NEW ESTIMATES OF CAPITAL STOCK FOR EUROPEAN REGIONS (1995-2007)[*]

JAVIER ESCRIBÁ PÉREZ
University of Valencia

Mª JOSÉ MURGUI GARCÍA
University of Valencia

This study estimates comparable series of capital stocks for 121 NUTS2 regions in nine European countries for the period 1995-2007 using the Perpetual Inventory Method (PIM). The capital stock data for each region is disaggregated into six major sectors: agriculture and fisheries, industry, construction, productive market services, real estate, financial and other services and non market services. The estimation is mainly based on the regional Gross Fixed Capital Formation (GFCF) data series from EURO-STAT and the level and time span of depreciation rates are assumed to be different across sectors, but the same for all the regions and countries in each sector or industry. We also discuss the robustness of the estimates and analyse their sensitivity to pre-established assumptions. In order to do so, the BD.MORES database is used as a reference, together with information from the AMECO, National Statistical Offices and EU-KLEMS databases for countries.

Key words: capital stock, NUTS2, estimation.

JEL Classification: C82, E22, R12.

There has been growing demand for regional and sectoral statistical information on behalf of both the European authorities and National Governments. Instruments are required to monitor, assess and control the regional and sectoral effects of regional cohesion and development policies. For this reason, it is becoming increasingly necessary to improve the availability of regional statistical information in Europe. The basic source of information for European regions is EUROSTAT. While this database has information on regional

value added and employment by sector, it lacks regional investment data for numerous regions, sectors and years and neither is there data on capital stock. In 2009, the European Commission charged Cambridge Econometrics with the task of establishing the feasibility of estimating capital stock series. As a result, this institution, which uses five types of assets, provides (upon receipt of payment) estimates disaggregated into three sectors for the regions in 27 European countries.

The objective of this research is to create capital stock series for European regions with an identical level of disaggregation to that used by EUROSTAT (NACE Rev.1) for the majority of variables, including investment, in six sectors. In order to do so, we will use official statistics, units of measurement and sectoral and regional definitions and classifications as much as possible, such as those included in the BD.MORES database[1].

The official starting point for Gross Fixed Capital Formation (GFCF) series for European regions is the REGIO, *GFCF, NUTS-Branch Accounts-ESA 95* EUROSTAT database. However, only data on total activities in each country disaggregated into six sectors is available, as shown in Table 1. It is also particularly interesting to estimate capital stock in the private sector. Obviously, non-market services should be excluded from this analysis. The disaggregation is shown in bold type in Table 1, that is: Agriculture (A+B), Industry (C+D+E), Construction (F) and Market Services (G to K).

The regions and the sample period covered will depend on the availability of reliable data. On the one hand, the sample period we aim to cover runs from 1995 to 2007[2]. The reliability, quality and availability of data on the European regions have all improved markedly since the mid-1990s (ESA-95), particularly where GFCF is concerned. On the other hand, in reference to the regions the study covers, EUROSTAT alone provides data for the main variables in all these years for 121 regions in nine European countries: Belgium, Germany, France, Italy, the Netherlands, Austria, Portugal, Sweden and Spain.

This proposal is less ambitious in terms of coverage than the estimation undertaken and submitted by Cambridge Econometrics (referred to hereafter as C.E.) for all the regions of the 27 countries[3]. This institution currently offers regional capital stock series disaggregated into three sectors: Agriculture and Fisheries (A+B), Industry (C to F) and Services (G to P). We consider this level of disaggregation to be insufficient to construct capital stock data for the private sector. Furthermore, we do not agree with the criteria whereby the investment-output

---

(1) The BD.MORES database [Dabán *et al.* (2002) and De Bustos *et al.* (2008)] is a Spanish regional database with information disaggregated into 20 branches of activity. This database is compiled by the *Dirección General de Presupuestos del Ministerio de Economía y Hacienda* (Budget General Directorate of the Spanish Ministry of Economic and Financial Affairs in English) and is compatible with the REMS database (*A Rational Expectations Model for Simulation and Policy Evaluation of the Spanish Economy*, Boscá *et al.* 2007, 2010 and 2011).

(2) The later EUROSTAT data is based on NACE Rev2 which contains major methodological differences compared to NACE Rev1.

(3) See Cambridge Econometrics (2010) and Derbyshire, Gardiner and Waights (2011 and 2013) for an explanation of the methodology employed.

(I/Y) ratio is used to fill the gaps in regional time series of the sectoral GFCF of a country, nor do we agree with the capital-output (K/Y) ratio of "similar countries" used to calculate initial capital stocks. These issues will be discussed later in the paper. In this study, we have decided to remove the regions, and therefore the countries, for which EUROSTAT does not provide full investment data and information on other variables such as GVA.

Table 1: Sectoral Disaggregation of EUROSTAT and Comparison to ESA-95

Sector	ESA-95 code	Description
Agriculture	A+B	Agriculture, hunting and forestry (A), Fishing (B)
Industry	C+D+E	Mining and quarrying (C); Manufacturing (D); Electricity, gas and water supply (E)
Construction	F	Construction
Productive market services	G+H+I	Wholesale and retail trade; repair of motor vehicles…(G); Hotels and restaurants (H); Transport, storage and communications (I)
Real Estate; Financial and Business services	J+K	Financial intermediation (J); Real estate, business services renting and business activities (K)
Non market services	L to P	Public administration and defense; compulsory social security (L); Education (M); Health and social work (N); Other community, social and personal service activities (O); Private households with employed persons (P)

Source: EUROSTAT, own elaboration.

With regard to the sample of sectors and regions in countries, the first problem with EUROSTAT's GFCF data that restricts this research is that the series are expressed in current prices: in millions of current ECUs up to 31 December 1998 and in millions of current Euros from January 1999 onwards. In order to estimate capital stocks, time series of investment data at constant prices are required. This situation led us to take the national total in real terms from the series provided by AMECO (base year 2000), which is the annual macroeconomic database of the European Commission, Directorate General of Economic and Financial Affairs (DG. ECFIN). In the case of the national information disaggregated by sector and for those coun-

tries for which data is available, we use the EU-KLEMS database as a reference (using percentages, as the information is provided at 1995 prices) as the national data in nominal terms provided by AMECO, EU-KLEMS and EUROSTAT coincides.

With regards to GFCF, a downward system is used in which the principle followed is for regional aggregates to be coherent with the national accounts. Only national and regional capital stocks are constructed by aggregating branches of activity. Therefore, the estimates generally start with the most aggregated data and move downwards to the most disaggregated data. Hence, the first step always consists of obtaining homogenous estimates to construct the national aggregates, the second of obtaining the branches of activity in each country and the third involves the regional disaggregation of each branch of activity within a particular country. Finally, we reconstruct the national total and the private sector of the region by aggregating its private sectors.

The next section introduces the Perpetual Inventory Method (PIM). In the three following sections, the relative advantages of our PIM implementation are discussed, in relation to that offered by C.E.: in Section 2 on Gross Fixed Capital Formation; in Section 3 on Depreciation rates; in Section 4 different procedures used in the literature to estimate initial capital are considered, and their best adjustment to existing national and regional evidence is discussed. Finally, in Section 5, the main conclusions are summarised and further lines of work and the improvement of the data base are discussed.

1. METHODOLOGY: PERPETUAL INVENTORY METHOD

The ESA95 recommends the Perpetual Inventory Method (PIM) for the calculation of the stocks of fixed assets whenever direct information is missing. The majority of countries that provide official estimates of capital stock take the PIM approach, and these estimates have been used as a guide to the methodology proposed by Ward (1976) and subsequently by the successive proposals of the Organisation for Economic Cooperation and Development (OECD, 2000, 2001 and 2009). This paper uses a version of the scheme of PIM similar to Ward (1976), Hulten (1991) and OECD (2001) to highlight the statistical requirements which are needed to create capital stock series[4].

