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CAPITAL SERVICES ESTIMATES IN PORTUGUESE INDUSTRIES, 1977-2003

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Capital services estimates in Portuguese industries, 1977-2003

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Abstract

This paper presents capital services estimates for 26 Portuguese industries for the 1977-2003 period. The estimation procedure follows an integrated approach under which the flows of capital services are approximated as a proportion of the capital stock converted into standard efficiency units. Our findings suggest a close proximity between the evolution of capital flows and the observed fluctuations of Portuguese macroeconomic growth. TFP growth estimates based on growth accounting reveal, furthermore, a very disappointing performance of the Portuguese economy during the period under study, with an average annual rate of TFP growth of 0.8% being observed. Performance varies across industries, but the bulk of activities show very modest rates of TFP growth.

Keywords: Capital services, TFP, Portugal.

JEL-Codes: O47, D24

1. Introduction

Rigorous measurement of capital is fundamental in order to analyse a multitude of different economic problems. Capital services measures are needed, in particular, to analyse capital and multifactor productivity changes over time, which are essential for the investigation of past growth trends and the anticipation of future growth prospects. Disaggregated estimates of capital flows permit furthermore to relate the overall economic performance with the dynamics of productivity and employment of capital at the sectoral level, allowing in this way to explore the sources of growth of the economy at a finer detail.

Despite their major importance to the analysis of growth and productivity issues, to the best of our knowledge no attempt has been made to provide a measure of capital services for the Portuguese economy. Some estimates of gross and net capital stocks have been derived (e.g., Teixeira and Fortuna, 2009; Pina and St. Aubyn, 2004; Santos, 1984), but not a measure of capital services. Capital stocks are not, however, the appropriate measures of capital to be used when assessing total factor productivity (TFP) growth (OECD, 2001a, 2001b). The first and most obvious reason is that all the other variables in the growth accounting framework (the traditional method used in the assessment of TFP) are flows, rather than stocks. At the same time, capital stock measures do not take into account the productive efficiency of capital assets, being thus inappropriate for productivity measurement. An additional shortcoming regarding the use of gross and net capital stocks in the measurement of the contribution of capital to production stems from the weighting procedure used in their calculus. The aggregation of assets based on market values provides erroneous information on their contribution to production, undervaluing the contribution from short-lived assets and overvaluing that from long-lived assets (OECD, 2001a, 2001b).

Furthermore, with the exception of Santos (1984), who provided capital stock estimates for a number of sectors between 1953 and 1976, all estimates have been derived at the broad macroeconomic level. This does not allow for an examination of the relationship between changes occurring at the industry level and overall macroeconomic changes, confining the interpretation of productivity trends to global macroeconomic factors.

In this paper an attempt is made to fill this gap, by providing an estimate of capital services flows for 26 Portuguese industries between 1977 and 2003. We follow the method pioneered by the United States Bureau of Labor Statistics, under which the flows of capital services by type of activity and by asset type are approximated as a

proportion of the capital stock converted into standard efficiency units. The standard efficiency units of different types of assets are then combined into an overall index – volume index of capital services –, applying the user costs of capital of the different types of assets as weights.

Using the estimated capital services and relying on a growth accounting framework, we compute TFP growth estimates at the industry and macroeconomic levels between 1977 and 2003. TFP growth results, identified as the 'residuals' resulting from the difference in the growth of output and the contribution of inputs, reveal a mediocre performance of the Portuguese economy over this time span. The low average rates of TFP growth in most of the industries under study, and their absolute decline in the more recent period, suggest that strong policy action has to be put in practice in order to reverse the situation and achieve sustained increases in productivity growth capable of promoting convergence to EU.

The paper is structured as follows. The next section clarifies the concept of capital services used in the present study and outlines the method applied in its measurement. Section 3 presents the data and the assumptions underlying the estimation. Section 4 presents the capital services series by sector and asset type, and a measure of the volume index of capital services per sector. Section 5 applies the capital services estimates in the estimation of TFP growth rates for the period 1977-2003. Section 6 concludes.

2. Measurement of capital services

Traditionally, three broad measures of capital are considered in the literature: the gross capital stock, the net capital stock and capital services. The first two measures are related to the concept of capital as a store of wealth. The gross fixed capital stock reflects the value of capital goods at a point in time with each asset valued at "as new" prices, that is, without considering economic depreciation. The net capital stock, on the other hand, deduces the value of the cumulative consumption of fixed capital from the gross stock value, providing an estimate of the market value of capital goods. The gross capital stock can be estimated directly, based on data from insurance records, book values or direct data collection, but the by far most common approach relies on the application of the Perpetual Inventory Method (PIM). This method produces an estimate of the stock of fixed assets in existence at a certain moment in time by accumulating past capital formation and deducting assets which are retired or written off. The net stock is usually calculated from the gross stock by deducting accumulated consumption

of fixed capital. The latter is typically obtained using a depreciation function such as straight line or geometric depreciation.[1]

Differently from gross and net stock measures, the concept of capital services – the measure of capital considered in the present work – is inherently related to the role of capital as a factor of production. Capital services are the inputs delivered by capital assets in the production process. As indicated earlier, these (quantitative) flows constitute the appropriate measure of capital for production and productivity analysis.

In the estimation of capital services we follow the method pioneered by the United States Bureau of Labor Statistics (BLS) and currently also in use by the Australian Bureau of Statistics (ABS). Under this methodology, the flows of capital services are approximated as a proportion of the stock of capital converted into standard efficiency units. An intermediate step towards the estimation of the capital input consists therefore in estimating the capital stock in efficiency units for each type of asset. This is shown in Equation (1):

$$S_t^i = \sum_{\tau=1}^{T^i} \left(\frac{IN_{t-\tau}^i}{q_{t-\tau,0}^i} \right) h_\tau^i F_\tau^i \qquad (1)$$

In this expression, the capital stock of asset i at period t is represented as the sum of all (nominal) vintage investment in the asset ($IN^i_{t-\tau}$) deflated by the purchase price of new capital goods in year t ($q^i_{t-\tau,0}$). This value is corrected for the loss of productive efficiency over time, by considering an age-efficiency function h^i_τ, and also for the probability of retirement of capital goods (F^i_τ).[2] T^i is the maximum service life of the asset in years (t = 1, 2,…, T).

After getting capital stocks converted to standard efficiency units for each type of asset, the next step consists in aggregating the stocks to obtain overall measures of capital services. This is done by considering the user costs of capital as the appropriate weights. User costs are prices for capital services (which represent quantities) and may be seen as reflecting the marginal productivity of the different assets under the usual assumptions regarding competitive markets.[3] More precisely, user costs of capital (μ_{it}) measure the

[1] See OECD (2001) for details on the measurement of gross and net capital stocks.
[2] F^i_τ gives the cumulative value of the retirement distribution, describing the probability of survival over the capital vintage's life span.
[3] By weighting the stocks of different assets by their relative productivity in production, the overall productive stock will then constitute a measure of the potential flow of productive services that all fixed assets can deliver in production.

cost of financing the asset, corresponding to the sum of depreciation (d_{it}) and the real cost of financial capital (r_{it}), minus the nominal capital gain (or loss) from holding the asset for each accounting period $(p_{it} - p_{i,t-1})$.[4]

$$\mu_{it} = r_{it} \cdot p_{i,t-1} + d_i \cdot p_{it} - (p_{it} - p_{i,t-1}) \quad (2)$$

After user costs have been derived, the next step is to combine the stocks of each asset type to obtain volume indices of capital services for activity types. This is usually done with recourse to a superlative index number such as the Törnqvist index:[5]

$$\ln\left[K_t / K_{t-1}\right] = \sum_i \bar{v}_i \ln\left[K_{it} / K_{i,t-1}\right] \quad (3)$$

In which $K_{i,t}$ represent the estimates of the capital stock in standard efficiency units for different types of assets and $\bar{v}_i = 0{,}5\left(v_{i,t} + v_{i,t-1}\right)$, where $v_{i,t} = \dfrac{\mu_{i,t} K_{i,t}}{\sum_i \mu_{i,t} K_{i,t}}$.

Once aggregation is made, an estimation of the volume index of capital services for each sector is obtained, which constitutes a measure for the potential flow of productive services of capital assets in that sector. This measure is used to approximate the flow of capital services in the measurement of total factor productivity growth.

3. Data and assumptions

3.1. Data sources

The measurement of capital services by type of activity requires information on two basic inputs: investment series by industry, cross-classified by type of asset, and producer price indices of investment goods to deflate investment expenditure series.

Regarding investment, our data source is the Portuguese Statistics Office (INE).[6] For the period under analysis (1977-2003), INE provides annual nominal gross investment data disaggregated by type of activity and further subdivided into the categories land (*animais e plantações*), machinery and equipment (*máquinas e aparelhos*), transport equipment (*material de transporte*), buildings (*construção*) and other investment (*Outros*).

[4] p_{it} is the market price of a new asset.
[5] The use of this index is based on its approximation to general functional forms of the production function [see in this respect OECD (2001b)].
[6] Data on investment per sector are not published, but can be obtained from INE under request.

Since it is our purpose to estimate a measure of capital input and land is a non-produced asset, this category of investment is not included in our computations.[7] Furthermore, we consider the broad 'buildings' category, although ideally owner-occupied residential capital should be excluded from our calculus.[8] However, such a distinction within the 'buildings' category would be problematic in the Portuguese case, since building investment made by sole proprietorship firms (which represent a very significant part of total Portuguese firms) is included within the households' residential investment. It was therefore necessary to consider all buildings, irrespective of the institutional nature of the investor, in the measurement of capital input.

During the period under study, INE changed the calculus procedure of the GFCF series, which were computed under different conceptual schemes. The most relevant change took place in 1995, when some adjustments were made in order to accommodate for the requirements stipulated by the European System of National and Regional Accounts (SEC 95). For the 1995-2003 period, INE provides a fully integrated GFCF series, but unfortunately the same does not apply for the preceding years. Thus, we had to remove discontinuities relative to the previous period, by applying backwards the growth rates implicit in the earlier temporal series. This allowed us to get an overall picture of the dynamics of the investment flows at current prices in the period under study, which is depicted in Figure 1.

[7] In this respect we follow the OECD (2001a) recommendations, which acknowledge that in general terms land should not be treated as gross fixed capital formation (GFCF) in the measurement of productivity (see OECD, 2001a: 76). Furthermore, in our case, this asset constitutes only a negligible part of the GFCF, never exceeding 2% of its total value during the whole period under study.

[8] Given our purpose of analysis – the measurement of TFP growth – the only relevant part of residential investment is the investment carried out by specialised producers of market services (OECD, 2001a).

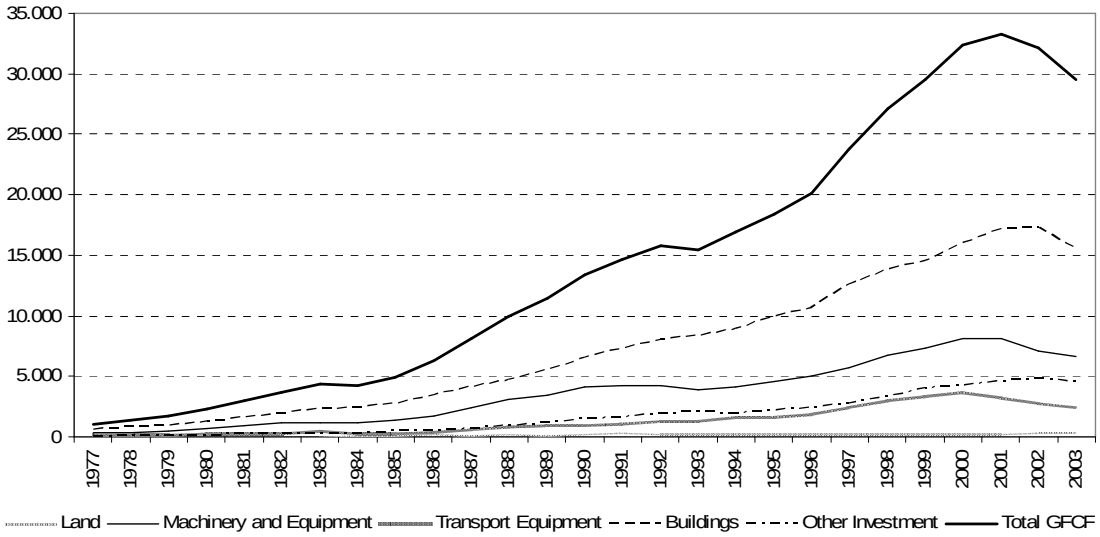


Figure 1: Portuguese GFCF, current prices 1977-2003 (10^6 euros)

Note: Author's computations based on data from INE

In order to deflate the investment expenditure series, the deflators from Banco de Portugal for the 1977-1995 period were applied,[9] and for the subsequent years, the deflators from INE. Deflators from Banco de Portugal consider only the breakdown of the GFCF by type of asset for the whole economy, whereas INE provides investment deflators that consider simultaneously the industry and asset types in which the investment was made. To avoid the introduction of (possible) noise from the consideration of a different detail level in the deflators used, we opted for deflators discriminated only by asset type in the estimation of constant prices investment series, taking 1977 as the base year.[10]

Taking into account price deflators, the evolution of the total GFCF and of the individual investment series on the different assets between 1977 and 2003 is as shown in Figure 2.

