Review of Income and Wealth
Series 46, Number 1, March 2000

ESTIMATION OF THE STOCK OF CAPITAL IN SPAIN

BY MATILDE MAS, FRANCISCO PÉREZ, AND EZEQUIEL URIEL

Universitat de València and Instituto Valenciano de Investigaciones Ecónómicas

The paper presents the methodology and results of the estimation of the endowments of capital in the Spanish economy. It distinguishes between endowments of public capital and private capital. The series corresponding to the public sector cover the period 1955–97 and consider seven categories (or functions). The estimates are disaggregated by 17 regions and 50 provinces. The level of disaggregation is regional and provincial (NUTS2 and NUTS3 in European terminology). The private capital series cover the period 1964–97 and consider 17 sectors of production, with disaggregation at regional level. The information refers to two variables: gross formation of fixed capital (in current and constant pesetas) and net capital stock in constant pesetas (base year 1990).

The stocks of fixed capital of countries and regions have in recent years occupied a prominent place in debates on economic policy and also in the new approaches to the analysis of growth. The discussions arising in different countries have been possible due to the availability of previous estimates of capital stock. The OECD's publication *Flows and Stocks of Fixed Capital* reproduces the estimates made in those member countries that have them, and makes evident the absence of capital stock estimates in many others. The countries referred to by the last document published (OECD, 1998) are Canada, U.S.A., Japan, Australia, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Norway, Sweden, and the U.K.. The information is available, though not for all countries and with some breaks in methodology, for the period 1964–96. Although the information is not always homogeneous, the variables considered are as follows: gross and net capital stock, gross fixed capital formation, and gross fixed capital consumption, all valued at current and constant prices. In turn, each of the variables presents the following sector disaggregation: 1, Agriculture; 2, Industry, 2.1, Manufacturing; 3, Services, excluding dwellings; 4, Dwellings; and 5, Producers of Government Services. The first four constitute the private sector of the economy, while the last refers to the public sector.

The first studies of the estimation of capital stock in Spain were centered on the measurement of national wealth and, from this perspective, considered not only physical capital but also natural resources.[1] In most of the countries of the OECD referred to above, the definition of capital stock is restricted to durable, tangible and reproducible assets.[2]

This is the approach adopted in the estimations presented in Section III. The endowments analysed are thus circumscribed to non-financial material reproducible assets.

Note: This article represents a part of the results of the research carried out by the Valencian Institute for Economic Research (IVIE) into capital endowments and regional development in collaboration with the BBV Foundation, in the framework of the DGICYT's research program SEC 98–0895. A summary of it appeared in the Appendix to Mas, Maudos, Pérez, and Uriel (1998).

[1]See, for example, the study by the Commercial University of Deusto (1968).

[2]See Ward (1976); U.S. Bureau of Economic Analysis (1993); Paccoud (1983); and OECD (1993).

The debate on the role of public capital in the United States illustrated the importance of the level of geographical disaggregation in the estimation of stocks. There are at least two reasons for analysing its effect from a territorial viewpoint. On the one hand, the inequalities in the regional endowments of public capital may condition access to its services and with it, the present welfare and the future growth opportunities of different economic areas. This aspect is especially important from the point of view of regional policy. Secondly, spillover effects, associated with a large number of public infrastructures due to the network characteristic associated with many of them, recommend the disaggregated analysis of the impact on growth of public investment[3]. The debate in other countries also showed the different impact on growth of the different types of public capital. In discussion, a distinction is usually made between infrastructures directly linked to the process of production (roads, railways, water cycle, urban structures, etc.) and those of a social character (education and health, fundamentally).

In Spain no suitable statistical information on the stock of capital was available until recently, so some of the debates which have taken place—e.g. on the role of infrastructures—have lacked the essential objective references and the analysis of the strong economic growth of the last few decades. The Valencian Institute for Economic Research (IVIE) has in recent years undertaken the task of covering this statistical vacuum. The initiative initially had the support of the European Commission, and has now become a joint project between the IVIE and the Banco Bilbao-Vizcaya Foundation, which currently supports its continuity. So far three editions have been made.[4] The last one covers the period 1964–97 in the series corresponding to the private sector, and 1955–97 in the public sector series. The regionalized series end in 1995. The diffusion of these have been received with great interest by Spanish researchers and by those researchers of other countries who, on specific occasions, have come to know of its existence. The complete series and their subsequent updatings are available on Internet.[5] The aim of this article is to make known the methodology and results of an ambitious project, potentially interesting not only for the academic community but also for other analysts and managers.