In essence, the PIM argues that capital stock is the accumulation of the stream of past gross investment and destruction of capital. Using the PIM, net capital stock in period t, K_t, is calculated as:

$$K_t = K_{t-1} + GFCFT - D_t \qquad [1]$$

where $GFCF_t$ is gross investment during period t and D_t is consumption of fixed capital during period t, and can be written as:

$$D_t = \delta_t K_{t-1} \qquad [2]$$

---

(4) See recent papers such as Kamps (2006) or Berlemann and Wesselhöft (2012). They use similar introductions to PIM as is usual in this literature.

where is the depreciation rate during period t and, if it is substituted in to equation [1], we obtain:

$$K_t = GFCFT_t + (1 - \delta_t)\, K_{t-1} \qquad [3]$$

The capital stock in period t is a weighted sum of gross fixed capital formation in the previous period and, if the depreciation is assumed to be at a constant rate, we obtain the following equation:

$$K_t = \sum_{i=0}^{\infty} (1 - \delta)^i GFCF_{t-i} \qquad [4]$$

In order to calculate the capital stock series, an infinite number of past investments is required[5]. In practice, however, the available time series of investments is limited but we can calculate the current capital stock if the initial capital stock is known (K_0)[6]:

$$K_t = (1 - \delta)^t K_0 + \sum_{i=0}^{t-1} (1 - \delta)^i GFCF_{t-i} \qquad [5]$$

Capital stock series estimates should go back as far as possible to ensure that the likely errors in initial levels of capital stocks have time to be corrected through the process of accumulating and retiring capital.

Therefore, the basic requirements to apply the PIM to estimate the Net capital stock are:

- An initial benchmark estimate of the capital stock.
- Statistics on gross fixed capital formation at constant prices extending back to the benchmark.
- Information is also required about the average expected service life of capital goods and there must be a distribution for the discarding of capital goods in order to obtain a capital depreciation rule.

2. Gross Fixed Capital Formation

With regards to measuring investment flows, the series used must be consistent, both in terms of level and evolution, with the main macroeconomic variables in the National Accounts in current and constant prices. For this reason, we use the EUROSTAT, AMECO and EU-KLEMS databases. As far as the total series of national GFCF in nominal terms is concerned, no significant discrepancies are observed between the various databases mentioned. Nevertheless, AMECO also provides information on the national aggregate at 2000 prices (EU-KLEMS at 1995 prices), while EUROSTAT only contains data in current prices. As a result,

---

(5) Logically, it is not necessary for the series of investment to be infinitely long. The investment series used in the PIM must therefore span the years for which the efficiency weights are positive or, at least, span the time period in which the weights are large enough to significantly affect the capital stock [Hulten (1991)].

(6) This method is called Indirect Estimates of Net capital stock by Ward (1976).

we use the AMECO data in real terms to construct the aggregate national series of GFCF. In the case of Spain, the BD.MORES can also be used directly. In 2000 euros, the only differences observed between the C.E. series (7% lower than the rest) are in the Portuguese national total.

National GFCF Information disaggregated into branches of activity is also available in the EU-KLEMS database for seven of the nine countries. In the case of these seven countries (Austria, Spain, Germany, Italy, the Netherlands, Portugal[7] and Sweden), EU-KLEMS provides both nominal and real GFCF series by sector or industry. Investment deflators are obtained for this group of countries (changing to base year 2000) to deflate the GFCF EUROSTAT series by industry. As regards the other two countries (France and Belgium), the same deflator will be used, namely the national aggregate of all branches of activity. Thus, we obtain percentages by industry to disaggregate GFCF series at constant prices of AMECO.

The requirement of the European Commission to retain asset disaggregation led to C.E. directly discarding sectoral GFCF deflators such as those in EU-KLEMS, and to use a procedure with dubious results, such as the RAS Scaling Procedure, that is applied to both constant and current price data[8].

The sectoral GFCF series of the various databases register appreciable differences, particularly where growth rates are concerned. The Investment/Output ratio used by C.E. to complete data series has led to big deviations in GFCF, particularly in agriculture: apart from Belgium, all countries have been markedly overestimated since 2001 (Germany, the Netherlands and Sweden), 2003 (France, Italy and Austria), or 2005 (Spain and Portugal). As regards total services, the series in real terms from the various databases coincide in most countries, with the exception of Portugal, where the services sector accounts for the entire 7% difference observed in the total series. Excluding this case, the differences in the series for industry and construction show the opposite trend to that observed in agriculture, albeit less noticeable due to accounting for a lower percentage of deviation with regards to the total for the sector.

The next step is the regionalisation of the sectoral investment series. We use nominal percentages of the EUROSTAT GFCF NUTS.2 to regionalise the GFCF of each of the six sectors in each country. A different deflator is used for each sector (except in France and Belgium) and each country and the same sectoral deflator for all the regions in a country.

As far as the GFCF series is concerned, our main differences with C.E. series are on the fact that we are mainly interested in obtaining the basic EUROSTAT desegregation of GFCF series at current and constant prices.

3. DEPRECIATION RATES

Apart from GFCF, one of the main determinants of the level and evolution of net capital stock estimated by PIM is the service life of equipment and the assumption made regarding the method of depreciation. In this database we use a

---

(7) The EU-KLEMS database only provided disaggregated data for this country in the 2008 version, which is prior to the current database which only dates back to 2005.

(8) See Appendix B of the Pilot Study, Cambridge Econometrics (2010).

harmonised approach to capital measurement and one set of asset depreciation rates for all countries and regions.

Our rates of depreciation are obtained on the basis of assuming similar depreciation rates in all countries and regions (NUTS 2) for each of the six branches of activity. More specifically, the depreciation rates for the various branches of activity in all the regions and countries are the average sector depreciation rates in the six countries for which the latest version of EU-KLEMS has data.

The depreciation method is that used by the majority of member states based on the usage of service lives of different assets. The EU KLEMS database folows the recommendations of the Organisation for Economic Cooperation and Development [OECD (2001 and 2009)] and the Declining Balance Rates of the US Bureau of Economic Analysis (BEA) are based on the industry by asset type depreciation rates for 11 assets. C.E. distinguishes five asset classes with a different average service life. These depreciation rates differ by asset type and industry, but neither for country nor over time. The changes over time in depreciation rates are a reflection of both differing amounts of asset use and industry mix.

The criteria used to prioritise regional comparability consist of using the same rates by industry for all the countries and regions in the sample. Indeed, this research assumes that the time course of the depreciation rates in the different branches of activity is the same for all regions and countries. As a result, in this study, we employ the assumption of Kamps (2006), the priority being to establish regional comparisons. As this author indicates, the same approach was taken by Maddison (1995) and O'Mahony (1996).

As can be observed in Figure 1, the total national depreciation rates from AMECO are relatively high, particularly in the first few years of the sample, except in the case of Sweden. This is also the case with EU-KLEMS and BD.MORES. AMECO uses national accounts data on the consumption of fixed capital. The depreciation rates implicit in the Cambridge Econometrics series are extremely low in comparison to any other database (AMECO, BD.MORES, OECD), including EU-KLEMS. In the graphs (Figure 1), the thickest line indicates the rate and its trend over time, which has been used in this research and which we will refer to hereafter as E-M.

With reference to the depreciation rates, according to C.E. they increase in agriculture and start at a much lower level (0.0275 in 1995) than our estimates, which yield similar values in 2007. We use depreciation rates averages of the countries for which information is available in EU-KLEMS, which remains quite constant at approximately 0.055. In the case of industry and construction, the rates used for each country in C.E. are much lower than the averages in EU-KLEMS. In this paper, the average depreciation rate rises from 0.07 in 1995 to 0.085 in 2007 whereas, in C.E., it increases from 0.032 to 0.072. The depreciation rate in total services also rises in both databases, but from 0.02 to 0.043 in C.E. and from 0.03 to 0.047 in this research.