[9] This information is available on-line at http://www.bportugal.pt.
[10] The list of deflators considered can be consulted in the annex (Table A.1).

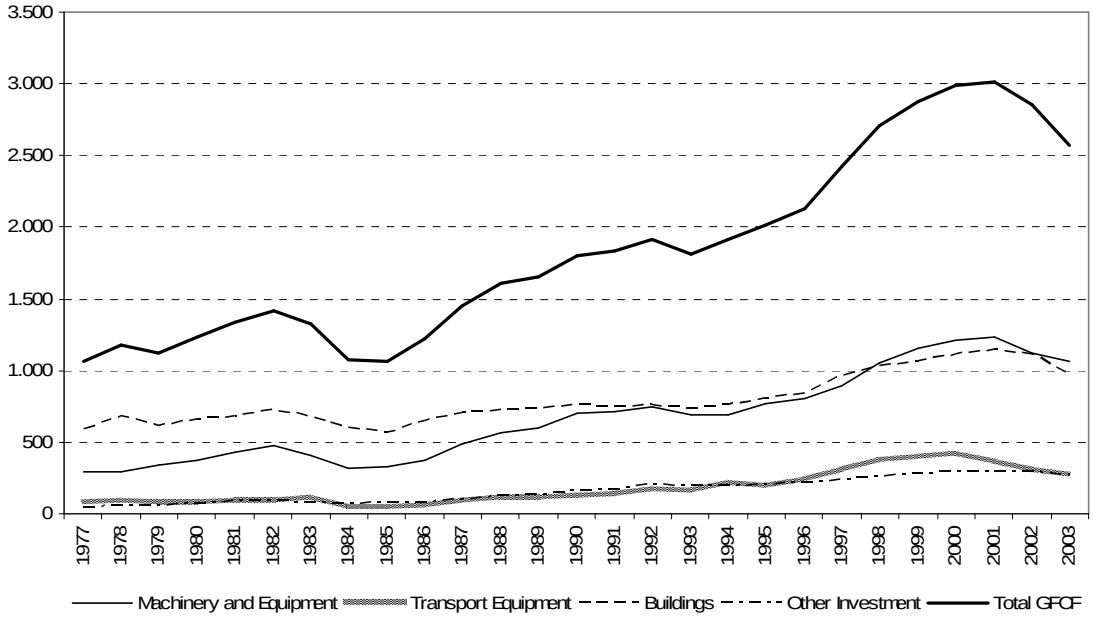


Figure 2: Portuguese GFCF at constant 1977 prices (10^6 euros).

Note: Author's computations based on data from INE and Banco de Portugal

Figures 1 and 2 show a general trend towards an increase in investment flows up to 2001, which is particularly intense between 1996 and 2000. The more recent years (2002 and 2003) reveal, however, an opposite tendency, due to the situation of economic recession that has since then affected the Portuguese economy (e.g., Blanchard, 2006). This evolution is also present when investment in individual assets is considered, with more pronounced increases in investment flows occurring in the machinery and equipment category.

The breakdown level of economic activity considered in the estimation of capital services was determined by the sectoral delimitation used in the collection of fixed capital formation by INE. During the period under study, INE changed the classification scheme of economic activities, using *NCN 86* (*Nomenclatura das Contas Nacionais 1986*) between 1977 and 1995, and *NCN 95* (*Nomenclatura das Contas Nacionais 1995*) in the subsequent period. In order to harmonise both classifications and obtain an integrated investment series for the different branches of the economy, we used INE's table of correspondences between branches under the two categorisations. This procedure was applied to the GFCF sectoral series obtained by applying backwards the

growth rates implicit in the 1977-1995 period, allowing us to get consistent investment series for the set of individual branches for the whole period under study.[11]

The harmonisation of nominal investment series during the period under study led to the initial consideration of 31 branches. However, because a very fine breakdown level could be problematic, since transfers of used assets between producers in different types of activities could affect the reliability of the capital estimates (OECD, 2001b), we restricted the analysis to 26 industries, including activities from agriculture, manufacturing and services.[12]

3.2. Assumptions underlying the estimation of capital services

In order to estimate capital services for the selected 26 industrial branches a number of assumptions regarding age-efficiency and retirement functions, service lives of assets and benchmark capital stocks had to be considered.

With respect to the age-efficiency profile, which describes the change in the quantity of capital services produced by an asset as it ages, a hyperbolic pattern was chosen. This pattern seemed to be preferable relative to alternative patterns, such as the geometric profile, given its more realistic account of the loss of productive capacity of capital goods as they age.[13] Indeed, it seems plausible to assume that, in most cases, the loss of the relative efficiency occurs at a relatively low rate in the first years of utilisation, increasing the rate of decline in later stages.[14]

The hyperbolic profile was calculated using the following expression:

$$h_\tau^i = \left(T^i - \tau\right) / \left(T^i - \beta\tau\right) \tag{4}$$

In this expression β is the slope-coefficient: the higher its value, the slower the loss of efficiency of the capital asset. In fixing β's value for each asset, we follow BLS and ABS practices, setting β at 0.5 for machinery and equipment, and 0.75 (a higher value corresponding to a slower rate of efficiency loss) for buildings and structures.[15]

[11] The total GFCF series for the 26 industrial branches, both in nominal and real terms, can be obtained from the author upon request.
[12] The full list of industries considered can be consulted in the annex (Table A.2).
[13] The geometric pattern assumes a constant rate of decline in the efficiency of an asset as it ages.
[14] A similar understanding is provided by Brito (2005), in her study of the application of age-efficiency profiles in the measurements of capital in the Portuguese case.
[15] It is worth mentioning that there is relatively little scientific basis for defining β values. ABS follows BLS practices, which, in turn, sets their values in order to yield age-price profiles similar to the ones implicit in BEA's (Bureau of Economic Analysis) estimates on wealth.

An additional set of assumptions refers to the service lives of the assets, that is, the period in which assets are retained in the capital stock, whether in first or second-hand usage.

A possible source for obtaining service lives relies on the estimates provided by the tax authorities in the definition of legal rates of depreciation. The estimates originating from this source are, however, frequently biased by political agendas, such as the encouragement of investment, which undermines their usage as an accurate measure of the time span of capital assets. Additional sources for obtaining service life estimates can be found in company accounts, statistical surveys and expert advice. However, none of these sources seem to be available in the Portuguese case, at least with the necessary detail and ample coverage that is required in the present work. In these circumstances, we had to rely on an alternative source, namely, service life estimates developed by other countries.[16] In this respect, the OECD manual for the measurement of capital (OECD, 2001b) identifies four countries which present service life estimates that seem to be based on more reliable information than that usually available in other countries. They are the United States, Canada, the Czech Republic and the Netherlands. In the present study, the Dutch classification scheme seemed to be the most appropriate given its similarities with the Portuguese case in terms of both the capital asset categories and the breakdown level of economic activity. It thus comprised the basis for the average service lives considered in our work.[17] Estimates of mean service lives from Statistics Netherlands constitute a compilation of 'best source' estimates, obtained by different methods. With respect to manufacturing branches, they are the result of the estimation of a Weibull distribution based on data gathered on discards and capital stock in Dutch manufacturing (Meinen, 1998; Meinen *et al.*, 1998). The computations derived for the asset category 'Machinery' include, however, installations along with machinery, which results in very large mean asset lives when compared with estimates from other countries.[18] Because Portuguese data includes only machinery equipment in the homologous category and does not provide an autonomous calculation of investment in computers, which have a shorter economic life, we replaced the original Dutch

[16] We realise that considering service lives from other countries does not capture the specificities of the Portuguese case. The determination of service lives specific to the Portuguese case would imply, however, an extensive amount of work which would go far beyond the scope of the present investigation. Such an effort can be seen as an important improvement to be carried out in future research.
[17] Service lives can be consulted in the annex (Table A.3).
[18] See, for example, the estimates presented by the US, Canada and the Czech Republic included in the OECD (2001b), and the estimates used by ABS, available on line at http://abs.gov.au/AUSSTATS.

information regarding this category for manufacturing branches with the Czech Republic's corresponding figures. We also considered a mean service life of 10 years for the residual category 'Other investment' in manufacturing branches, the same value presented for the other sectors in the Dutch service life estimates, and which is close to the average value set by BLS (7 years). Furthermore, for the industries not explicitly taken into account under the Dutch or Czech classification schemes, we considered the available figures in the closest economic branches.[19]

Other assumptions relate to the distribution of retirements around the average service life. Most studies consider bell-shaped retirement patterns, although other profiles are also available (e.g., simultaneous exit, linear and delayed linear patterns).[20] The greater adherence to reality of the bell-shaped profile, which assumes a gradual increase of retirements in the early years until a peak is reached around the average service life, followed by a gradual slowdown in subsequent years, seems to explain the preference.

Several mathematical functions can be used to provide such a bell-shaped pattern (e.g., gamma, quadratic, Weibull, Winfrey and lognormal functions). The present study follows the method outlined by Shreyer (2003), assuming a normal distribution with a standard deviation of 25 percent of the average service life, and truncating the distribution at an assumed maximum service life of 1.5 times the average service life.

The use of PIM in the estimation of capital stocks requires additionally an initial benchmark estimate of the capital stock. In this case, because investment series start in 1977 and we consider 26 sectors with four different types of capital assets, 104 initial estimates are required for the beginning of 1977.

Once again, the estimation of an initial benchmark capital stock can be obtained directly, using information provided by sources such as population censuses, fire insurance records, company accounts and administrative property records. However, reliable information of this type is very hard to find (particularly for the Portuguese case), and therefore most studies (e.g., Osada, 1994; Timmer, 1999; Kamps, 2006) rely on indirect shortcut methods for this purpose. In the present study we follow Kamps (2006) and Pina and St. Aubyn (2004), constructing artificial investment series starting in 1877 by assuming an initial value of capital stock at zero and a constant rate of

[19] For example, we assumed the mean asset lives of the rubber and plastics industry to be similar to the ones regarding the chemicals industry.
[20] See OECD (2001b) for details on these profiles.

investment increase (4% per annum) from that year to the values observed in 1977.[21] Capital stocks were obtained considering the previously indicated assumptions regarding efficiency decay, the shape of the survival function and asset lives.[22] Despite being based on relatively *ad-hoc* assumptions, we believe that this procedure does not imply a considerable impact on the dynamics of the resulting capital stock series, providing reliable estimates of the capital input.[23]

4. Capital services estimates

Having defined the set of assumptions, the calculus of capital services by sector and asset type was performed using the methodology described in Section 1. Table 1 provides a summary of the results.[24]

Table 1: Volume growth of capital services by sector and asset type (compound annual % changes)

Industries		Machinery	Transport	Construction	Other Investment
AAeBB	1977-1985	9.58	4.73	2.94	16.20
	1986-1994	2.91	-0.51	6.10	13.84
	1995-2003	2.50	0.28	1.73	-8.84
	1995-2000	2.97	0.21	1.72	-7.58
	2001-2003	1.56	0.40	1.76	-11.30
CAeCB	1977-1985	15.82	8.86	5.58	-25.12
	1986-1994	5.58	3.36	3.96	-40.98
	1995-2003	12.36	2.52	3.34	1.28
	1995-2000	14.32	3.70	3.83	5.71
	2001-2003	8.54	0.21	2.37	-7.03
DA	1977-1985	8.68	8.56	5.70	17.96
	1986-1994	6.03	2.44	5.49	29.34
	1995-2003	2.65	10.25	4.44	0.95
	1995-2000	2.55	11.50	4.58	0.29
	2001-2003	2.83	7.80	4.15	2.28
DB	1977-1985	9.81	10.77	7.75	16.35
	1986-1994	5.17	6.11	3.91	21.47
	1995-2003	0.44	3.97	3.09	-4.02
	1995-2000	1.70	5.62	3.61	-3.70
	2001-2003	-2.03	0.74	2.07	-4.66
DC	1977-1985	29.41	15.86	7.31	3.15
	1986-1994	7.71	4.36	7.43	32.69
	1995-2003	0.58	1.34	4.20	-15.62
	1995-2000	2.24	2.73	5.51	-12.38

[21] The choice of the 4% rate, similarly to Kamps (2006) and Pina and St. Aubyn (2005), is justified on the grounds that it is a reasonable order of magnitude for a long-term macroeconomic series.
[22] Initial capital stocks estimates can be consulted in the annex (Table A.4).
[23] Kamps (2006) develops a sensitivity analysis, showing that the assumption regarding the initial capital stock does not influence significantly the dynamics of the resulting capital stock series. Furthermore, its importance diminishes over time as the initial capital stock wears out, and we have considered a considerably distant starting year in the estimation of artificial GFCF time series.
[24] By their very nature, capital service flows are presented as rates of change or indices, and not as levels of stocks as is the case for measures of net and gross stocks.