The research undertaken had to fulfill the following requirements.

(a) Be consistent, in methodology and demarcation of the agents, with the estimations made in the other countries of the OECD.

(b) Take the regions as the geographical unit of reference. In the case of public capital stock the information also enables further disaggregation, to province level.[6]

[3]See Munnell (1992) for a description of the effects of public capital according to the level of geographical disaggregation (national or state). For the Spanish case, the spillover effects between regions have been analysed in Mas, Maudos, Pérez, and Uriel (1996).

[4]BBV Foundation—IVIE (1995), (1996) and (1998).

[5]See http://www.bancoreg.fbbv.es

[6]Spain has a population of close to forty million inhabitants. Administratively it is divided into seventeen regions, some of them enjoying a high level of autonomy, especially in expenditure decisions. The regions are of very unequal size, in terms both of area and of population. Of the seventeen regions, ten consist of more than one province, Andalucía and Castilla-León being the biggest in area, with eight and nine provinces respectively. The seven remaining regions consist of a single province, Madrid having the highest proportion of the population of this group.

(c) Distinguish, as far as the statistical information allowed, between different types of public infrastructures and particularly between productive and social infrastructures.

(d) Disaggregate by sectors, as far as possible, the stock of private capital.

The paper is structured as follows. Section I describes the basic lines of the methodology followed in the estimation of the public capital series, and Section II those corresponding to the private sector. Section III presents some results giving information in the Spanish regions with regard to capital endowments, Section IV illustrates some applications already made and Section V concludes.

I. Estimation of Public Capital[7]

I.1. *Demarcation of the Government Sector*

The demarcation adopted is that applied by the Spanish National Accounts (CNE) and by the government accounts of Spain (CAP). In CNE–85 the sector is disaggregated into the following sub-sectors (two digits) and agents (three digits):

S.61. General Government;
- S.611. Central government;
- S.612. Autonomous Government Bodies.

S.62. Territorial Administrations;
- S.621. Regional government;
- S.622. Local government.

S.63. Social Security Funds Administration;
- S.631. Social Security System;
- S.632. Other Social Security Administrations.

The above classification is currently valid, but has undergone substantial modifications with the passage of time. For this reason it has been necessary, in the analysis of the time series, to make adjustments to allow comparability of the magnitudes across time.

I.2. *Classifications of Public Capital Stock: Functional and Territorial*

The criterion of classification of the public capital stock followed in the study is twofold: (a) the evaluation on a territorial basis of the government capital stock, and (b) the composition of the public capital stock in terms of its purpose or function. With regard to the territorial criterion it has already been indicated that the information has been classified at the level of regions and provinces.

In the selection of the functions considered two criteria have been followed. On the one hand, the statistics available restrict the feasible level of disaggregation that fulfills the necessary requirement of homogeneity. On the other, we have concentrated on those functions which the specialist literature recognizes as having greatest influence on growth.

The two considerations have led us to distinguish the following functions: 1, Road infrastructures; 2, Urban infrastructures; 3, Water infrastructures; 4, Ports, coasts and maritime signaling; 5, Health; and 6, Education.

[7]For a detailed description of the methodology followed see Fundación BBV/IVIE (1996).

The above classification applies exclusively to the capital stock belonging to Government. However, due to their interest, the series corresponding to other investment agents offering public services have also been compiled: 7, Toll motorways; 8, Ports not belonging to the Government; 9, Airports; and 10, Railways.

I.3. *The Permanent Inventory Method (PIM)*

For the calculation of the capital stock, several estimation procedures can be considered, but the most used is the Permanent Inventory Method (PIM).[8] This procedure derives capital series from the accumulation of investment series. It is the method adopted by all the countries of the OECD that make estimations of capital stock. The difficulty and the cost of estimating capital series from census information, and the rigidity of the procedure, which makes frequent updating complicated, have led to this method being the one generally adopted by countries. The accumulation of investment series is the basic point of reference for the method, but does not prevent its results being enriched with additional information taken from the Census or referring to the physical characteristics of the assets. In the estimations made, we have included all the additional information available relating to the inventory of physical assets, to complement the investment series in some cases and also as a criterion of territorialization.