Consequently, the capital series will differ from those in any other database, as will the depreciation rates. The resulting depreciation rate for each country or for the partial grouping of six branches of activity will be implicit in the corresponding groups of capital stock.
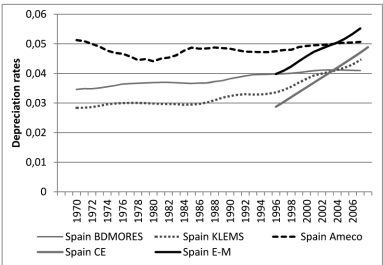
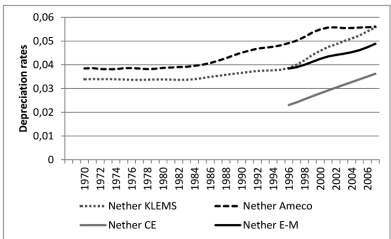Figure 1: Depreciation Rates in European Countries
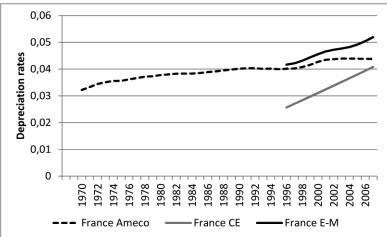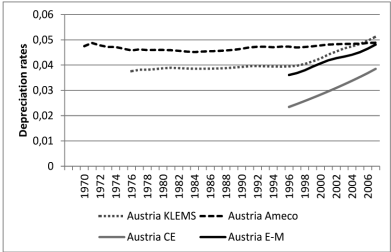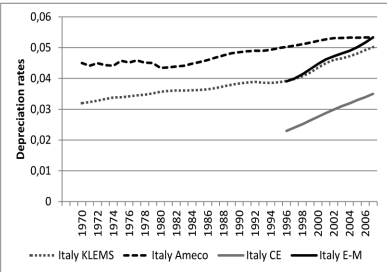Comparison using different databases
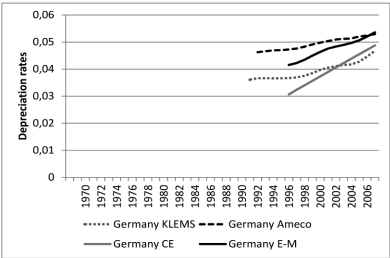
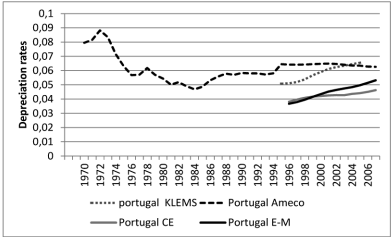Germany
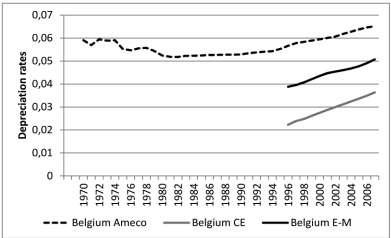
Belgium

Spain

The Netherlands
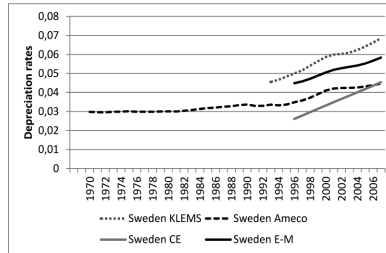
France

Austria

Italy

Portugal

Source: Own elaboration.

Figure 1: Depreciation Rates in European Countries
Comparison using different databases (continuation)

Sweden

4. Initial capital stocks

The total national capital stock at AMECO at constant prices (base 2000) is used as a starting point, except in the case of Spain and Sweden[9]. AMECO Capital stock in 1995 for Sweden is too high as a result of recording extraordinarily low depreciation rates since 1970 that cannot be compared to those in any other country. For this reason, total initial capital stock was taken from the EU-KLEMS database, albeit with a base year of 2000.

The C.E. database states that the Initial National Capital series of reference used are, when they exist, based on EU-KLEMS. Some of the discrepancies between EU-KLEMS and AMECO are large where initial capital stock in 1995 is concerned, as can be observed in Figure 2. As regards C.E., initial capital stock does not fully coincide with EU-KLEMS: in the case of Spain[10], it is clearly overestimated by C.E. while, in the case of Italy, it is underestimated.

When determining initial capital stocks for each branch of activity, we once again have to distinguish on the basis of the information that EU-KLEMS offers for each country. In the case of Austria, Germany, Italy, the Netherlands, Portugal and Sweden, the percentage that the capital of each branch of activity represents in regard to total activities in EU-KLEMS in 1995 is multiplied by the capital of total AMECO activities, except in the case of Sweden. The BD.MORES in 1995 is used directly in Spain for all branches of activity except agriculture, which is so different to EU-KLEMS that we decided to take the percentage from the latter database with a base year of 1995 in order to ensure Spain could be compared to other countries. In the case of France and Belgium, EU-KLEMS provides no informa-

---

(9) In both countries the total capital stock is the sum of the sectors. In Spain, the BD.MORES is used and, in Sweden, the EU-KLEMS.

(10) As we will show later in the paper, there must be a mistake in the capital stock of industry in Spain. The figure provided by C.E. is double the estimate in this paper and that of EU-KLEMS, while the opposite occurs in the case of France.

Figure 2: Comparison of initial capital stocks,
year 2000 prices. Total economy
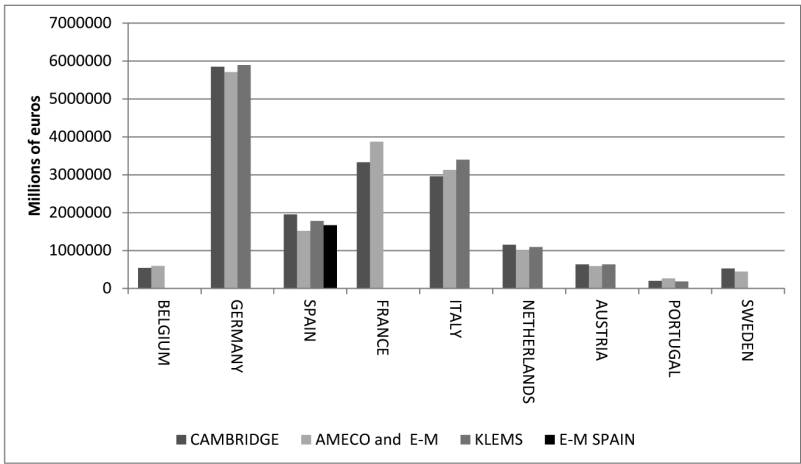
Source: Own elaboration.

tion whatsoever on sectoral capital stocks. Nevertheless, in the case of Belgium we have sector-disaggregated series on capital stock from the National Bank of Belgium and for France from the OECD International Sectoral Data Base.

Once again, the percentage that the capital of each branch of activity represents with regard to total activities in those databases in 1995 is multiplied by the capital stock of total activities from AMECO to obtain initial capital stocks by branch of activity.

When no source of information is available, we do not believe it is suitable to use the sectoral share of total GVA (the capital/output ratio) to disaggregate capital stock by branch of activity. The reason is that this implies assuming an identical K/Y ratio for sectors that are technologically very different. As we will see later in this research, if there is no other more or less official information existed, capital stock could be estimated using other methods.

Moving on, initial capital stocks should only differ when AMECO (and E-M) or EU-KLEMS (C.E.) are used as aggregates because the information used to disaggregate them came from EU-KLEMS. Notwithstanding, Figures 3a to 3c present the initial capital stocks and large differences can be observed in some countries, particularly in industry and construction and, above all, according to C.E. when compared to the other two databases[11].

---

(11) It must be taken into account that there is an additional series in the case of the Spanish economy for industry, construction and services – E-M Spain – as information from BD.MORES is used for these branches of activity, as mentioned previously.

