193	1
Manufacture of (other) electronic machinery and equipment	4.69	1.47	0.193	5
Manufacture of audio-, video- and telecommunication equipment	4.69	1.47	0.193	1
Manufacture of medical instruments and equipment	**4.98**	**1.46**	**0.189**	5
Manufacture of cars and trailers	4.69	1.47	0.193	9
Manufacture of transport equipment (other than cars and trailers)	4.69	1.47	0.193	3
Other manufacturing	**5.81**	**1.21**	**0.163**	24

Table D3: Machinery and equipment (including internal transport equipment)

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**26.77**	**1.75**	**0.033**	946
Manufacture of textile and leather products	**35.27**	**2.50**	**0.025**	72
Manufacture of wood and wood products	29.82	1.52	0.030	61
Manufacture of paper and paper products	26.77	1.75	0.033	205
Publishing and printing	**34.66**	**1.53**	**0.026**	295
Manufacture of petroleum products	**22.06**	**1.49**	**0.041**	99
Manufacture of basic chemicals, chemical products and man-made fibres	**43.46**	**2.18**	**0.020**	957
Manufacture of rubber and plastic products	43.46	2.18	0.020	244
Manufacture of building material	**29.82**	**1.52**	**0.030**	279
Manufacture of basic metals	32.78	2.50	0.027	176
Manufacture of fabricated metal products	**32.78**	**2.50**	**0.027**	295
Manufacture of machinery and equipment n.e.c.	32.78	2.50	0.027	343
Manufacture of office machines and computers	**20.80**	**1.83**	**0.043**	30
Manufacture of (other) electronic machinery and equipment	17.55	1.54	0.055	62
Manufacture of audio-, video- and telecommunication equipment	**17.55**	**1.54**	**0.054**	361
Manufacture of medical instruments and equipment	**15.01**	**1.27**	**0.062**	49
Manufacture of cars and trailers	**11.90**	**2.11**	**0.074**	107
Manufacture of transport equipment (other than cars and trailers)	**36.47**	**1.29**	**0.025**	34
Other manufacturing	29.82	1.52	0.030	129

Table D4: Computers

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**11.84**	**1.50**	**0.076**	59
Manufacture of textile and leather products	**13.55**	**1.57**	**0.066**	5
Manufacture of wood and wood products	7.67	2.05	0.115	4
Manufacture of paper and paper products	**6.12**	**1.32**	**0.150**	14
Publishing and printing	**7.57**	**1.52**	**0.119**	81
Manufacture of petroleum products	**8.14**	**2.84**	**0.109**	6
Manufacture of basic chemicals, chemical products and man-made fibres	**11.91**	**2.03**	**0.074**	42
Manufacture of rubber and plastic products	11.91	2.03	0.074	12
Manufacture of building material	7.67	2.05	0.115	12
Manufacture of basic metals	7.67	2.05	0.115	7
Manufacture of fabricated metal products	**7.67**	**2.05**	**0.115**	33
Manufacture of machinery and equipment n.e.c.	**11.78**	**1.43**	**0.077**	89
Manufacture of office machines and computers	6.31	1.55	0.143	11
Manufacture of (other) electronic machinery and equipment	6.31	1.55	0.143	14
Manufacture of audio-, video- and telecommunication equipment	**6.31**	**1.55**	**0.143**	16
Manufacture of medical instruments and equipment	6.31	1.55	0.143	18
Manufacture of cars and trailers	**3.56**	**1.14**	**0.268**	6
Manufacture of transport equipment (other than cars and trailers)	3.56	1.14	0.268	9
Other manufacturing	**9.90**	**2.25**	**0.092**	23