The estimations based on the PIM distinguish between two measurements of capital stock: gross and net. The gross capital stock represents the total volume of the physical productive assets available in a country, and is considered to be the volume of capital available for the productive process at a moment in time when it may be used in an economic system.[9] The gross capital stock in a given year is obtained by accumulating the past flows of investment and deducting from them the accumulated value of the investment that has been withdrawn, using for this a given withdrawal pattern and estimates of average life.

Net capital stock represents the accumulated value, minus depreciation, of the existing gross capital stock. This magnitude reflects the effect of the composition by years or by generations of the productive equipment on its productive capacity. Thus, the net stock correct gross stock for the reduction in its value originated by use, obsolescence and ageing.[10] The Spanish capital series are provided only, following SNA–93 suggestion, in net terms.

I.4. *Valuation Method*

The valuation of the investment series, and therefore of the stock itself, is usually done at current prices and at constant prices.[11] To deflate the investment

[8]One permanent inventory method; 2. Inventory of physical assets; and 3. Composite physical indices. For the estimation of private capital the following procedures have also been used: 4. Analysis based on accounting values; 5. Analysis of insured values; 6. Analysis of Stock Exchange values; 7. Savings accumulation models; and 8. Capitalization of income flows. See Ward (1976).

[9]The appropriateness of using capital stock series obtained by the permanent inventory procedure in estimations of aggregate production functions has been questioned from several viewpoints. See, for example, Miller (1990).

[10]A more detailed description can be found in Ward (1976).

[11]In the latest publication of the OECD (1998), the data for the U.S.A. are expressed at constant prices using chained quantity indices.

of the Government a specific deflator should be available, for each type of asset, at the maximum level of disaggregation. Reasons of statistical availability limit the disaggregation to four items from 1954, and to a single item in the previous period (which goes back to 1857). The four deflators drawn up for the period beginning in 1954 are: 1, Residential properties; 2, Other construction; 3, Transport material; and 4, Machinery, equipment and other products. These deflators have been applied to the investment series—which are provided at current prices and at constant prices (base year 1990). The net stock series are expressed only in constant prices of 1990.

I.5. *Average Lives*

Average Life is understood to be the period of time during which the capital asset is expected to remain in the stock (and not the period of time that it is considered in the accounts for financial or tax reasons). The period during which the asset remains in the stock will depend on its technical characteristics and also on the conditions in which it is used (maintenance, working conditions, etc.).

This study takes into account the average lives used in the following estimations: 1. Bureau of Economic Analysis (BEA) of the U.S.A.; 2, INSEE of France, in the report by Mairesse (1972); 3, Munnell (1990), in his estimation of public capital by regions in the U.S.A.; 4, The maximum lives permitted for taxation purposes in Spanish company tax, as many countries, e.g. the U.S.A. and Germany, derive from this source their estimations of average lives; 5, A summary of the average lives used in different countries reproduced in the studies by Ward (1976) and Keese *et al.* (1991); and 6, The opinion of Spanish experts, fundamentally architects and engineers, who work for the Government. Of all the above, only the BEA and Munnell refer explicitly to public capital. The remainder are applied basically to estimations of private capital.

There are notable differences in average lives among the above-mentioned sources, which may have at least two different origins. First, they may be due to differences in the productive structure and/or in the technology used, and second, to differences in the period of time considered. There seems to be agreement on the reduction of life expectancy of capital in recent decades, due to the faster obsolescence or the technology used in production. This process must have been especially intense in the case of machinery and equipment, but was by no means negligible even in "buildings and other constructions."

In Table 1 there is a summary of the average years of life used in the estimations of capital stock for the Spanish economy.

The assumptions as to average lives have a significant influence on the results obtained by the permanent inventory method. In a simulation exercise carried out in the European Community with five survival functions (quasi-logistic, gamma, sudden death, delayed linear and lognormal) and different assumptions as to the average life and growth rate of investment, it was found that if the duration of the average life were to be extended from 10 to 20 years, and the rate of investment to remain constant, the gross capital stock estimated would be doubled; it would increase by 50 percent if investment increased at a rate of 5 percent per year, and finally, it would increase by 30 percent or 40 percent if investment grew at

TABLE 1

AVERAGE LIVES USED IN THE ESTIMATION OF PUBLIC CAPITAL

	Average Years of Life	
Roads	Until 1965:	60
	From 1966:	40
Water works	Basic infrastructures:	60
	Supply and irrigation infrastructures:	30
	Unclassified:	40
Urban structures		30
Ports		50
Railways		40
Education	Buildings:	50
	Equipment:	15
Health	Buildings:	50
	Equipment:	15
	Transport material:	10
Airports		20