Figure 3a: COMPARISON OF INITIAL CAPITAL STOCKS,
YEAR 2000 PRICES – AGRICULTURE
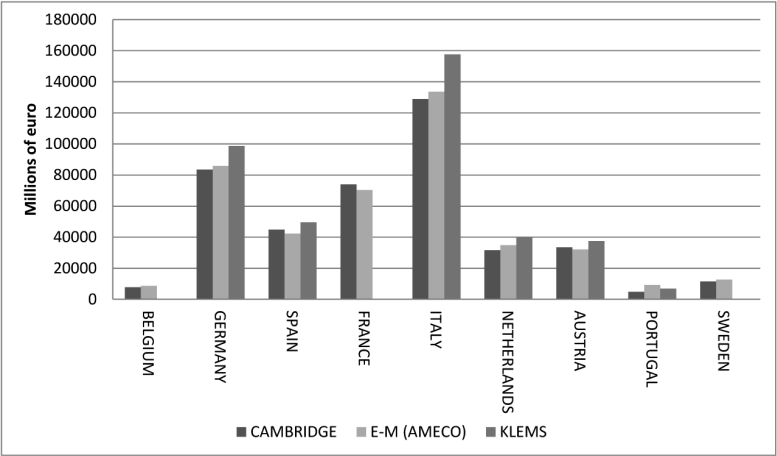
Source: Own elaboration.

Figure 3b: COMPARISON OF INITIAL CAPITAL STOCKS,
YEAR 2000 PRICES – INDUSTRY AND CONSTRUCTION
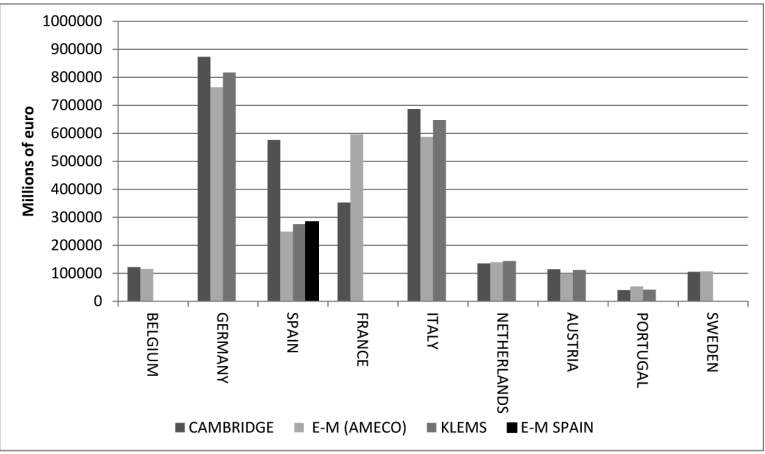
Source: Own elaboration.

Figure 3c: COMPARISON OF INITIAL CAPITAL STOCKS,
YEAR 2000 PRICES – SERVICES
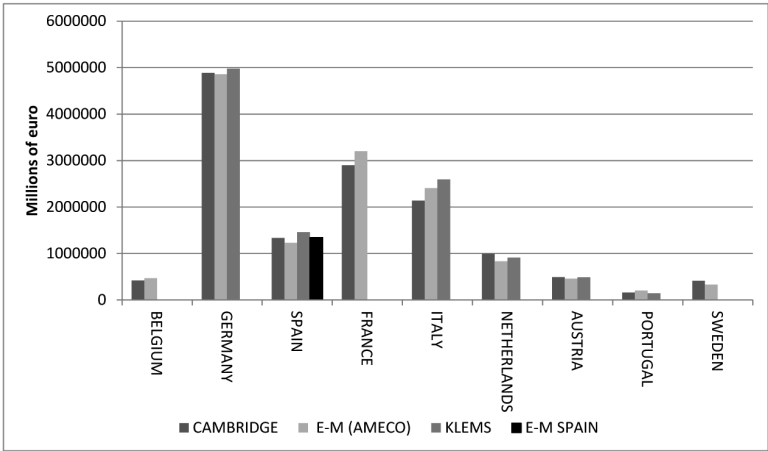
Source: Own elaboration.

Furthermore, if EU-KLEMS is the original source for all databases when it comes to sectoral disaggregation, the percentage shares of the total should be identical. Surprisingly, this is not the case with C.E., as can be observed in Figures 4a-4c.

Figure 4a: COMPARISON OF SECTORAL DISAGGREGATION
PERCENTAGES – AGRICULTURE
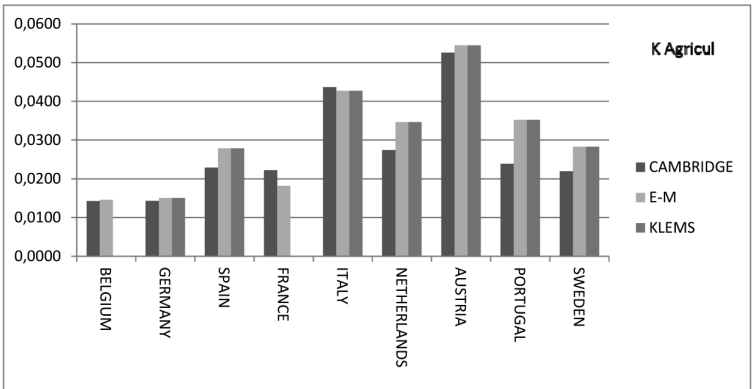
Source: Own elaboration.

Figure 4b: Comparison of sectoral disaggregation percentages – Industry and Construction
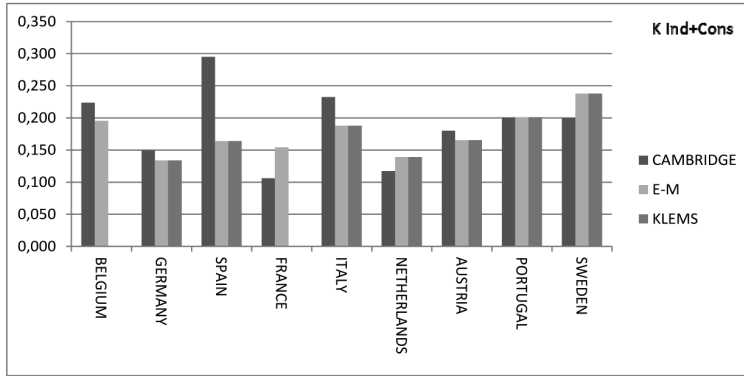
Source: Own elaboration.

Figure 4c: Comparison of sectoral disaggregation percentages – Services
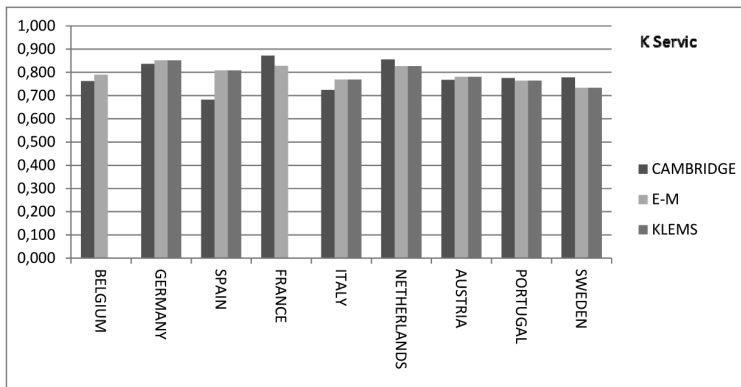
Source: Own elaboration.

Once the initial capital stocks for each sector in each country are obtained, the next step is the regionalisation to NUTS-2. The main problem involved in regionalising sectoral capital stock is that there is no direct information on sector-by-sector initial capital stocks for each region. The non availability of initial capital stock is frequent where PIM is implemented at country level (Berlemann and Wesselhöft, 2012). Three methods have been frequently used to construct initial stock data by country. We use them here to distribute the initial national capital stock of a sector among the regions in a country:

A) Flows Investment Accumulation. Initial stock is calculated using the average percentage that the investment of region i in sector j represents with regard to nation N during the period 1995-2007. This percentage is used to assign a region its share of initial capital in 1995, as expressed below:

$$K_{ij,0} = \frac{\sum\limits_{t=1995}^{2007} GFCF_{ij,t}}{\sum\limits_{t=1995}^{2007} GFCF_{Nj,t}} \cdot K_{Nj,0} \qquad [6]$$

B) Accumulation Equation. The method is based on Harberger (1978). It employs neoclassical growth theory under the assumption that steady-state growth capital stock could be estimated using information on capital growth rates, using the following expression:

$$K_{t-1} = \frac{GFCF_t}{\delta_t + g_t} \qquad [7]$$

g_t being the growth rate in capital stock. If this growth rate were also unknown, investment growth rate (μ_t) is a fair proxy of the growth rate in capital stock (g_t).