	2001-2003	-2.65	-1.40	1.62	-21.74
DD	1977-1985	8.16	6.56	7.28	-92.91
	1986-1994	4.55	2.03	3.53	29.77
	1995-2003	4.87	0.18	6.88	-10.70
	1995-2000	5.18	1.51	6.72	-9.84
	2001-2003	4.25	-2.42	7.21	-12.40
DE	1977-1985	12.14	13.38	9.83	-40.31
	1986-1994	5.75	3.92	5.73	45.62
	1995-2003	0.47	11.32	5.61	8.76
	1995-2000	1.83	9.99	5.20	4.29
	2001-2003	-2.19	14.03	6.44	18.26
DF	1977-1985	2.49	25.63	0.83	-44.61
	1986-1994	0.21	-1.10	2.05	-3.23
	1995-2003	0.73	6.44	11.14	0.19
	1995-2000	-0.15	-179.,15	10.70	-1.59
	2001-2003	2.50	-292.49	12.02	3.86
DG	1977-1985	7.67	11.63	6.25	-19.02
	1986-1994	-0.94	0.80	0.68	30.69
	1995-2003	3.39	9.61	2.54	-1.10
	1995-2000	2.58	13.55	2.88	-0.72
	2001-2003	5.03	2.15	1.86	-1.85
DH	1977-1985	11.39	9.84	7.23	2.16
	1986-1994	3.20	-0.36	3.72	58.61
	1995-2003	10.16	12.40	9.55	-2.86
	1995-2000	11.63	12.45	8.84	-4.15
	2001-2003	7.27	12.29	11.00	-0.24
DI	1977-1985	9.02	7.17	4.80	73.49
	1986-1994	2.77	0.26	3.14	27.03
	1995-2003	3.98	3.68	3.46	-16.60
	1995-2000	5.28	5.52	3.75	-14.67
	2001-2003	1.42	0.08	2.88	-20.35
DJ	1977-1985	9.00	7.85	3.25	2.28
	1986-1994	3.27	-1.02	2.27	16.30
	1995-2003	2.48	2.86	2.25	-6.99
	1995-2000	2.35	5.39	2.17	-5.83
	2001-2003	2.73	-2.03	2.40	-9.27
DK	1977-1985	10.47	10.56	5.79	6.56
	1986-1994	3.73	0.21	2.71	26.52
	1995-2003	7.37	6.56	4.99	-11.42
	1995-2000	8.80	9.60	4.93	-9.67
	2001-2003	4.57	0.74	5.12	-14.81
DL	1977-1985	13.86	7.47	9.85	-3.30
	1986-1994	3.69	7.21	5.20	-54.53
	1995-2003	12.44	9.63	9.57	-6.24
	1995-2000	12.97	11.08	9.62	-5.19
	2001-2003	11.37	6.79	9.49	-8.29
DM	1977-1985	18.99	13.47	675	0.35
	1986-1994	4.79	-2.54	1.82	23.56
	1995-2003	11.19	13.01	3.74	0.81
	1995-2000	12.50	16.64	4.30	1.06
	2001-2003	8.61	6.09	2.64	0.33
DN	1977-1985	7.71	7.84	6.30	9.71
	1986-1994	2.64	1.81	2.75	26.08
	1995-2003	-0.08	-1.28	3.27	-11.82

	1995-2000	0.59	-1.41	3.50	-7.66
	2001-2003	-1.40	-1.02	2.82	-19.58
EE	1977-1985	5.55	15.99	6.60	34.23
	1986-1994	7.95	0.55	0.40	-11.89
	1995-2003	12.17	8.36	1.84	-8.22
	1995-2000	10.42	15.56	1.38	-11.21
	2001-2003	15.75	-4.72	2.77	-1.93
FF	1977-1985	6.14	6.48	2.21	7.20
	1986-1994	6.44	3.32	0.76	7.24
	1995-2003	4.27	3.28	0.90	-6.04
	1995-2000	5.43	3.00	0.84	-5.17
	2001-2003	1.98	3.85	1.02	-7.76
GG	1977-1985	7.61	9.58	7.31	8.29
	1986-1994	2.72	4.49	5.34	23.92
	1995-2003	3.60	6.05	6.34	-1.88
	1995-2000	3.73	8.03	7.07	-1.80
	2001-2003	3.35	2.19	4.89	-2.03
HH	1977-1985	10.76	21.34	9.45	-49.03
	1986-1994	10.16	2.41	5.96	35.60
	1995-2003	11.57	18.71	6.88	12.86
	1995-2000	12.21	27.10	7.92	13.67
	2001-2003	10.32	3.56	4.82	11.26
II	1977-1985	7.17	4.89	3.70	-6.50
	1986-1994	8.66	2.55	2.15	20.19
	1995-2003	2.96	5.23	4.81	4.56
	1995-2000	2.71	5.94	4.56	6.47
	2001-2003	3.47	3.84	5.30	0.85
JJeKK	1977-1985	15.33	10.38	3.80	12.42
	1986-1994	20.67	32.47	3.88	2.45
	1995-2003	2.17	8.09	2.87	4.90
	1995-2000	3.65	12.50	3.00	5.83
	2001-2003	-0.73	-0.23	2.61	3.06
LL	1977-1985	9.05	10.74	5.63	-20.81
	1986-1994	7.48	1.18	5.15	104.13
	1995-2003	5.82	14.94	5.23	-164.9
	1995-2000	6.91	21.89	5.58	-13.35
	2001-2003	3.68	2.22	4.52	-136.37
MM	1977-1985	14.67	18.46	5.43	8.81
	1986-1994	13.56	14.36	3.66	47.13
	1995-2003	16.44	23.97	4.15	11.95
	1995-2000	15.20	31.48	4.38	13.87
	2001-2003	18.96	10.21	3.71	8.22
NN	1977-1985	10.71	21.69	5.72	40.46
	1986-1994	8.02	5.66	4.59	-23.06
	1995-2003	12.92	24.05	4.58	14.50
	1995-2000	13.61	33.92	4.37	20.95
	2001-2003	11.54	6.44	4.99	2.63
OO	1977-1985	13.16	15.14	4.82	-8.54
	1986-1994	22.36	36.59	4.80	34.35
	1995-2003	8.89	-11.05	3.89	32.75
	1995-2000	11.48	-9.05	3.55	44.91
	2001-2003	3.89	-14.91	4.58	11.40

Note: Author's computations based on data from INE and Banco de Portugal

The capital services series by sector and asset type show an increasing trend over most of the time period under study. The rise in capital services is particularly intense in most of the sectors/assets in the mid-1990s, which reflects the aforementioned acceleration of investment flows in this period. The more recent years (2001-2003), however, are characterised by a decrease in the growth rate of the capital services in a significant part of the sectors/assets considered, which is related with the overall decline of the macroeconomic environment during this period. The 'Other Investment' capital services series exhibit very volatile growth rates, which are explained by the residual nature of this category.

After getting capital stocks converted to standard efficiency units for each type of asset, the next step consists in aggregating the stocks to obtain overall measures of capital services for different types of activities. This is done by considering the user costs of capital as the appropriate weights (cf. Section 1). As indicated earlier, the determination of user costs of capital requires information on depreciation rates, on the net return of capital, and on the nominal capital gain (or loss) from holding the asset for each accounting period (see Equation (2)). Following the literature (e.g., OECD, 2001b; Schreyer *et al.*, 2003; Oulton and Srinivasan, 2003), we assume that the rate of return of capital is the same in all types of assets, considering implicitly that the firms' behaviour is consistent with profit maximisation. Its value is obtained by considering the gains from capital in total available income as reported in the national accounts provided by INE. The rates of change in the price of asset type *i* are taken from the data used to estimate the capital stocks of individual assets. Finally, and following Schreyer *et al*. (2003), we define the rate of depreciation as the ratio of the purchase price of a one-year old asset over that of a new asset:[25]

$$d_{t,0} = 1 - \frac{q^i_{t,1}}{q^i_{t,0}}$$

With the general expression of the rate of vintage prices being given by:

$$\frac{q^i_{t,s+1}}{q^i_{t,s}} = \frac{\sum_{\tau=0} \frac{h^i_{s+\tau+1}}{\left[(1+r)/(1+\xi^i)\right]^{\tau+1}}}{\sum_{\tau=0} \frac{h^i_{s+\tau}}{\left[(1+r)/(1+\xi^i)\right]^{\tau+1}}}$$

[25] Differences in tax treatment between asset types have not been considered due to lack of data.

Where the *h* terms represent the hyperbolic age-efficiency profile, *s* is the capital vintage, and $(1+r)/(1+\xi^{i})$ is a real interest rate, where ξ^{i} is an asset-specific price index.[26] OECD (2001b) sets this interest rate at 4%, considering it to be a reasonable value for a long-term real interest rate. We follow the OECD standard procedure setting $(1+r)/(1+\xi^{i})$ at 1.04.

The estimates of the annual deterioration rates by sector and asset type are presented in Table 2.

Table 2: Estimates of annual deterioration rates (%)

Industries	Buildings	Transport Equipment	Machinery and Equipment	Other Investment
Agriculture, forestry and fishing	0.95	7.39	5.58	9.03
Mining and quarrying	1.16	9.03	4.06	7.39
Food, beverages and tobacco	1.02	9.03	5.31	9.03
Textiles and clothing	0.88	9.03	4.62	9.03
Leather and footwear	0.88	9.03	4.62	9.03
Wood and wood products	0.68	9.03	4.62	9.03
Pulp, paper and paper products, printing and publishing	0.68	9.03	4.62	9.03
Coke, refined petroleum products and nuclear fuel	0.92	9.03	4.62	9.03
Chemicals and chemical products	1.19	9.03	4.62	9.03
Rubber and plastics	1.19	9.03	4.62	9.03
Non-metallic mineral products	0.88	9.03	4.62	9.03
Basic metals and fabricated metal products	0.88	9.03	4.62	9.03
Machinery and equipment n.e.c	0.88	9.03	4.62	9.03
Electrical and optical equipment.	0.88	9.03	4.62	9.03
Transport equipment	0.88	9.03	4.62	9.03
Manufacture n.e.c.	0.88	9.03	4.62	9.03
Electricity, gas and water supply	0.88	9.03	4.62	9.03
Construction	0.88	9.03	4.06	9.03
Wholesale and retail trade	0.59	11.46	5.58	9.03
Hotel and restaurant services	0.59	11.46	5.58	9.03
Transport, storage and communication	0.59	3.02	5.58	9.03
Financial intermediation, real estate, renting and business activities	0.59	11.46	5.58	9.03
Public administration and defence; compulsory social security	0.59	11.46	5.58	9.03
Education	0.59	11.46	5.58	9.03
Health and social work	0.59	11.46	5.58	9.03
Other community, social and personal services	0.59	11.46	5.58	9.03

Note: Author's computations.

[26] ξ^{i} is the expected rate of change of nominal user costs.

As would be expected, deterioration rates are higher in the case of transport equipment, and lower in the longest-lived assets (buildings). A similar pattern is found in the studies by Jorgenson and Stiroh (2000) and Oulton and Srinivasan (2003), although the transport equipment deterioration rate assumes relatively higher values. It is important to recall, however, that the rates used in these latter works are obtained by considering a geometric decay efficiency profile and generally lower asset lives.

The results of the estimation of aggregate indices of capital services are presented in Figures 3 to 7.[27]

Taking the economy as a whole, our findings suggest the existence of five distinct phases during the period under study, which follow very closely the observed fluctuations of Portuguese macroeconomic growth.[28] Between 1977 and 1984, most industries show a considerable decline in the rate of (productive) capital accumulation, which is followed by a phase of recovery during 1986-1990. Subsequently, there is a new period of decay which lasts up to 1994. The second half of the 1990s is characterised by an increase in the rate of capital accumulation and capital services, but the more recent years reveal a consistent pattern of decline in the large majority of the industries considered, and at the overall economic level.