Table D5: Other tangible fixed assets

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**24.07**	**0.98**	**0.042**	166
Manufacture of textile and leather products	**29.74**	**2.69**	**0.030**	10
Manufacture of wood and wood products	31.99	1.99	0.028	8
Manufacture of paper and paper products	24.07	0.98	0.042	15
Publishing and printing	24.07	0.98	0.042	55
Manufacture of petroleum products	24.07	0.98	0.042	8
Manufacture of basic chemicals, chemical products and man-made fibres	24.07	0.98	0.042	65
Manufacture of rubber and plastic products	24.07	0.98	0.042	14
Manufacture of building material	**31.99**	**1.99**	**0.028**	21
Manufacture of basic metals	**30.21**	**1.50**	**0.030**	3
Manufacture of fabricated metal products	30.21	1.50	0.030	36
Manufacture of machinery and equipment n.e.c.	30.21	1.50	0.030	28
Manufacture of office machines and computers	8.23	2.63	0.108	10
Manufacture of (other) electronic machinery and equipment	8.23	2.63	0.108	13
Manufacture of audio-, video- and telecommunication equipment	**8.23**	**2.63**	**0.108**	35
Manufacture of medical instruments and equipment	**12.34**	**2.50**	**0.072**	14
Manufacture of cars and trailers	11.16	1.43	0.081	15
Manufacture of transport equipment (other than cars and trailers)	**11.16**	**1.43**	**0.081**	11
Other manufacturing	31.99	1.99	0.028	33

Annex E – Final table of service lives and discard patterns for the manufacturing industry: input for the calculation of consumption of fixed capital and net capital stock for the National Accounts.

Figures printed in bold represent real estimates (at the industry by asset level). Figures that are not printed in bold are estimates borrowed from another industry or imputed figures based on expert guesses because of the low quality of data in the own industry. Capital formation in 2001 is added to give an indication of the relative significance of the industries.

Table E1: Industrial buildings

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**42**	**2.16**	**0.022**	186
Manufacture of textile and leather products	42	2.16	0.022	8
Manufacture of wood and wood products	42	2.16	0.022	27
Manufacture of paper and paper products	42	2.16	0.022	34
Publishing and printing	42	2.16	0.022	59
Manufacture of petroleum products	**36**	**1.30**	**0.025**	22
Manufacture of basic chemicals, chemical products and man-made fibres	**41**	**1.77**	**0.022**	142
Manufacture of rubber and plastic products	41	1.77	0.022	43
Manufacture of building material	42	2.16	0.022	57
Manufacture of basic metals	31	1.01	0.033	22
Manufacture of fabricated metal products	**31**	**1.01**	**0.033**	77
Manufacture of machinery and equipment n.e.c.	**44**	**1.34**	**0.021**	94
Manufacture of office machines and computers	30	1.33	0.050	15
Manufacture of (other) electronic machinery and equipment	30	1.33	0.050	20
Manufacture of audio-, video- and telecommunication equipment	30	**1.33**	**0.050**	50
Manufacture of medical instruments and equipment	30	1.33	0.050	14
Manufacture of cars and trailers	**36**	**2.21**	**0.024**	27
Manufacture of transport equipment (other than cars and trailers)	36	2.21	0.024	26
Other manufacturing	42	2.16	0.022	86

Table E2: External transport equipment

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**6**	**1.41**	**0.173**	53
Manufacture of textile and leather products	**5**	**1.13**	**0.210**	5
Manufacture of wood and wood products	5	1.47	0.193	10
Manufacture of paper and paper products	**5**	**1.27**	**0.231**	3
Publishing and printing	5	**2.12**	**0.235**	14
Manufacture of petroleum products	**5**	**1.09**	**0.220**	1
Manufacture of basic chemicals, chemical products and man-made fibres	**7**	**1.30**	**0.154**	9
Manufacture of rubber and plastic products	5	1.47	0.193	7
Manufacture of building material	5	1.47	0.193	21
Manufacture of basic metals	**7**	**2.00**	**0.134**	3
Manufacture of fabricated metal products	**5**	**1.47**	**0.193**	36
Manufacture of machinery and equipment n.e.c.	5	**1.79**	**0.251**	28
Manufacture of office machines and computers	5	1.47	0.193	1
Manufacture of (other) electronic machinery and equipment	5	1.47	0.193	5
Manufacture of audio-, video- and telecommunication equipment	5	1.47	0.193	1
Manufacture of medical instruments and equipment	**6**	**1.46**	**0.189**	5
Manufacture of cars and trailers	5	1.47	0.193	9
Manufacture of transport equipment (other than cars and trailers)	5	1.47	0.193	3
Other manufacturing	**7**	**1.21**	**0.163**	24

Table E3: Machinery and equipment (including internal transport equipment)