In order to obtain the initial regional capital stock of each branch of activity, we assume that the growth rate in investment (μ_t) is an accurate proxy for growth in capital stock (g_t). As the economy may be outside the steady state[12] and in view of the fact that investment flows are highly volatile, the investment series have been filtered using the Hodrick and Prescott (1997) filter with a smoothing parameter of $\lambda = 6,25$, in line with Ravn and Uhlig (2002). Bearing in mind the problems this filter has with the beginning and end of the sample, we have used the year 2000 to calculate capital stocks.

$$K_{ij,2000} = \frac{I_{ij,2001}}{\delta_j + \mu_{ij,1995-2007}} \qquad [8]$$

In this expression $I_{ij, 2001}$ is the trend value of investment of sector j in region i in 2001 obtained using the Hodrick and Prescott (1997) filter and μ_{ij}, 1995-2007 is the trend growth rate in the filtered investment series throughout the entire period. Using the year 2000 as a basis, we estimate initial capital stocks in 1995 using the PIM.

Notwithstanding this, the initial capital stocks estimated are only used to obtain percentages to distribute the national total for each branch of activity in 1995 amongst NUTS2 regions[13]. It is worth noting that the intention is to distribute capital

---

(12) The version proposed by Griliches (1980), Doménech and Taguas (1999) and De la Fuente and Doménech (2000) is used.

(13) The choice of the year 2000 and the values of λ, δ and μ were the result of applying this methodology to the countries that could be compared by means of direct estimates. The validity of this method has been tested by comparing the series that were obtained from applying the method to those provided directly by AMECO for each country in the aggregate and, in some countries, for the six branches of activity depending on the proportions of EU-KLEMS.

stock, and directly using the average growth rates in investment for the region alone could lead to negative values in some cases, thereby either overestimating their initial capital or even making it negative. For this reason, and for each region, a growth rate in investment is obtained from averaging the mean for the region and the nation during the period. Once we have obtained the initial capital stock of a sector for each region in a country, it is divided by the sum of the regional capitals to obtain a coefficient of participation that is applied to the initial national capital stock.

C) Value Added. This consists of regional distribution in proportion to the regional participation in national sectoral value added. This procedure can be useful for regional distribution within a branch of activity but not between sectors[14].

$$K_{ij,0} = \frac{GVA_{ij,0}}{\sum_i GVA_{ij,0}} \cdot K_{Nj,0} \qquad [9]$$

In the case of the NUTS2 sectorial capital stock, the only available reference is the BD.MORES database for the case of Spanish regions. We have used three procedures to regionally disaggregate each national sector. Figures 5a-5f present the regionalisation of the initial capital stocks of the six sectors in Spanish regions using all three methods –accumulation equation, flows investment accumulation and value added– together with the average of the first two and the reference of BD.MORES.

The best results are achieved using the average between the accumulation equation and flows investment accumulation[15] for all sectors, with the exception of construction, where the best fits were provided by the value added method[16].

The procedure used by C.E. to regionalise the initial stocks of each industry is different to the most common in the literature, the scaling method based on GVA.

The method employed was "the ratio of capital stock in each industry to GVA in that industry was calculated for each asset type at the national level and then applied to GVA by industry at the NUTS2 level". This series obtained are compared with the IVIE-FBBVA estimates for the Spanish regions and considerable differences are observed, despite the fact that the C.E. Spanish national total is taken from that source. In effect, the deviations between the C.E. and FBBVA regional totals are strangely large in 1995.

We have also compared the percentage shares of the initial capital stock of regions in each national branch of activity with the BD.MORES database for Spanish regions. Initial capital stock in industry is hugely overestimated in the C.E. database in the case of all Spanish regions, whereas the regional distribution of the services sector favours Madrid, Catalonia and Valencia and works against the rest.

---

(14) Noticeable differences exist between the sectors in a country in terms of the capital/output ratio, which makes this method unsuitable for disaggregating by sector and for determining levels of capital in "similar countries".

(15) We only opted for the flows investment accumulation method in the case of certain investment series that displayed negative average growth rates.

(16) The nature of the construction industry entails peculiarities that affect regionalisation criteria. Companies do not have premises equipped with machinery and fixed equipment; instead, they are characterised by their mobility.

The initial capital stocks of the German and French regions provided by C.E. and the database in this research are also compared. Strikingly, the industry is greatly underestimated in all French regions in the C.E. database.

Figure 5a: COMPARISON OF REGIONAL DISAGGREGATION METHODS. AGRICULTURE
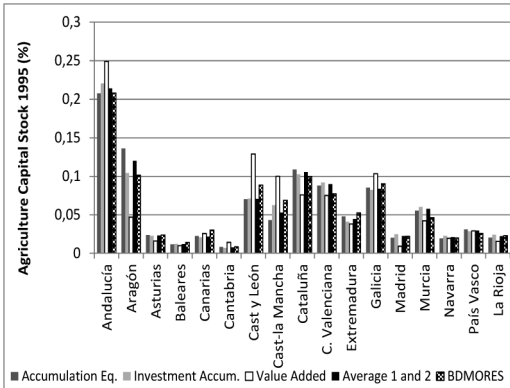
Source: Own elaboration.

Figure 5b: COMPARISON OF REGIONAL DISAGGREGATION METHODS. INDUSTRY
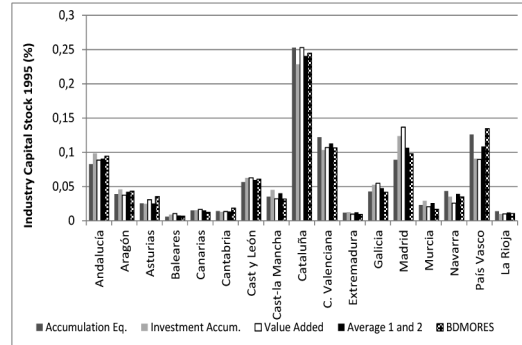
Source: Own elaboration.

Figure 5c: COMPARISON OF REGIONAL DISAGGREGATION METHODS. CONSTRUCTION
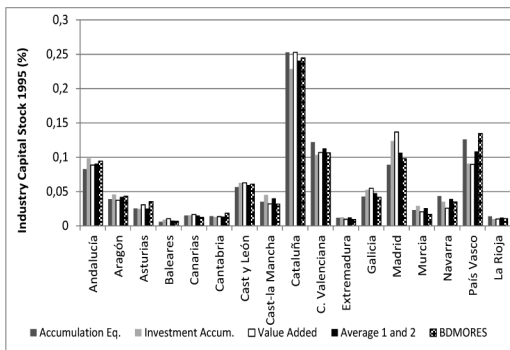
Source: Own elaboration.

Figure 5d: COMPARISON OF REGIONAL DISAGGREGATION METHODS. PRODUCTIVE MARKET SERVICES
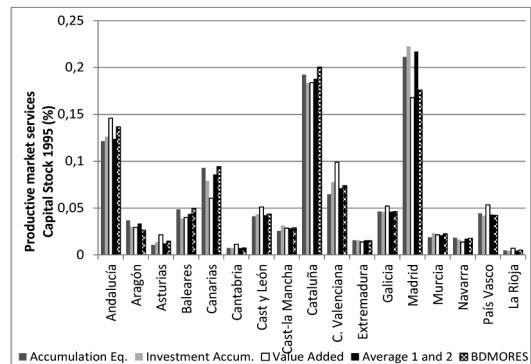
Source: Own elaboration.

Figure 5e: COMPARISON OF REGIONAL
DISAGGREGATION METHODS.
REAL ESTATE AND FINANCIAL SECTOR
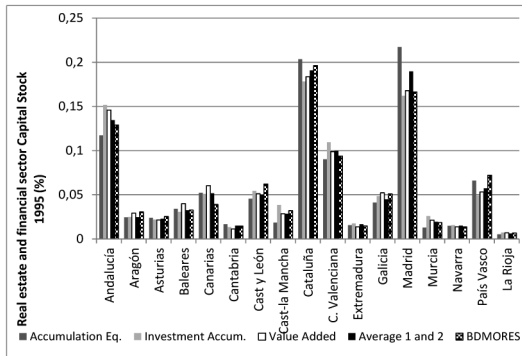
Source: Own elaboration.