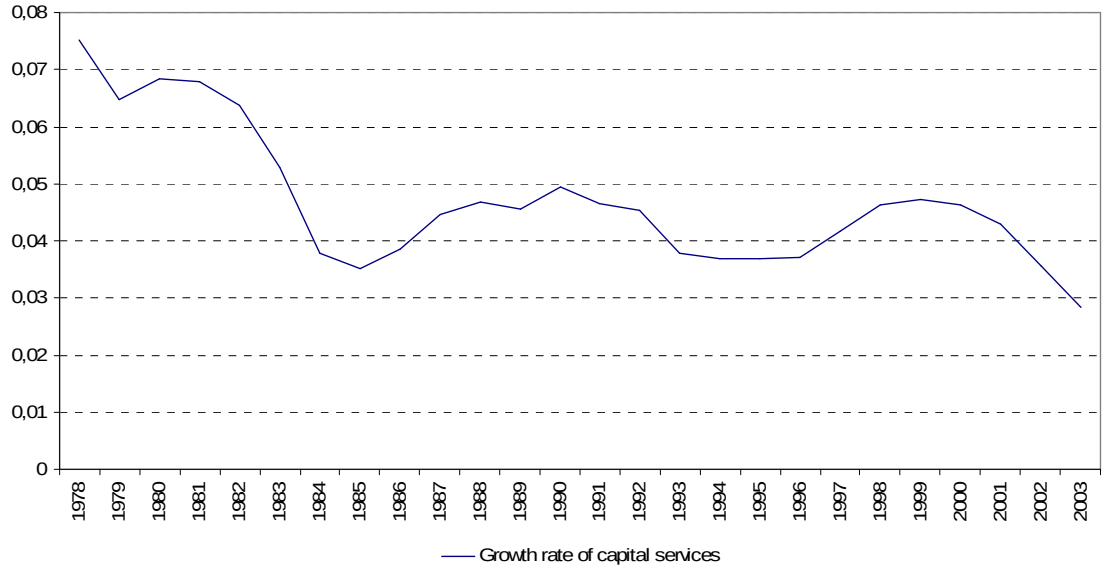


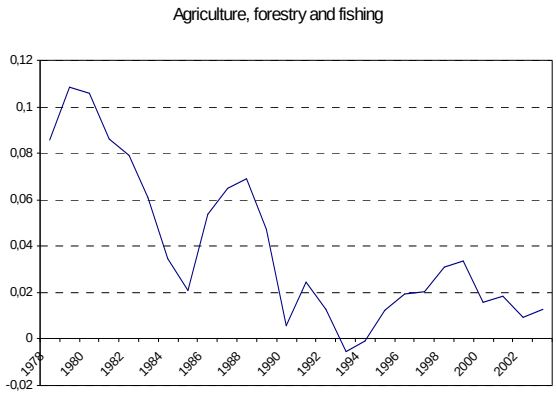
Figure 3: Growth of capital services, total economy (1977-2003).

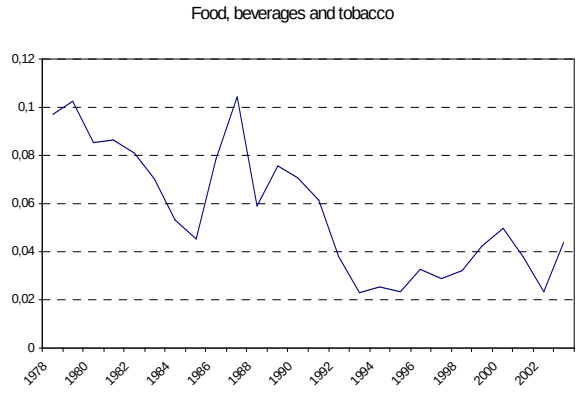
Note: Author's computations based on data from INE and Banco de Portugal

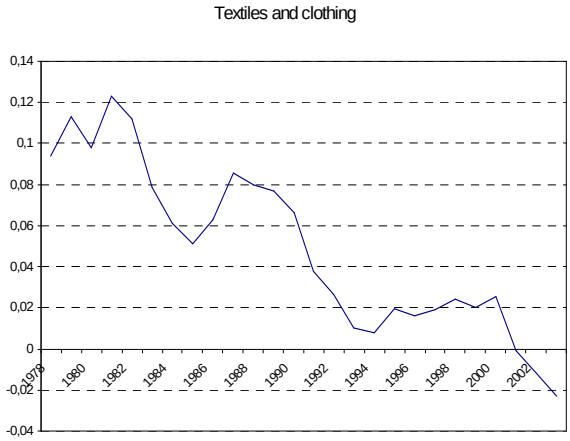
[27] The full list of results, with the estimates of the volume index of capital services by sectors can be found in Table A.5 in the annex.
[28] See Lopes (1996), and more recently Lains (2003).

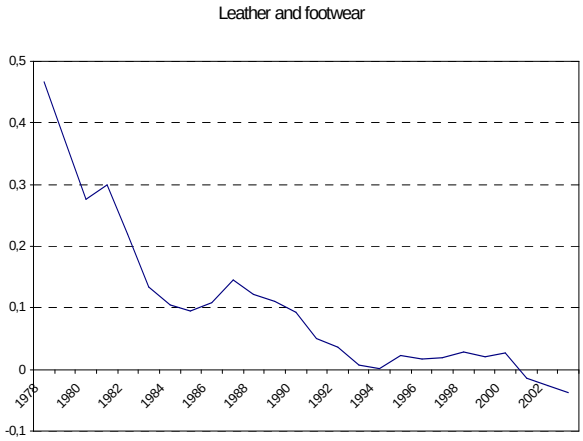
The observed chronological regularities are, however, accompanied by considerable differences across industries. Some industries, included in what we label Group 1, show a general tendency of decline in capital accumulation rates over the whole period analysed. This group is significantly represented by the so-called 'traditional' industries, such as textiles and clothing, leather and footwear, pulp, paper and paper products, and non-metallic mineral products.

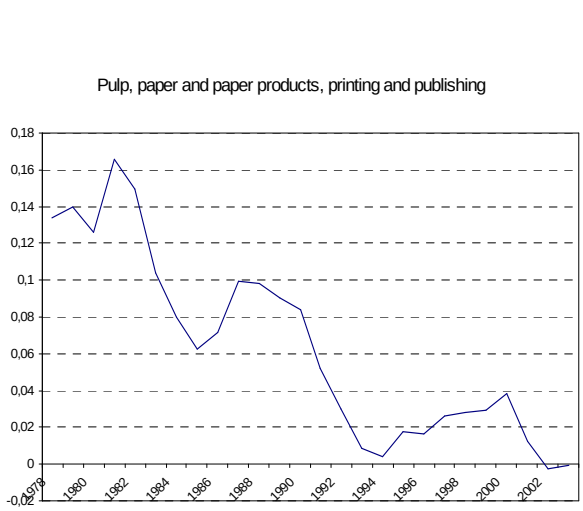
Group I:

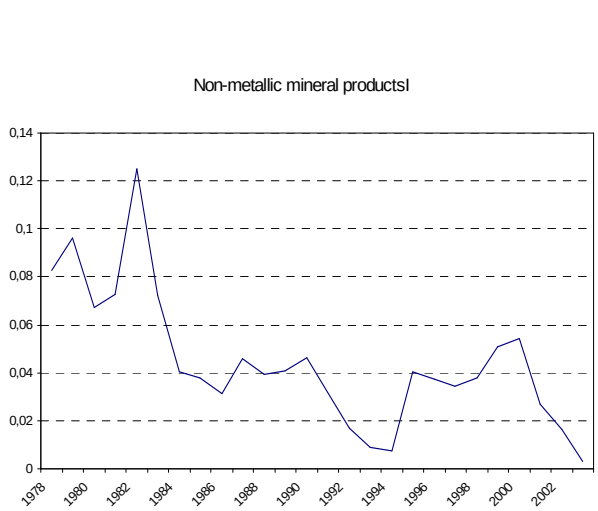












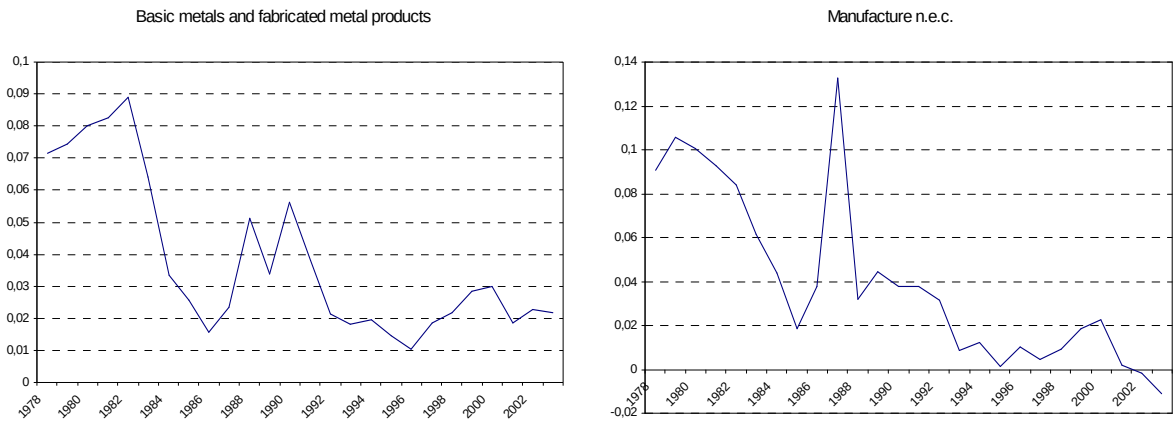
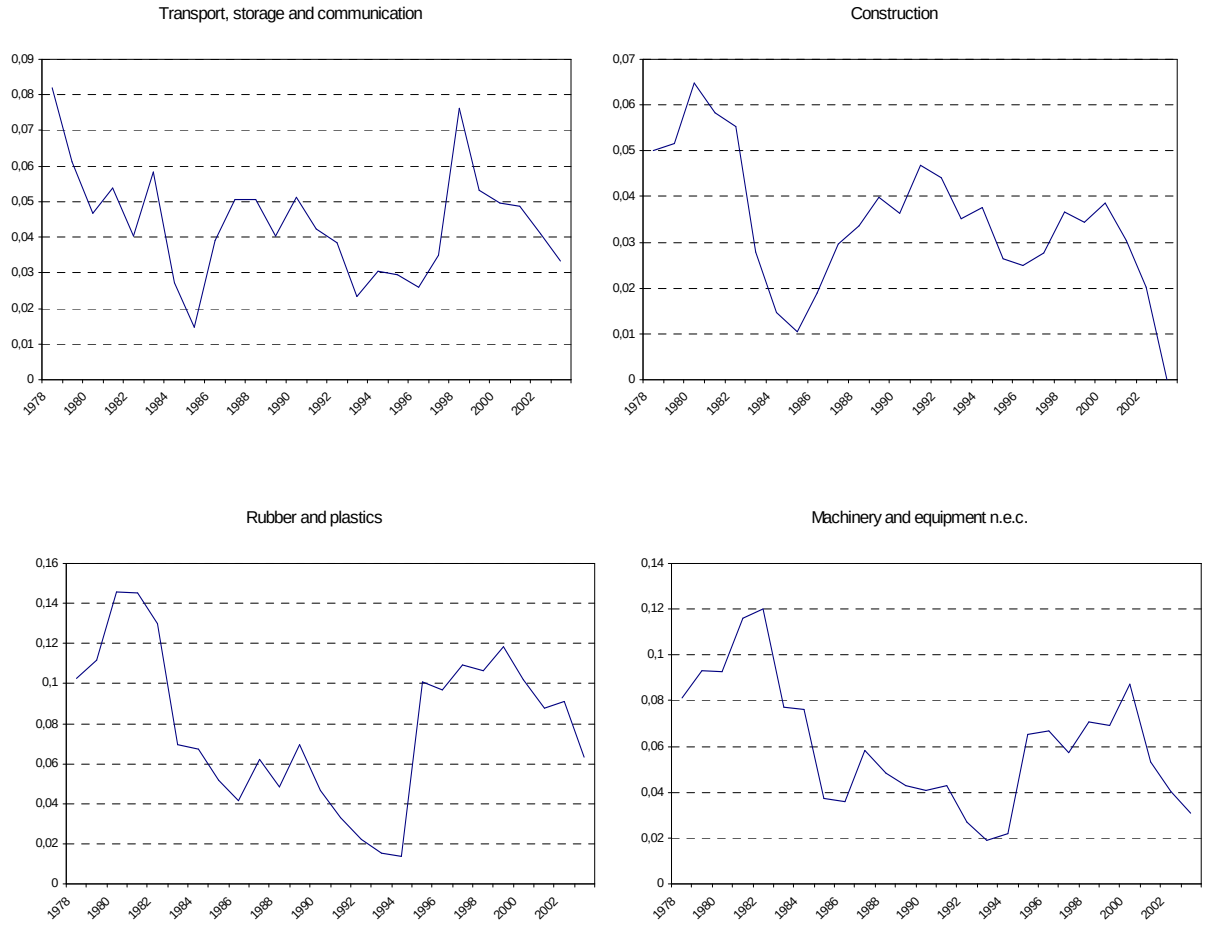


Figure 4: Growth of capital services in Group I of industries (1977-2003).