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**27**	**1.75**	**0.033**	946
Manufacture of textile and leather products	**35**	**2.50**	**0.025**	72
Manufacture of wood and wood products	30	1.52	0.030	61
Manufacture of paper and paper products	27	1.75	0.033	205
Publishing and printing	**35**	**1.53**	**0.026**	295
Manufacture of petroleum products	**22**	**1.49**	**0.041**	99
Manufacture of basic chemicals, chemical products and man-made fibres	30	**2.18**	**0.020**	957
Manufacture of rubber and plastic products	30	2.18	0.020	244
Manufacture of building material	**30**	**1.52**	**0.030**	279
Manufacture of basic metals	33	2.50	0.027	176
Manufacture of fabricated metal products	**33**	**2.50**	**0.027**	295
Manufacture of machinery and equipment n.e.c.	33	2.50	0.027	343
Manufacture of office machines and computers	**21**	**1.83**	**0.043**	30
Manufacture of (other) electronic machinery and equipment	18	1.54	0.055	62
Manufacture of audio-, video- and telecommunication equipment	**18**	**1.54**	**0.054**	361
Manufacture of medical instruments and equipment	**15**	**1.27**	**0.062**	49
Manufacture of cars and trailers	30	**2.11**	**0.074**	107
Manufacture of transport equipment (other than cars and trailers)	30	**1.29**	**0.025**	34
Other manufacturing	30	1.52	0.030	129

Table E4: Computers

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	**12**	**1.50**	**0.076**	59
Manufacture of textile and leather products	**14**	**1.57**	**0.066**	5
Manufacture of wood and wood products	8	2.05	0.115	4
Manufacture of paper and paper products	**6**	**1.32**	**0.150**	14
Publishing and printing	**8**	**1.52**	**0.119**	81
Manufacture of petroleum products	**8**	**2.84**	**0.109**	6
Manufacture of basic chemicals, chemical products and man-made fibres	**12**	**2.03**	**0.074**	42
Manufacture of rubber and plastic products	12	2.03	0.074	12
Manufacture of building material	8	2.05	0.115	12
Manufacture of basic metals	8	2.05	0.115	7
Manufacture of fabricated metal products	**8**	**2.05**	**0.115**	33
Manufacture of machinery and equipment n.e.c.	**12**	**1.43**	**0.077**	89
Manufacture of office machines and computers	6	1.55	0.143	11
Manufacture of (other) electronic machinery and equipment	6	1.55	0.143	14
Manufacture of audio-, video- and telecommunication equipment	**6**	**1.55**	**0.143**	16
Manufacture of medical instruments and equipment	6	1.55	0.143	18
Manufacture of cars and trailers	5	**1.14**	**0.268**	6
Manufacture of transport equipment (other than cars and trailers)	5	1.14	0.268	9
Other manufacturing	**10**	**2.25**	**0.092**	23

Table E5: Other tangible fixed assets

Industry	e.s.l. (years)	alpha	lambda	Capital formation 2001 (mln euro)
Manufacture of food products, beverages and tobacco	12	**1.01**	**0.042**	166
Manufacture of textile and leather products	12	**2.69**	**0.030**	10
Manufacture of wood and wood products	12	1.99	0.028	8
Manufacture of paper and paper products	12	1.01	0.042	15
Publishing and printing	12	1.01	0.042	55
Manufacture of petroleum products	12	1.01	0.042	8
Manufacture of basic chemicals, chemical products and man-made fibres	12	1.01	0.042	65
Manufacture of rubber and plastic products	12	1.01	0.042	14
Manufacture of building material	12	**1.99**	**0.028**	21
Manufacture of basic metals	12	**1.50**	**0.030**	3
Manufacture of fabricated metal products	12	1.50	0.030	36
Manufacture of machinery and equipment n.e.c.	12	1.50	0.030	28
Manufacture of office machines and computers	8	2.63	0.108	10
Manufacture of (other) electronic machinery and equipment	8	2.63	0.108	13
Manufacture of audio-, video- and telecommunication equipment	**8**	**2.63**	**0.108**	35
Manufacture of medical instruments and equipment	12	**2.50**	**0.072**	14
Manufacture of cars and trailers	11	1.43	0.081	15
Manufacture of transport equipment (other than cars and trailers)	**11**	**1.43**	**0.081**	11
Other manufacturing	12	1.99	0.028	33