Figure 5f: COMPARISON OF REGIONAL
DISAGGREGATION METHODS.
NON MARKET SERVICES
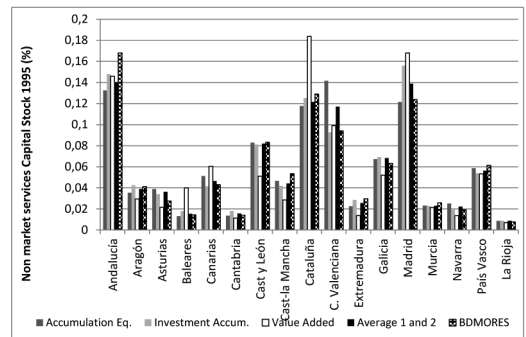
Source: Own elaboration.

After determining the initial capital stocks of each branch of activity and region, the deflated gross fixed capital formation of the sector in each region and the depreciation rate of the sector enable us to construct a time series of capital stock using the perpetual inventory method. Once the capital stocks for the six branches of economic activity in each NUTS2 region have been obtained, different aggregates can then be constructed: national and/or regional totals, as well as approximations to private productive capital or regional business capital.

The series of national capital stocks in this research differ from those in EU-KLEMS, AMECO, Cambridge Econometrics and BD.MORES for the following reasons:

- The use of the AMECO total at constant prices as initial capital stock in 1995.
- A sectoral structure of initial capital stock from other sources (mainly EU-KLEMS).
- Common sectoral depreciation rates for all countries, although they are different for each branch of activity and therefore different to those implicit in AMECO, C.E., EU-KLEMS and BD.MORES.
- Sectoral GFCF series from EUROSTAT with specific sectoral deflators.
- Construction of the capital stock series for each branch of activity in the country and aggregation of sectoral capital stocks to obtain national capital stock series.

Having obtained the capital stocks for the six branches of economic activity, it is also possible to construct different aggregates.

The series of regional capital stocks in this research differ from those in Cambridge Econometrics and BD.MORES (in case of Spain) for the following reasons:

- The use of the initial capital stock regional distribution method in 1995 for each national sector used frequently for international estimates.
- A more disaggregate sectoral structure in keeping with EUROSTAT.
- Common sectoral depreciation rates for all regions, though they differ for each branch of activity. The implicit resulting rates in the aggregates are more in keeping with the existing data bases.
- Sectoral GFCF series from EUROSTAT with specific sectoral deflators common to the regions but different for each country.
- Construction of the capital stock series for each branch of activity in the region and aggregation of sectoral capital stocks to obtain regional capital stock series.

In Appendix A, a comparison between our estimates and those in C.E. for the 121 regions is given. The three columns reflect the ratio between the estimates in 1995, 2000 and 2007. If the ratio is higher (lower) than unity, this indicates that our estimate is higher (lower) than C.E.'s estimate. Our estimates of initial capital stock in 55 European regions are lower than C.E. (45 percent). However, in 2007, almost all European regions (97 of 121) have higher levels of capital in C.E.'s estimate. In order to better appreciate the results yielded by the two databases, we present Figure A.1 which includes the average growth rates of the K/Y ratio in this database and C.E over the period 1995-2007. In order to establish comparisons, we use C.E. data as the output variable, but different capital data: from C.E. and the calculated in this paper. The fact that the dots that represent the 121 regions and 9 countries are located on the bisecting line should indicate that both estimates coincide. However, as can be observed, there are marked differences. Figure A.1 clearly shows that the average growth rate of the K/Y ratio is much higher in the case of C.E. data. In the C.E. database, only two regions (Stockholm and Utrecht) recorded decreases in the K/Y ratio for the regional economy. The existing evidence for countries[17] (including European nations) does not show such a general upturn in the K/Y ratio as the C.E. data does.

5. Conclusions

This study estimates capital stock series disaggregated into six branches of activity for 121 regions in nine European countries for the period 1995-2007. The main objective is to make them comparable to other similar series and they are calculated using the Perpetual Inventory Method (PIM). Regional series of GFCF taken from EUROSTAT are the basic input of the estimation, while the criteria followed to prioritise regional comparability consists, on the one hand, of using the same sectoral depreciation rates for all the countries and regions in the sample and, on the other, of constructing sectoral regional capital stocks under identical criteria for all the regions in the different countries. We address the robustness of the estimates by analysing their sensitivity to the hypotheses, using both the BD.MORES database and the information available for countries, particularly that provided by the AMECO and EU-KLEMS databases.

---

(17) See Pérez (2011).

This paper constitutes a small first step for the regions in Europe that have higher quality and more information, even if it is national and sectoral. We preferred to test the methodology followed in the regions of these countries in order to be able to increase the number of countries and regions included in the database in the future. Therefore, this proposal is currently not as large as the only other one that exists at present, developed by Cambridge Economics. However, there are relevant differences between our database and Cambridge's, as we have detailed throughout this presentation. The differences are mainly due to the way initial capital stocks are obtained and, above all, to the implicit depreciation rates used. There are obviously specific regional factors that may influence the service life of assets, but few countries and even fewer regions have carried out rigorous research into this issue. For this reason, in this study, we follow the assumption of Kamps (2006), with the primary intention of establishing regional comparisons.

The database we present provides a more detailed disaggregation of capital by sector than C.E. and is similar to that used by EUROSTAT (NACE Rev.1) for regional GFCF. This makes it possible to better estimate the private sector, by separating the capital of public services, unlike C.E., where all services are considered jointly.

Currently, the majority of the European countries are immersed in a process of adapting their national and regional accounts to the NACE Rev.2 norms, to harmonise them with other EU members. At the level of national accounts, since the end of 2011, a new accounting system has been available that adapts to the new features of productive activities and which involves significant changes with respect to the year 2000 base (NACE Rev.1) which is what is used in this work and in the BD.EURS database.

There is no direct correspondence with the previous classification of activities but the signs appear to be identical: branches classified as industrial (e.g. edition) now become information services, others go from services to construction (real estate development or services related to the sale of housing) or industry (sanitation and water treatment), there are more detailed service branches and differentiation between market and non market service activities has ceased. Therefore, there are serious difficulties when it comes to linking the results of the current estimates with new data.

Indeed, as regards the regional and sectoral accounting, the availability of the new NACE Rev.2 is developing at different rates in different countries, with considerable delays. Besides the inherent difficulties in being able to directly link the national and sectoral magnitudes of Rev.1 with Rev.2, the necessary and sufficient base information is not currently available to establish satisfactory link of the accounts to a sufficiently disaggregated NUTS2 level. However this has to be the immediate objective.

It is essential to analyze, in detail, the compatibility of the classifications used in NACE Rev.1 and NACE Rev.2 at NUTS2 level, with the aim of providing the basic evolution indicators. At its highest level of disaggregation is required retrospective series that match a few years in both Rev.1 and Rev.2 methodologies to address the development of sufficiently long homogeneous series.