Note: Author's computations based on data from INE and Banco de Portugal

Other industries, such as construction, transport, storage and communication, and rubber and plastics, present considerable signs of recovery during the recent periods of economic expansion (1986-1990 and 1996-2000), experiencing, however, a considerable decline in the rate of growth of capital services between 2001 and 2003.

Group II:



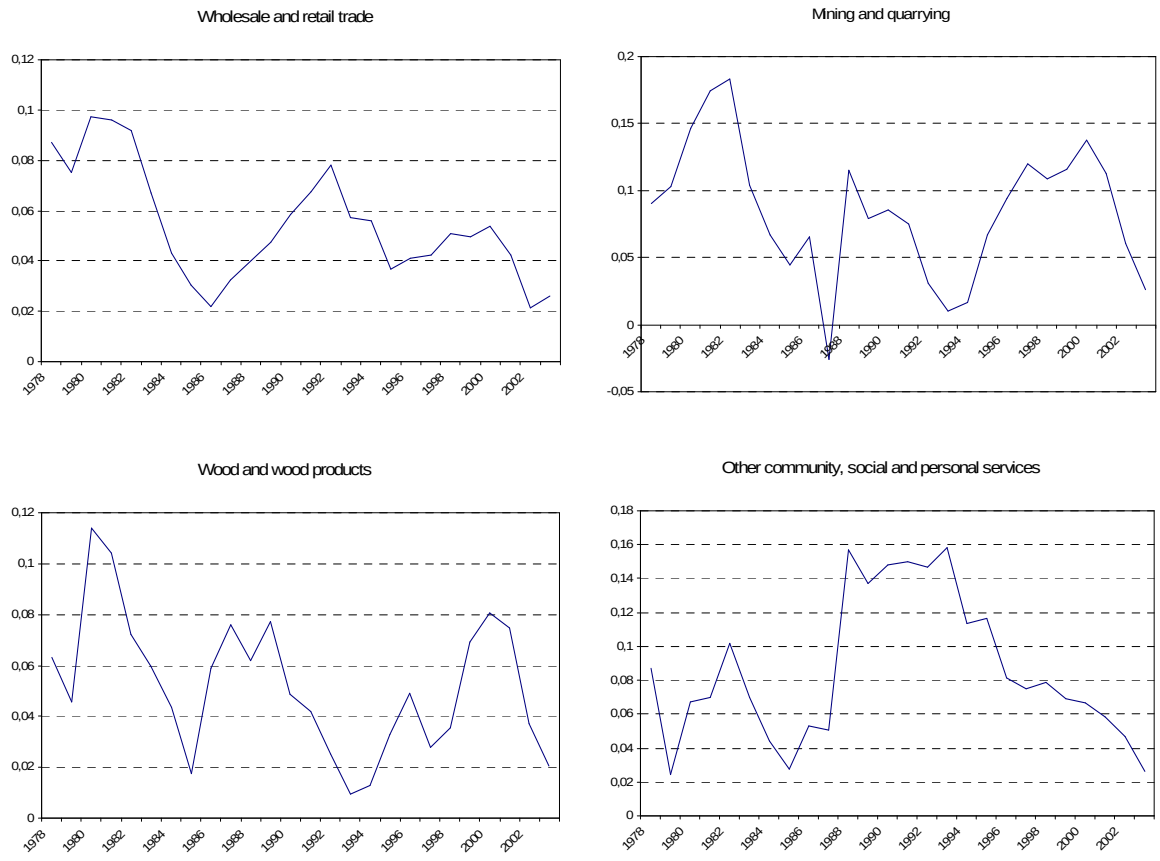
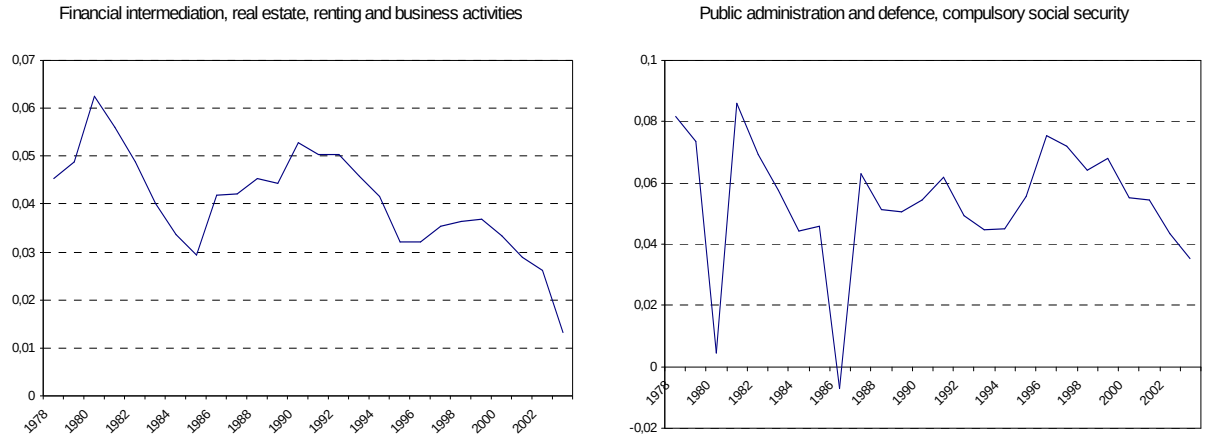


Figure 5: Growth of capital services in Group II of industries (1977-2003).

Note: Author's computations based on data from INE and Banco de Portugal

Another group of industries (financial intermediation, real estate and business activities, public administration and defence, education, health and social work, transport equipment, hotel and restaurant services) shows relative stability of productive capital growth rates during most of the period under study, experiencing a decline in these rates between 2001 and 2003.

Group III:



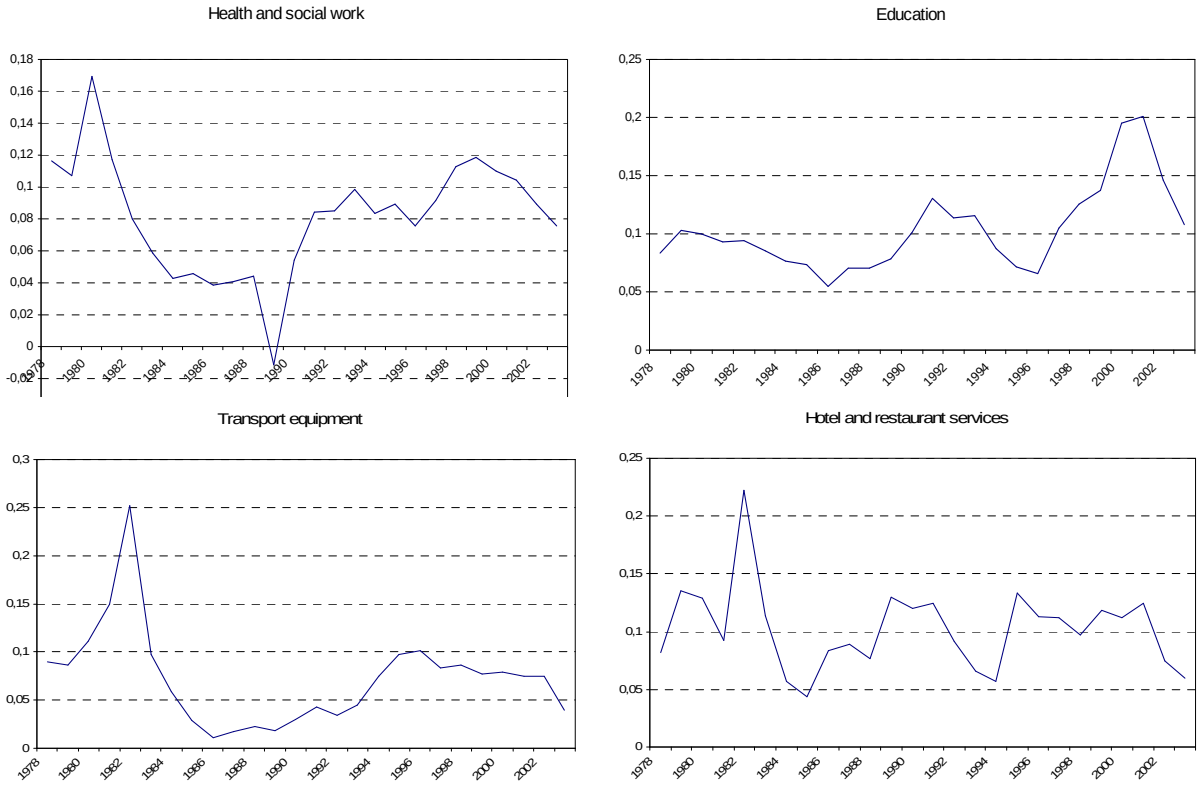
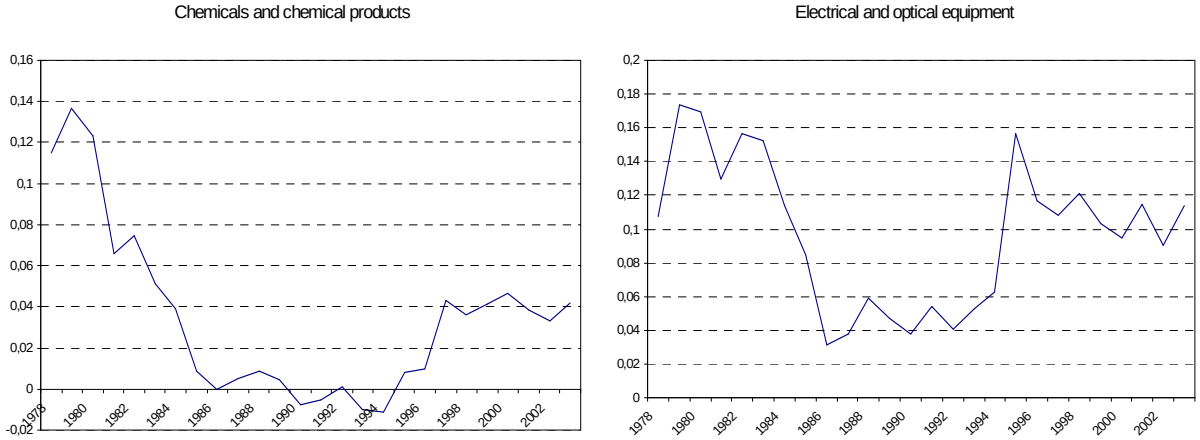


Figure 6: Growth of capital services in Group III of industries (1977-2003).

Note: Author's computations based on data from INE and Banco de Portugal

Finally, and in contrast with the evidence found in the overwhelming majority of industries, a fourth group is characterised by a significant recovery from the mid-1990s onwards, after a period of marked decline, with no signs of deterioration in the more recent years. This is the case of electrical and optical equipment, chemical and chemical products, electricity, gas and water supply, and coke, refined petroleum products and nuclear fuel.

Group IV:



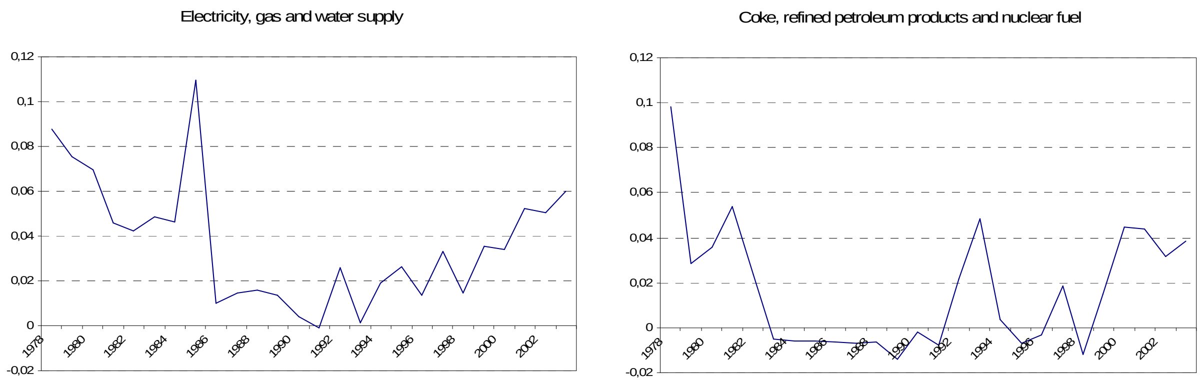


Figure 7: Growth of capital services in Group IV of industries (1977-2003).

Note: Author's computations based on data from INE and Banco de Portugal

The steady decline in the rate of accumulation of physical capital in the more traditional industries, together with the recent improvement in the corresponding rates associated with more technology-intensive industries suggests that a process of structural change towards the latter industries has been taking place during 1977-2003, expressed at least with respect to the capital factor. The global significance of this process has, however, to be established in conjunction with the labour shifts among sectors.

5. Total factor productivity growth estimates

We estimate TFP growth using the Törnqvist TFP indices based on a translog value added production function. TFP growth is given by the following expression:[29]

$$T\hat{F}P_t = \hat{Y}_t - \alpha_t \hat{L}_t - (1-\alpha_t)\hat{K}_t \qquad (9)$$

Where L and K are the labour and capital inputs, respectively, $\alpha_t = 1/2(v_t + v_{t-1})$, and v_t is the share of labour in value added.

The computation of TFP growth was made using the capital input data derived in the previous section. With respect to the output variable (real value added) we used data from the Groningen Growth and Development Centre (GGDC) Database for the 1979-2003 period,[30] and data from the OECD STAN Database for 1977 and 1978.[31] Because

[29] This expression is obtained considering the traditional Cobb-Douglas production function differentiated with respect to time. See, for example, Griliches (1990) and Jorgenson (1995) for more details on the application of the growth accounting framework in the estimation of TFP growth.

[30] This database, which is available on-line at http//:www.ggdc.net, provides data on current value added, value added deflators and hours worked for 56 industries in the 1979-2003 period for several countries, including Portugal.

the data provided by this latter source was available in more aggregate terms, grouping together DB and DC, DK and DL, and GG and HH sectors, respectively, we used the sectoral output proportions data provided by INE for 1977 and 1978 to discriminate among sectors and obtain consistent value added series for the selected sectors during the period under study. Moreover, because data on CA+CB output and VAB deflators were not available in the OECD STAN Database, we estimated them by applying backwards the corresponding growth rates available at INE to the 1979 value.

Data on the labour variable, expressed as the number of hours worked per employee, were also taken from the GGDC database for the 1979-2003 period. Data regarding 1977 and 1978 were obtained by applying backwards the annual variation rates of employment provided by INE to GGDC 1979 sectoral values.[32]

Figure 8 presents trends in output per hour worked and per unit of capital services (labour and capital productivity, respectively), capital intensity and TFP growth for the Portuguese economy between 1977 and 2003. The picture does not change much over the whole period under study, which is characterised by a significant mismatch between the rapid increase in the capital input and the (lower) increase in labour input.[33] The strong shift towards more capital-intensive production (by 2003, capital deepening had increased more than three times in relation to the 1977 level), allowed labour productivity to grow at a faster rate than total factor productivity, which increased at a much more modest rate (about 0.8% a year, whereas labour productivity grew at 2.7%). TFP growth, relatively stable between 1977 and 2003, is punctuated by moments of

[31] This is the same source used by GGDC in the compilation of Portuguese output and output deflators data.

[32] During the 1977-1979 period there were no changes in the number of established working days and in the total number of hours worked per day (Leite and Almeida, 2001). It seems reasonable therefore to expect that the variation of the total number of hours worked should follow closely the employment variation rates in each sector.

[33] In ideal terms, the measure of labour input should be adjusted for the effects of changing labour composition. Unfortunately, there is no information regarding changes in labour quality for the Portuguese case at the sectoral level for the whole period under study (the only available sources are the General Population Censuses, which are conducted every ten years, and *Quadros de Pessoal*, which have information only from the end of the 1980s onwards). We believe, however, that our estimates would not be significantly affected by the additional consideration of changes in the composition of the labour force. According to the evidence found in studies investigating human capital trends in Portugal in the last few decades, the rate of increase in this factor has been relatively low [see Teixeira and Fortuna (2004) and Teixeira (2002)]. Furthermore, according to the last Population Census, from 2001, the large majority of the Portuguese workforce still has a very low level of schooling, which is apparent from the huge percentage of individuals who do not possess more than six years of formal education (about half of the total labour force), and from the small percentage of those who have a university diploma (only 12%).

absolute decline, which coincide with the periods of more severe deterioration in the economic cycle, such as 1984, 1993, and more recently, 2003.

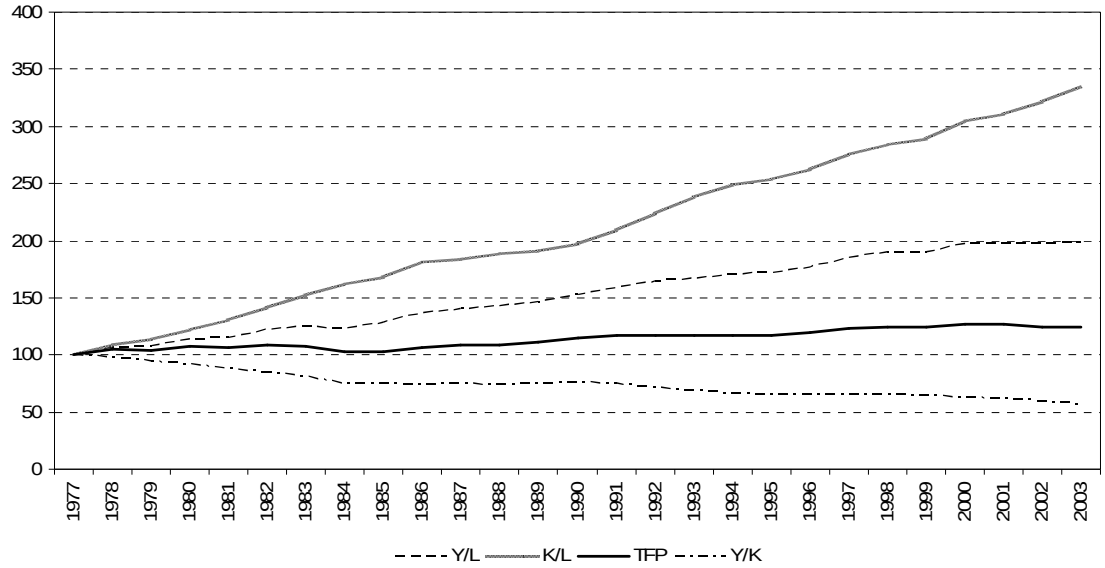


Figure 8: Labour productivity, capital productivity, capital intensity and TFP growth Portuguese Economy: 1977-2003 (1977 = 100).

Note: Author's computations

Our estimates of aggregate TFP growth are not very far from the ones found in previous studies regarding the Portuguese economy (cf. Table 3). The overall TFP growth series shows, furthermore, relatively similar trends to the ones described in Teixeira and Fortuna (2004) over the 1977-2001 period, although presenting globally more pessimistic estimates. Our approach is based, however, on a more refined calculus procedure of the capital input. In particular, indices of net and gross capital stock, used in Teixeira and Fortuna's work, tend to rise at a slower rate than measures of capital services, and therefore they tend to understate the contribution from capital to output growth and to overstate the productivity residual.

Table 3: Summary results of growth accounting for the Portuguese economy in previous studies

		Annual growth rate (%)s					As percentage of output growth			
Author	**Period**	**Labour**	**Capital**	**Human capital**	**TFP**	**Output**	**Labour**	**Capital**	**Human capital**	**TFP**
Lains (2003)	1973-90	0.02	1.74	1.61	0.56	3.93	0.5	44.3	41.0	14.2
Afonso (1999)	1974-85	0.69	1.51	-	0.16	2.36	29.2	64.0	-	6.8
	1986-93	0.17	1.46		1.30	2.93	5.8	49.8	-	44.4
Lopes (1996)	1974-92	1.80		-	0.60	2.40	75.0		-	25.0
Neves (1994)	1974-79	0.94	1.79	-	0.72	3.45	27.2	52.0	-	20.9
	1980-91	0.82	1.51	-	0.12	2.45	33.5	61.6	-	4.9

At the sectoral level (cf. Table 4), there is also a clear prevalence of relatively low TFP growth, although the results show some variation across industries. There are even some cases, such as Chemicals, Machinery and equipment, and Hotel and restaurant services, which show a decline in TFP levels between 1977 and 2003. Moreover, TFP growth in services is lower than that for the economy as a whole, similarly to the evidence found for other European countries (e.g., Sakurai *et al.*, 1997; O'Mahony, 1999; van Ark *et al*., 1999). In agreement with these latter studies we also find the relatively poor performance of financial intermediation activities, which seems to be primarily related with the severe measurement problems affecting the sector.[34]

The evidence found shows additionally a clear coincidence between phases of economic expansion and periods of higher TFP growth, and vice-versa, which confirms the pro-cyclical character of the TFP series. Indeed, most industries experience an increase in TFP growth rates between 1986-90 and 1986-2000, and a decline in these rates during the 1982-85 and 2001-03 periods.[35]

[34] See in this respect, van Ark *et al*. (1999).

[35] Several studies report this pro-cyclical feature (e.g., Timmer, 1999; OECD, 2001a), which seems to be partially related with measurement problems. Although statistical data capture output volume changes relatively well, the same does not occur with regard to changes in the rate of utilisation of inputs. As a consequence, output changes tend to be followed by generally more stable input measures, which lead to the observed pro-cyclical nature of productivity growth estimates.

Table 4: Average annual TFP growth by sector, 1977-2003 (%)

Industries	1977-81	1982-85	1986-90	1991-95	1996-2000	2001-03	1977-2003
Agriculture, forestry and fishing	3.4	4.6	2.0	2.8	1.1	-0.5	**2.3**
Mining and quarrying	3.4	-9.9	5.6	1.0	1.1	8.0	**1.3**
Food, beverages and tobacco	1.2	-4.1	-2.6	-0.5	2.0	-1.3	**-0.8**
Textiles and clothing	2.7	-1.5	-0.6	-0.6	0.6	0.5	**0.1**
Leather and footwear	-0.9	-0.5	-0.5	1.4	0.4	-4.6	**-0.5**
Wood and wood products	-4.1	-4.6	5.0	0.8	2.8	1.4	**0.4**
Pulp, paper and paper products, printing and publishing	-1.9	-3.1	-3.1	3.1	0.7	1.1	**-0.5**
Coke, refined petroleum products and nuclear fuel	18.5	-11.0	10.9	0.2	6.9	-0.6	**4.1**
Chemicals and chemical products	-11.0	1.6	3.0	-0.4	3.1	-4.3	**-1.0**
Rubber and plastics	8.4	-11.9	-4.9	-4.2	0.2	5.8	**-1.8**
Non-metallic mineral products	-7.5	-0.8	2.8	1.9	6.0	-4.1	**0.2**
Basic metals and fabricated metal products	0.4	-7.2	8.0	-1.9	0.8	2.4	**0.5**
Machinery and equipment n.e.c	-13.4	-6.9	-4.5	-1.1	-1.4	4.9	**-4.1**
Electrical and optical equipment.	6.1	-5.0	3.6	2.9	5.0	-2.2	**2.1**
Transport equipment	0.6	-14.2	6.4	1.9	8.1	0.0	**0.8**
Manufacture n.e.c.	-1.0	-3.4	0.1	4.2	3.9	-0.4	**0.8**
Electricity, gas and water supply	-13.8	10.5	1.1	6.3	5.1	0.8	**1.7**
Construction	3.0	-3.4	2.7	1.2	1.0	-4.3	**0.3**
Wholesale and retail trade	-0.5	-3.8	1.2	-0.4	1.3	-1.3	**-0.4**
Hotel and restaurant services	-7.0	-3.9	-1.7	-3.4	-3.3	-4.2	**-3.8**
Transport, storage and communication	3.4	2.9	3.5	4.6	2.8	3.0	**3.4**
Financial intermediation, real estate, renting and business activities	-0.7	-1.6	2.8	-4.3	2.2	-0.4	**-0.3**
Public administration and defence; compulsory social security	0.1	-2.0	-1.0	-1.6	0.0	-1.4	**-1.0**
Education	-1.7	-2.0	-0.6	-2.1	-3.1	-4.3	**-2.2**
Health and social work	-1.5	-0.5	-0.4	-2.5	-2.1	-2.8	**-1.6**
Other community, social and personal services	9.1	-0.1	2.0	-2.5	-0.6	-1.3	**1.0**
Aggregate TFP growth	**1.6**	**-0.8**	**2.2**	**0.4**	**1.7**	**-0.8**	**0.8**

Similarly to the pattern observed for the economy as a whole, there is also a general tendency for a decrease in capital productivity during the period under study (cf. Table 5). With the exception of coke, refined petroleum and nuclear fuel, all industries display an average negative growth rate of capital productivity. Furthermore, all industries experienced increases in the capital-labour ratios, which seem to indicate the prevalence of Hicks-labour saving technical change during the period under study. Capital deepening has been particularly intense in leather and footwear, electrical and optical equipment, mining and quarrying, transport equipment and hotel and restaurant services.