Appendix A: Regional Stocks of Capital Comparison

Region	$\dfrac{K_{E-M}}{K_{C.E.}}$			Region	$\dfrac{K_{E-M}}{K_{C.E.}}$		
	1995	2000	2007		1995	2000	2007
Région de Bruxellest	0.886	0.894	0.922	Rhône-Alpes	1.183	1.056	0.981
Prov. Antwerpen	1.039	0.985	0.950	Auvergne	1.174	1.049	0.962
Prov. Limburg	1.357	1.194	1.104	Languedoc-Roussillon	1.257	1.115	1.020
Prov. Oost-Vlaanderen	1.194	1.088	1.026	Alpes-Côte d'Azur	1.144	1.047	0.987
Prov. Vlaams Brabant	1.101	1.023	0.992	Corse	1.208	1.079	0.964
Prov. West-Vlaanderen	1.264	1.128	1.041	Piemonte	1.060	0.992	0.927
Prov. Brabant Wallon	1.166	1.082	1.041	Valle d'Aosta	1.427	1.232	1.092
Prov. Hainaut	1.017	0.964	0.936	Liguria	0.823	0.830	0.832
Prov. Liège	1.057	0.997	0.947	Lombardia	0.968	0.938	0.933
Prov. Luxembourg (B)	1.315	1.152	1.040	Bolzano-Bozen	1.406	1.206	1.088
Prov. Namur	1.053	1.006	0.993	Prov. Trento	1.443	1.219	1.091
Baden-Württemberg	0.843	0.836	0.837	Veneto	1.145	1.059	1.000
Bayern	0.963	0.930	0.908	Friuli-Venezia Giulia	1.055	0.999	0.954
Berlin	0.877	0.873	0.866	Emilia-Romagna	1.069	1.005	0.964
Brandenburg	1.971	1.460	1.248	Toscana	0.923	0.897	0.883
Bremen	0.817	0.808	0.792	Umbria	1.142	1.066	1.011
Hamburg	1.448	1.284	1.125	Marche	1.086	1.022	0.938
Hessen	0.882	0.871	0.870	Lazio	0.971	0.943	0.927
Mecklenburg-Vorpom	1.639	1.307	1.152	Abruzzo	1.052	0.981	0.919
Niedersachsen	0.857	0.849	0.829	Molise	1.222	1.096	1.011

Appendix A: Regional Stocks of Capital Comparison (continuation)

Region	$\dfrac{K_{E-M}}{K_{C.E.}}$			Region	$\dfrac{K_{E-M}}{K_{C.E.}}$		
	1995	2000	2007		1995	2000	2007
Nordrhein-Westfalen	0.876	0.866	0.862	Campania	1.092	1.028	0.991
Rheinland-Pfalz	0.817	0.819	0.817	Puglia	1.059	1.009	0.940
Sachsen	1.748	1.343	1.158	Basilicata	1.444	1.260	1.084
Saarland	0.769	0.775	0.769	Calabria	1.237	1.123	1.053
Sachsen-Anhalt	1.672	1.306	1.131	Sicilia	1.200	1.109	1.033
Schleswig-Holstein	0.840	0.842	0.850	Sardegna	1.325	1.170	1.024
Thüringen	1.698	1.332	1.159	Groningen	0.855	0.826	0.811
Galicia	0.862	0.824	0.848	Friesland (NL)	0.958	0.921	0.884
Asturias	0.902	0.845	0.833	Drenthe	1.012	0.954	0.913
Cantabria	0.868	0.852	0.828	Overijssel	0.828	0.819	0.813
País Vasco	1.049	0.981	0.887	Gelderland	0.874	0.853	0.824
Navarra	1.035	0.982	0.895	Flevoland	1.998	1.502	1.237
La Rioja	0.865	0.851	0.843	Utrecht	0.781	0.795	0.808
Aragón	0.944	0.913	0.870	Noord-Holland	0.770	0.777	0.776
Comunidad Madrid	0.752	0.779	0.783	Zuid-Holland	0.829	0.819	0.809
Castilla y León	0.913	0.873	0.876	Zeeland	1.036	0.956	0.896
Castilla-la Mancha	0.866	0.821	0.867	Noord-Brabant	0.960	0.914	0.879
Extremadura	0.797	0.757	0.805	Limburg (NL)	0.838	0.819	0.814
Cataluña	0.826	0.813	0.795	Burgenland (A)	1.056	0.983	0.936
Comunidad Valenciana	0.751	0.767	0.772	Niederösterreich	0.945	0.903	0.874

Appendix A: Regional Stocks of Capital Comparison (continuation)

Region	$\frac{K_{E-M}}{K_{C.E.}}$			Region	$\frac{K_{E-M}}{K_{C.E.}}$		
	1995	2000	2007		1995	2000	2007
Illes Balears	1.017	0.958	0.906	Wien	0.768	0.785	0.808
Andalucía	0.927	0.889	0.874	Kärnten	0.951	0.912	0.888
Región de Murcia	0.767	0.767	0.821	Steiermark	1.018	0.956	0.910
Canarias	0.908	0.917	0.878	Oberösterreich	1.044	0.972	0.923
Île de France	1.109	1.027	0.927	Salzburg	0.881	0.868	0.866
Champagne-Ardenne	1.034	0.950	0.892	Tirol	0.987	0.931	0.894
Picardie	1.118	1.004	0.918	Vorarlberg	1.000	0.946	0.910
Haute-Normandie	1.167	1.028	0.941	Norte	1.070	1.021	0.981
Centre	1.106	1.001	0.951	Algarve	1.061	1.000	0.950
Basse-Normandie	1.069	0.963	0.834	Centro (PT)	1.130	1.042	0.962
Bourgogne	1.147	1.027	0.942	Lisboa	1.417	1.211	1.101
Nord - Pas-de-Calais	1.038	0.945	0.905	Alentejo	1.418	1.173	0.935
Lorraine	1.105	0.997	0.919	Stockholm	0.901	0.875	0.856
Alsace	1.084	0.978	0.956	Östra Mellansverige	0.862	0.834	0.839
Franche-Comté	1.236	1.079	0.965	Småland med öarna	0.855	0.820	0.825
Pays de la Loire	1.118	1.013	0.948	Sydsverige	0.848	0.818	0.824
Bretagne	1.108	1.009	0.939	Västsverige	0.877	0.835	0.834
Poitou-Charentes	1.145	1.027	0.955	Norra Mellansverige	0.759	0.755	0.760
Aquitaine	1.113	1.015	0.954	Mellersta Norrland	0.806	0.793	0.772
Midi-Pyrénées	1.067	0.983	0.928	Övre Norrland	0.800	0.788	0.820
Limousin	1.187	1.061	0.960				

Source: Own elaboration.

Figure A.1.: GROWTH K/Y RATES

Source: Own elaboration.

E
A
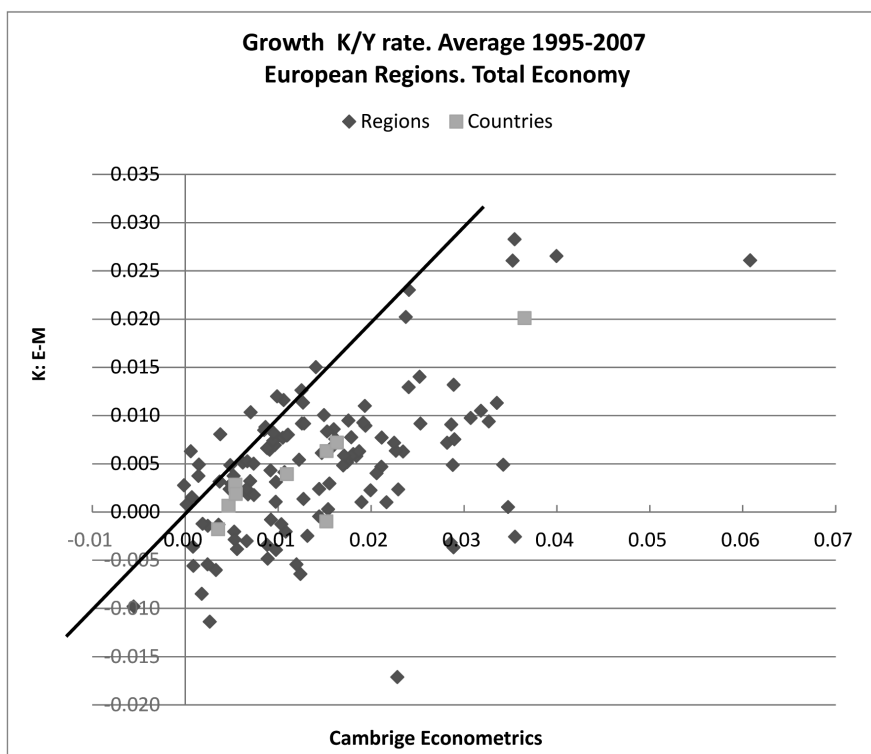
REFERENCES

AMECO. Annual macro-economic database of the European Commission s Directorate General for Economic and Financial Affairs (DG ECFIN).

BD.EURS (NACE Rev.1). Ministerio de Hacienda y Administraciones Públicas. Dirección General de Presupuestos. Bases de datos macroeconómicos. *http://www.sepg.pap.min-hap.gob.es/sitios/sepg/es-ES/Presupuestos/Documentacion/Paginas/BasededatosB-DEURS.aspx*

Berlemann, M. and J.E. Wesselhöft (2012): "Estimating Aggregate capital stocks Using the Perpetual Inventory Method-New Empirical Evidence for 103 Countries-" W.P Series. Nº 125. Helmut Schmidt Universitat.

Boscá, J.E., R. Doménech, J. Ferri, and J. Varela (Eds.) (2011): "*The Spanish Economy: A General Equilibrium Perspective*". Editorial Palgrave MacMillan. London (UK) 227 pages.

Boscá, J.E., A. de Bustos, A. Díaz, R. Doménech, J. Ferri, E. Pérez and L. Puch (2007a): The REMSDB Macroeconomic database of the Spanish economy, Dirección General de Presupuestos, Ministerio de economía y Hacienda. Work Document D-2007-03.

Boscá, J.E., A. Díaz, R. Doménech, J. Ferri, E. Pérez and L. Puch (2010): "A Rational Expectations Model for Simulation and Policy Evaluation of the Spanish Economy", *SERIEs Journal of the Spanish Economic Association,* vol. 1(1-2), pp. 135-169.

Bureau of Economic Analisis, U.S. Department of Comerce (1999): "Fixed Reproducible Tangible Wealth in the United Status, 1925-94". Washington D.C., U.S. Government Printing Office, August.

Cambridge Econometrics (2010): *Pilot Study on the Estimation of Regional capital stocks.* A Final Report for the European Commission (Directorate General Regional Policy). 74 pages and Appendices A-E.

Coe, D.T. and E. Helpman (1996): "International R&D spillovers", *European Economic Review,* vol. 39, pp. 859-887.

Dabán, T., A. Díaz, J. Escribá and M.J. Murgui (2002): "La Base de datos BD.MORES", *Revista de Economía Aplicada*, vol. X (30), pp. 165-184.

De Bustos, A., A. Diaz, A. Cutanda, J. Escribá, M.J. Murgui and M.J. Sanz (2008): "La BD.MORES en base 2000: Nuevas estimaciones y variables". Ministerio de Economía y Hacienda. DGAPP. D-2008-08. This database is available at the following link: *http://www.sgpg.pap.meh.es/SGPG/Cln_Principal/Presupuestos/Documentacion/Basesdatosestudiosregionales.htm*

De Bustos, A., J. Escribá and M.J. Murgui (2008): "Comparación de la BD.MORES con otras base de datos: Una ilustración gráfica". Mimeo, Dirección General de Análisis y Programación Presupuestaria, Ministerio de Economía y Hacienda.

De la Fuente, A. and R. Doménech (2000): "Human Capital in Growth Regressions: How Much Difference Does Data Quality Make?" Economics Departement Working Paper 262, OECD, Paris.

Derbyshire, J., B. Gardiner and S. Waights (2011): "Estimating the capital stock for the NUTS2 Regions of the EU27", European Union. Regional Policy, Nº 01/2011.

Derbyshire, J., B. Gardiner and S. Waights (2013): "Estimating the capital stock for the NUTS2 Regions of the EU27", *Applied Economics,* vol. 45(9), pp. 1133-1149.

Doménech, R. and D. Taguas (1999): "El impacto a largo plazo de la Unión Económica y Monetaria sobre la economía española" en *El Euro y sus repercusiones sobre la economía española*, Fundación BBVA.

Escribá, J. and M.J. Murgui (2013): "La base de datos BD.EURS (NACE Rev 1)" Ministerio de Hacienda y Administraciones Públicas. Dirección General de Presupuestos. D-2013-02.

EU-KLEMS *Growth and Productivity Accounts: November 2009 Release. http://www.euklems.net/*

EUROSTAT, REGIO database, General and regional Statistics, Regions and cities. *http://epp.eurostat.eC.E.uropa.eu/portal/page/portal/region_cities/regional_statistics/data/database.*

Griliches, Z. (1980): "R&D and the Productivity Slowdown", NBER Working Paper Series, 434.

Hodrick, R. and E. Prescott (1997): "Post-war U.S. business cycles: An empirical *investigation*", *Journal of Money, Credit and Banking*, vol. 29(1), pp. 1-16.

Hulten, Ch. (1991): "The Measurement of capital". Cap. 4 pp. 119-158. Volume Title: *Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth.* Berndt and Triplett Edit. University of Chicago Press.

Hulten, Ch. and F.C. Wykoff (1981): "The estimation of economic depreciation using vintage asset prices", *Journal of Econometrics*, vol. 15, pp. 367-397.

Kamps, Ch. (2006): "New estimates of government net capital stocks for 22 OECD countries, 1960-2001", IMF Staff Papers vol 53, No. 1.

Maddison, A. (1995): "Standardised Estimates of Fixed capital stock: A Six Country Comparison"en *Explaining the Economic Performance of Nations: Essays in Time and Space*, ed. A. Maddison, Economists of the twentieh century series (Brookfield, Vermont: Edward Elgar).

Mas, M., F. Pérez and E. Uriel (2007): *El stock y los servicios de capital en España y su distribución territorial (1964-2005), Nueva Metodología*, Fundación BBVA. *National Bank of Belgium. Belgostat Online. Macroeconomics Statistics. National Accounts. capital stock. Net capital stock per Branch of activity and per product. http://www. nbb.be/pub/stats/stats.htm?l=en*

OECD (2000): *Methods used by OECD countries to measure stock of capital.*

OECD (2001): *Measuring capital. A manual of the measurement of capital stocks, consumption of fixed capital and capital services.*

OECD (2009): *Measuring capital: Measurement capital stocks.* Paris: OECD (http://www. olis.oced.org/olis/2009doc.nsf/LinkTo/NT0000962/$FILE/JT03258144.PDF).

OECD International Sectoral Data Base. Available in Stata format over the web (BC network only): use *http://fmwww.bC.E.du/ec-p/data/oecd/oecd_isdb.dta*

O'Mahony, M. (1996): "Measures of Fixed capital stocks in the Post-War Period: A five-Country Study" en *Quantitative Aspects of Post-War European Economic Growth*, ed. Bart van Art and N.Crafts (Cambridge United Kingdom).

Pérez, F. (2011): *Patrones de Capitalización y Crecimiento (1985-2008). Panorama Internacional*. Fundación BBVA. Bilbao. 305 pages.

Ravn, M.O. and H. Uhlig (2002): "On adjusting the Hodrick-Prescott filter for the frequency of observations", *Review of Economics and Statistics*, vol. 84(2), pp. 371-376.

Ward, M. (1976): *The Measurement of Capital: The Methodology of capital stock Estimates in OECD Countries*, OECD, Paris.

RESUMEN

En este trabajo se estiman series comparables de stock de capital de 121 regiones de 9 países europeos para el periodo 1995-2007 calculadas usando el método del inventario permanente. Los datos del stock de capital de cada región se presentan desagregados en seis grandes sectores: agricultura y pesca, industria, construcción, servicios productivos de mercado, inmobiliarios, financieros y otros servicios y servicios de no mercado. El ingrediente básico de la estimación son las series regionales de FBCF de EUROSTAT y se supone que el nivel y el perfil temporal de las tasas de depreciación son diferentes por sectores pero las mismas para todas las regiones y países en cada sector. Se discute la robustez de las estimaciones analizando su sensibilidad a los supuestos utilizando como referencia tanto la base de datos BD.MORES para las regiones españolas como la información existente para países especialmente en las bases AMECO y EU-KLEMS.

Palabras clave: stock de capital, NUTS2, estimación.

Clasificación JEL: C82, E22, R12.