Table 5: Average annual changes in labour productivity, capital productivity and capital intensity by sector, 1977-2003 (%)

Industries	Labour Productivity	Capital Productivity	Capital-labour ratio
Agriculture, forestry and fishing	5,1	-2,5	7,5
Mining and quarrying	4,8	-4,5	8,8
Food, beverages and tobacco	1,8	-5,1	6,8
Textiles and clothing	2,6	-3,9	6,5
Leather and footwear	3,2	-7,7	9,9
Wood and wood products	3,1	-3,8	6,7
Pulp, paper and paper products, printing and publishing	2,0	-4,5	6,3
Coke, refined petroleum products and nuclear fuel	5,4	2,2	2,8
Chemicals and chemical products	1,2	-4,8	5,8
Rubber and plastics	1,2	-6,7	7,8
Non-metallic mineral products	2,3	-3,0	5,0
Basic metals and fabricated metal products	2,3	-2,2	4,3
Machinery and equipment n.e.c	-1,0	-8,8	7,5
Electrical and optical equipment.	5,7	-3,6	9,0
Transport equipment	4,5	-5,2	8,5
Manufacture n.e.c.	2,0	-0,7	2,5
Electricity, gas and water supply	3,2	-0,7	3,9
Construction	1,8	-1,8	3,5
Wholesale and retail trade	1,4	-3,4	4,7
Hotel and restaurant services	-0,8	-9,4	8,4
Transport, storage and communication	5,5	-0,1	5,5
Financial intermediation, real estate, renting and business activities	-0,1	-0,5	0,3
Public administration and defence; compulsory social security	0,5	-3,5	3,9
Education	0,4	-7,1	7,3
Health and social work	0,3	-5,4	5,5
Other community, social and personal services	3,8	-3,7	7,3
Total Economy	**2,7**	**-2,1**	**4,8**

Analysing the relative importance of the contributions from labour, capital and TFP growth to average annual growth (cf. Figure 9), it can be seen furthermore that over this period the major contributor to growth was capital deepening (about 66%). TFP contributed in about 33%, and labour made an overall insignificant contribution (about 1%).[36] The dominant role played by capital is also apparent in all sub-periods under study, with the exception of 1996-2000, in which the TFP contribution is slightly above that from capital.

[36] It is worth noting, however, that the non-adjustment of labour input to quality changes has probably underestimated the contribution from labour to production.

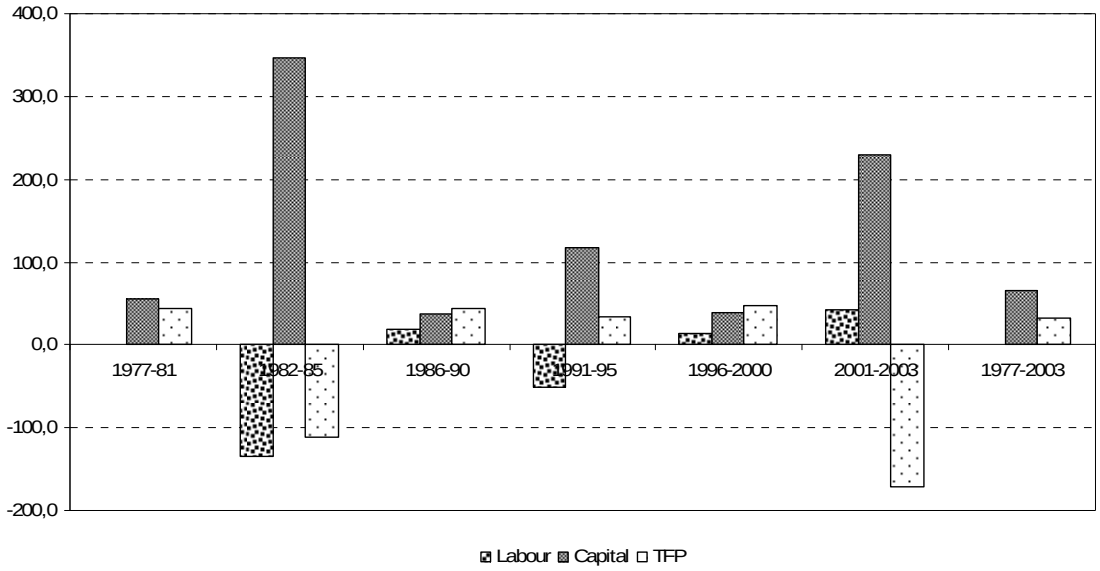


Figure 9: Labour productivity, capital intensity and TFP growth

Portuguese Economy: 1977-2003 (1977 = 100).

Note: Author's computations

These results are to a large extent in agreement with previous findings for the Portuguese economy summarised in Table 3. In all the studies, capital deepening is identified as the main source of output growth, although its importance varies over time, and the contribution from labour to output growth is very small. In Afonso (1999), for example, the contribution of the growth of capital stock to output growth is about 64% between 1974 and 1985, and approximately 50% for the 1986-1993 period. Lains (2003), in his turn, finds that capital contributes in about 44% to overall output growth during 1973-1990.

Growth in capital accounts also for the major part of the increase in value added in most of the industries under study (cf. Table 6). More precisely, capital was the major contributor to growth in 16 of the 26 industries considered (about 62% of the total). The second largest contributor is TFP, although at a considerable distance. The contribution of labour is generally low, with the exception of chemicals, financial and business activities, and social and personal services, sectors in which labour was the major source of growth.

Table 6: Contribution of labour, capital and TFP to average annual growth in value added, 1977-2003 (%)

Industries	Growth in Value Added	Contribution of		
		Labour	Capital	TFP
Agriculture, forestry and fishing	1,66	-142,0	103,4	138,6
Mining and quarrying	2,85	-4,7	60,4	44,3
Food, beverages and tobacco	0,20	-352,0	865,7	-413,7
Textiles and clothing	0,83	-120,7	207,3	13,4
Leather and footwear	1,39	-11,4	145,7	-34,3
Wood and wood products	1,31	-63,2	130,3	32,9
Pulp, paper and paper products, printing and publishing	1,28	4,9	137,6	-42,5
Coke, refined petroleum products and nuclear fuel	5,04	-16,4	34,3	82,1
Chemicals and chemical products	-0,67	217,0	-260,7	143,7
Rubber and plastics	0,14	146,5	1225,6	-1272,1
Non-metallic mineral products	1,72	-11,7	100,1	11,7
Basic metals and fabricated metal products	1,96	-10,2	87,1	23,1
Machinery and equipment n.e.c	-3,18	26,6	-53,9	127,3
Electrical and optical equipment.	4,36	12,8	39,9	47,3
Transport equipment	1,74	-44,8	99,2	45,6
Manufacture n.e.c.	3,47	27,1	49,7	23,1
Electricity, gas and water supply	3,26	-4,9	52,8	52,1
Construction	2,13	4,5	79,4	16,2
Wholesale and retail trade	1,78	27,5	96,6	-24,1
Hotel and restaurant services	-1,09	-90,4	-157,9	348,3
Transport, storage and communication	4,46	-14,7	38,5	76,3
Financial intermediation, real estate, renting and business activities	3,65	62,4	46,1	-8,5
Public administration and defence; compulsory social security	1,68	55,6	101,9	-57,5
Education	1,43	133,6	123,0	-156,6
Health and social work	1,70	90,3	102,8	-93,1
Other community, social and personal services	3,57	25,1	48,2	26,8
Total Economy	**2,57**	**0,7**	**66,6**	**32,7**

6. Conclusion

In this paper we present estimates of capital services for 26 Portuguese industries during 1977-2003. Despite the major importance of capital services measures for the analysis of capital and multifactor productivity trends, to our knowledge such an effort had not yet been undertaken. Our findings suggest a close proximity between the evolution of capital flows and the observed fluctuations of Portuguese macroeconomic growth for the economy as a whole, and for most of the industries considered. The observed chronological regularities are, however, accompanied by considerable differences across industries. In particular, the steady decline in the rate of accumulation of capital in the

more traditional industries, together with the recent improvement in the corresponding rates associated with more technology-intensive industries suggests that a process of structural change towards the latter industries has been taking place during the period under study, expressed at least with respect to the capital factor.

Based on the capital input growth estimates we obtained TFP growth rates, both at the industry and macroeconomic levels, for the period 1977-2003. The aggregate average TFP growth rate was quite modest, less than 1 % per year. At the sectoral level, there is also a clear prevalence of relatively low TFP growth. More than 70% of the industries considered presented average annual TFP growth rates below 1%, and 12 industries showed even an absolute decline of TFP during the period under study. Our findings reveal, furthermore, that a strong shift towards more capital-intensive production has taken place between 1977 and 2003, which is apparent by the marked increase in the capital-labour ratios both at the industry and macroeconomic levels of analysis. In all but one industry – coke, refined petroleum products and nuclear fuel– the average annual growth rate of capital productivity is negative, which seems to be representative of the strong mismatch between the increase in the capital input and the (much lower) increase in labour input.

Analysing the relative importance of the contributions from labour, capital and TFP growth to average annual growth, it can be seen furthermore that over this period the major contributor to growth was capital deepening at the overall macroeconomic level and in the majority of industries under study.

The low average rates of TFP growth in most of the branches of economic activity, and their absolute decline in the more recent period, constitute a matter of deep concern. The achievement of a sustained increase in productivity growth is, undeniably, a national imperative, which is essential to improve competitiveness and increase the rate of convergence to EU. The aim of the present paper consisted essentially in providing more rigorous assessment of capital and productivity measures, but the evidence found calls naturally for some explanation. In these circumstances, the analysis of the main causes behind the poor performance results observed, and the identification of the range of policies to be implemented in order to improve productivity seem to constitute very important topics for future research.

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Table A.1: Price deflators of investment by asset type (base year: 1977)

	Machinery and equipment	Vehicles	Buildings	Other investment	GFCF
1977	1	1	1	1	1
1978	1,18	1,34	1,17	1,17	1,20
1979	1,42	1,79	1,48	1,44	1,51
1980	1,78	2,14	1,85	1,71	1,87
1981	2,00	2,57	2,28	2,07	2,24
1982	2,37	2,74	2,71	2,54	2,61
1983	2,92	3,29	3,39	3,44	3,25
1984	3,70	3,96	4,08	4,46	3,99
1985	4,17	4,40	4,86	5,23	4,63
1986	4,62	4,94	5,35	6,42	5,17
1987	4,88	5,54	5,88	6,78	5,61
1988	5,41	6,03	6,51	7,73	6,21
1989	5,82	6,64	7,43	8,55	6,90
1990	5,80	6,91	8,56	9,24	7,44
1991	5,95	6,88	9,71	9,43	7,95
1992	5,69	7,19	10,51	9,72	8,24
1993	5,66	7,24	11,23	10,18	8,55
1994	5,90	7,27	11,75	10,32	8,86
1995	5,95	7,52	12,27	10,63	9,15
1996	6,25	7,47	12,62	11,03	9,44
1997	6,41	7,70	13,11	11,82	9,79
1998	6,45	7,70	13,43	12,75	10,02
1999	6,34	8,03	13,69	13,92	10,23
2000	6,73	8,50	14,50	14,71	10,85
2001	6,57	8,65	15,02	15,33	11,04
2002	6,35	8,54	15,56	16,19	11,26
2003	6,23	8,49	15,91	17,29	11,46

Source: 1977–1995: Banco de Portugal (http://www.bportugal.pt); 1995-2003, INE.

Table A.2: Industries considered in the measurement of capital services

NACE rev 1 categories	ISIC rev 3 categories	Industries
AA + BB	01-05	Agriculture, hunting, forestry and fishing
CA + CB	10-14	Mining and quarrying
DA	15-16	Manufacture of food products; beverages and tobacco
DB	17-18	Manufacture of textiles and textile products
DC	19	Manufacture of leather and leather products
DD	20	Manufacture of wood and wood products
DE	21-22	Manufacture of pulp, paper and paper products; publishing and printing
DF	23	Manufacture of coke, refined petroleum products and nuclear fuel
DG	24	Manufacture of chemicals, chemical products and man-made fibres
DH	25	Manufacture of rubber and plastic products
DI	26	Manufacture of other non-metallic mineral products
DJ	27-28	Manufacture of basic metals and fabricated metal products
DK	29	Manufacture of machinery and equipment n.e.c.
DL	30-33	Manufacture of electrical and optical equipment
DM	34-35	Manufacture of transport equipment
DN	36-37	Manufacturing n.e.c.
EE	40-41	Electricity, gas and water supply
FF	45	Construction
GG	50-52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
HH	55	Hotels and restaurants
II	60-64	Transport, storage and communication
JJ + KK	65-74	Financial intermediation, real estate, renting and business activities
LL	75	Public administration and defence; compulsory social security
MM	80	Education
NN	85	Health and social work
OO+ PP	90-95	Other community, social and personal service activities; Private households with employed persons

Table A.3: Service lives of assets considered in the measurement of capital stock statistics

Industries	Buildings	Transport Equipment	Machinery and Equipment	Other Investment
Agriculture, forestry and fishing	45	12	15	10
Mining and quarrying	40	10	20	12
Food, beverages and tobacco	43	10	16	10
Textiles and clothing	47	10	18	10
Leather and footwear	47	10	18	10
Wood and wood products	55	10	18	10
Pulp, paper and paper products, printing and publishing	55	10	18	10
Coke, refined petroleum products and nuclear fuel	46	10	18	10
Chemicals and chemical products	39	10	18	10
Rubber and plastics	39	10	18	10
Non-metallic mineral products	47	10	18	10
Basic metals and fabricated metal products	47	10	18	10
Machinery and equipment n.e.c	47	10	18	10
Electrical and optical equipment.	47	10	18	10
Transport equipment	47	10	18	10
Manufacture n.e.c.	47	10	18	10
Electricity, gas and water supply	47	10	18	10
Construction	47	10	20	10
Wholesale and retail trade	60	8	15	10
Hotel and restaurant services	60	8	15	10
Transport, storage and communication	60	25	15	10
Financial intermediation, real estate, renting and business activities	60	8	15	10
Public administration and defence; compulsory social security	60	8	15	10
Education	60	8	15	10
Health and social work	60	8	15	10
Other community, social and personal services	60	8	15	10

Table A.4: Initial capital stocks (10^6 euros; constant 1977 prices)

Industries	Buildings		Transport Equipment		Machinery and Equipment		Other Investment	
	GFCF 1977	Initial stock	GFCF 1977	Initial stock	GFCF 1977	Initial stock	GFCF 1977	Initial stock
Agriculture, forestry and fishing	4,37	80,76	7,25	53,10	18,99	166,93	0,20	1,27
Mining and quarrying	0,75	13,22	0,55	3,48	0,94	10,16	-0,03	0[1]
Food, beverages and tobacco	5,02	91,13	2,94	18,55	19,34	177,52	0,16	0,99
Textiles and clothing	4,17	78,58	1,00	6,30	19,81	198,27	0,17	1,06
Leather and footwear	0,39	7,29	0,16	1,02	1,56	15,59	0,06	0,39
Wood and wood products	1,03	20,49	1,02	6,45	3,04	30,38	0,00	0
Pulp, paper and paper products, printing and publishing	1,75	34,88	0,58	3,67	14,21	142,22	-0,03	0[1]
Coke, refined petroleum products and nuclear fuel	1,62	30,20	0,01	0,06	32,16	321,91	0,01	0,07
Chemicals and chemical products	8,49	141,45	0,77	4,86	19,90	199,14	-0,22	0[1]
Rubber and plastics	0,67	11,11	0,34	2,13	2,42	24,22	0,01	0,07
Non-metallic mineral products	5,56	104,76	2,66	16,74	11,07	110,75	0,004	0,02
Basic metals and fabricated metal products	6,48	121,99	1,42	8,92	10,10	101,15	0,74	4,65
Machinery and equipment n.e.c	1,61	30,31	0,43	2,73	3,77	37,71	0,10	0,62
Electrical and optical equipment.	0,73	13,82	0,28	1,79	3,56	35,66	0,02	0,15
Transport equipment	4,07	76,53	0,63	3,96	2,19	21,94	0,14	0,88
Manufacture n.e.c.	1,53	28,83	0,77	4,84	4,89	48,93	0,06	0,37
Electricity, gas and water supply	53,55	1008,16	0,25	1,56	5,48	54,8	-0,23	0[1]
Construction	36,30	683,28	9,58	60,34	26,39	284,49	1,63	10,29
Wholesale and retail trade	8,02	164,5	11,53	58,98	31,44	276,35	2,46	15,52
Hotel and restaurant services	1,52	31,17	0,13	0,68	2,66	23,37	-0,04	0[1]
Transport, storage and communication	41,85	858,74	45,33	563,02	24,16	212,40	3,58	22,56
Financial intermediation, real estate, renting and business activities	313,20	6426,54	1,29	6,62	5,01	44,01	39,37	247,99
Public administration and defence; compulsory social security	56,82	1165,88	2,65	13,53	13,66	120,08	-0,73	0[1]
Education	13,29	272,64	0,07	0,34	7,07	62,13	0,05	0,34
Health and social work	5,51	113,12	0,08	0,39	4,47	39,30	-0,05	0[1]
Other community, social and personal services	7,99	163,85	0,32	1,66	1,87	16,43	0,41	2,61

Notes:1) Initial stocks were set at zero because the 1977 GFCF values were negative; 2) Author's computations based on data from INE and Banco de Portugal

Table A.5: Volume index of capital services (all assets) by sectors

	AAeBB	CAeCB	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK
1977	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1978	108,6	109,0	109,7	109,4	146,6	106,3	113,4	109,8	111,5	110,3	108,3	107,1	108,1
1979	120,3	120,3	121,0	121,7	201,3	111,2	129,2	113,0	126,7	122,6	118,7	115,1	118,2
1980	133,1	137,9	131,3	133,6	256,6	123,9	145,5	117,0	142,3	140,4	126,6	124,4	129,1
1981	144,5	161,9	142,6	150,1	333,6	136,8	169,7	123,3	151,6	160,9	135,8	134,6	144,2
1982	156,0	191,5	154,2	166,9	406,8	146,6	195,0	126,2	163,0	181,8	152,8	146,6	161,5
1983	165,4	211,4	165,0	180,0	461,5	155,4	215,3	125,6	171,3	194,4	163,9	156,0	174,0
1984	171,2	225,6	173,8	191,0	509,7	162,2	232,5	124,8	178,0	207,5	170,5	161,2	187,3
1985	174,8	235,7	181,7	200,8	558,0	165,0	247,0	124,1	179,6	218,3	176,9	165,3	194,2
1986	184,2	251,0	196,0	213,5	618,8	174,7	264,7	123,3	179,6	227,4	182,5	167,9	201,2
1987	196,2	244,5	216,5	231,7	709,4	188,0	291,0	122,5	180,5	241,5	190,8	171,9	212,9
1988	209,7	272,6	229,2	250,2	795,6	199,7	319,5	121,7	182,1	253,3	198,4	180,6	223,2
1989	219,5	294,1	246,5	269,5	883,5	215,1	348,5	120,0	182,9	270,9	206,5	186,8	232,8
1990	220,8	319,2	263,9	287,4	965,2	225,6	377,7	119,8	181,5	283,6	216,1	197,3	242,3
1991	226,2	343,2	280,1	298,3	1014,3	235,0	397,4	118,8	180,6	293,0	223,0	204,8	252,6
1992	229,1	353,8	290,7	306,3	1050,5	241,0	409,4	121,4	180,8	299,4	226,8	209,2	259,4
1993	227,8	357,3	297,4	309,5	1058,7	243,3	412,8	127,3	179,0	303,9	228,8	213,0	264,3
1994	227,7	363,1	305,0	311,9	1059,8	246,3	414,5	127,7	176,9	308,2	230,5	217,2	270,2
1995	230,5	387,3	312,2	318,0	1083,2	254,4	421,8	126,8	178,3	339,2	239,8	220,4	287,8
1996	235,0	423,9	322,4	323,0	1100,7	266,8	428,6	126,4	180,1	372,2	248,8	222,7	307,1
1997	239,8	474,8	331,7	329,2	1121,0	274,2	439,7	128,7	187,8	412,9	257,3	226,8	324,7
1998	247,3	526,3	342,3	337,3	1153,6	283,9	451,9	127,2	194,6	456,8	267,0	231,7	347,7
1999	255,6	587,2	356,8	344,1	1176,6	303,5	465,3	129,1	202,7	510,9	280,5	238,3	371,8
2000	259,7	667,8	374,6	352,8	1209,0	328,0	483,3	134,9	212,1	563,0	295,7	245,4	404,2
2001	264,5	742,9	388,8	352,5	1192,0	352,5	489,2	140,8	220,2	612,5	303,8	249,9	425,7
2002	266,9	787,9	397,9	348,4	1161,3	365,6	487,8	145,3	227,4	668,4	308,8	255,6	442,9
2003	270,3	808,5	415,4	340,5	1118,2	373,1	487,7	150,8	237,0	710,7	309,8	261,1	456,6

Table A.5: *(cont.)***:** Volume index of capital services (all assets) by sectors

	DL	DM	DN	EE	FF	GG	HH	II	JJeKK	LL	MM	NN	OO	Total Economy
1977	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	**100,0**
1978	110,7	109,0	109,1	108,8	105,0	108,7	108,1	108,2	104,5	108,2	108,4	111,6	108,7	**107,5**
1979	130,0	118,4	120,6	117,0	110,4	116,9	122,8	114,8	109,6	116,1	119,5	123,6	111,4	**114,5**
1980	152,0	131,5	132,7	125,1	117,6	128,3	138,6	120,2	116,5	116,6	131,5	144,5	118,8	**122,3**
1981	171,7	151,2	145,0	130,9	124,4	140,6	151,4	126,7	123,0	126,7	143,7	161,4	127,1	**130,6**
1982	198,5	189,2	157,2	136,4	131,3	153,5	185,1	131,8	129,0	135,5	157,2	174,3	140,1	**138,9**
1983	228,8	207,6	166,9	143,1	135,0	163,8	206,2	139,5	134,2	143,2	170,7	184,5	149,8	**146,2**
1984	254,9	219,7	174,2	149,7	136,9	170,9	217,8	143,2	138,7	149,6	183,8	192,4	156,5	**151,8**
1985	276,4	225,9	177,4	166,1	138,4	176,1	227,3	145,3	142,8	156,4	197,2	201,3	160,8	**157,1**
1986	285,0	228,4	184,1	167,7	141,0	179,9	246,4	151,0	148,8	155,3	208,1	209,1	169,3	**163,2**
1987	295,8	232,3	208,6	170,2	145,2	185,7	268,4	158,7	155,0	165,1	222,7	217,6	177,9	**170,5**
1988	313,3	237,6	215,2	172,9	150,0	193,2	288,8	166,7	162,1	173,6	238,4	227,2	205,8	**178,4**
1989	328,1	241,9	224,8	175,2	156,0	202,4	326,4	173,4	169,2	182,4	257,0	224,6	234,0	**186,6**
1990	340,6	249,1	233,3	175,9	161,7	214,2	365,6	182,3	178,2	192,4	283,0	236,7	268,7	**195,8**
1991	359,1	259,9	242,1	175,8	169,2	228,7	411,1	190,0	187,1	204,3	319,8	256,7	308,9	**204,9**
1992	373,6	268,6	249,8	180,3	176,7	246,5	448,6	197,3	196,6	214,3	356,1	278,5	354,2	**214,2**
1993	393,2	280,5	252,0	180,6	182,9	260,6	478,1	201,9	205,6	223,9	397,1	305,9	410,3	**222,3**
1994	417,7	301,4	255,0	184,1	189,8	275,2	505,5	208,1	214,1	234,0	431,9	331,5	456,7	**230,5**
1995	483,0	330,7	255,3	189,0	194,8	285,3	573,0	214,2	221,0	247,0	462,9	361,0	510,0	**239,0**
1996	539,2	364,0	257,9	191,6	199,6	297,0	637,8	219,8	228,2	265,6	493,5	388,4	551,3	**247,9**
1997	597,5	394,4	259,1	198,0	205,1	309,6	709,3	227,4	236,2	284,7	545,2	423,9	592,7	**258,2**
1998	670,0	428,3	261,4	200,8	212,6	325,4	778,1	244,8	244,8	303,0	613,5	471,6	639,5	**270,2**
1999	739,3	461,4	266,2	208,0	219,9	341,6	870,5	257,8	253,8	323,6	697,9	527,6	683,7	**283,0**
2000	809,2	498,0	272,2	215,1	228,4	359,9	968,1	270,6	262,3	341,4	834,1	585,6	729,1	**296,1**
2001	902,0	535,1	272,7	226,3	235,3	375,2	1088,4	283,8	269,8	360,0	1002,1	646,7	771,7	**308,8**
2002	983,4	575,3	272,1	237,7	240,1	383,1	1170,2	295,5	276,9	375,6	1148,4	704,2	807,8	**319,8**
2003	1095,6	598,1	269,1	251,9	240,1	393,1	1240,1	305,3	280,6	388,9	1272,5	757,8	829,2	**328,9**

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