10 percent per year. These results clearly illustrate the importance of assumptions of average lives for the results.[12]

I.6. *Depreciation and Survival Functions*

In international estimations, the use of the Winfrey S-3 survival function has become general, and for this reason it has been selected for application in this study.[13] Winfrey (1935), on the basis of a statistical analysis of withdrawal of capital goods in the U.S.A., established general equations of eighteen frequency curves to determine withdrawals.[14] These eighteen curves are grouped into three types: with the mode at the right (five curves), with the mode at the left (six curves) and symmetrical (seven curves). In his study, Winfrey was inspired by a family of twelve type-curves, developed by Karl Pearson, reflected in the study by Elderton (1927). The Pearson family of curves was designed to determine the theoretical curve most suitable for a given distribution of frequencies[15].

A further question to be kept in mind is the time reference for the capital stock and for the investment flows. Investments have been considered to be made at the mid-point of each year. The capital stock refers to December 31 of each year.

I.7. *Statistical Sources*

A large number of sources have been used. We consider that a detailed description of them is of little interest to a non-Spanish reader. It is enough to say

[12]See Paccoud (1983).

[13]See Ward (1976), BEA (several years) and Munnell (1990).

[14]In current statistical terminology they are called "density functions" instead of "frequency curves."

[15]In subsequent literature, although Winfrey's work has been quoted on numerous occasions, the original source has hardly ever been used. Proof of this is the fact that, on various occasions [e.g. in Paccoud (1983)], the Winfrey symmetrical curves have been presented as normal curves.

that for public capital the basic source of information was the budget settlements available, though not homogeneously for the whole period, since 1857. The functional classification was made according to the COFOG, the functional classification of public expenditure proposed by the United Nations in 1980. For the consideration or otherwise of the different budget items, the criteria of ESA have been taken into account for defining the gross fixed capital formation.[16]

II. Estimation of Private Capital

II.1. *Demarcation of the Private Sector*

Consistency requires Spanish total investment to correspond to that given by the National Statistical Institute in Spain's National Accounts and Regional Accounts. Therefore, the aggregate investment series for the private sector has been obtained as the difference between total investment and that made by the Government and other quasi-public infrastructures. Observe that the investment made by Public Enterprises thus appears included in the private sector of the economy. On the other hand, the private capital of the transport services sector does not include the part corresponding to ports, airports, railway infrastructures and motorways, since this capital is reflected in the public capital series. In the same way, the capital of the agricultural sector does not include the result of the public investments in the sector, not even when these public investments revert to the private sector (as is the case with irrigation infrastructures), as they have been considered in the public capital stock.

II.2. *Disaggregation by Sector and Territory*

Two kinds of consideration have influenced the decision on the level of disaggregation by sectors: that it should be the maximum possible allowed by the information available, and that it should correspond to the disaggregation by branches of production used in standard classifications of economic activities in the European Union. The sectors for which information is provided on investment and capital stock at regional level for the period 1964–94 are those appearing in Table 2.

Also in this case the series are those corresponding to gross fixed capital formation, at current and constant prices, and to the net capital stock at constant prices (base 1990). The level of territorial disaggregation is regional, as the statistical information makes the extension to the fifty provinces of Spain a difficult task.

II.3. *Method of Estimation*

As has been indicated, the application of the PIM requires the availability of long time series of investment. For investments made by the private sector the information is more limited and this situation makes it difficult to start the series in the year 1955. Furthermore, if it is intended to estimate the capital of the

[16]European System of Integrated Economic Accounts. This system is fully consistent with the System of National Accounts (SNA).

TABLE 2

PRIVATE SECTOR DISAGGREGATION

1.	Agriculture
2.	Fishing
3.	Energy products
4.	Industrial products
	4.1. Metallic minerals and metal production
	4.2. Non-metallic minerals and products
	4.3. Chemical products
	4.4. Other metallic products
	4.5. Industrial and agricultural machinery
	4.6. Office machinery and computers
	4.7. Electric material and accessories
	4.8. Transport material
	4.9. Food products, drinks and tobacco
	4.10. Textiles, leather and footwear, clothing
	4.11. Paper, paper articles, printing
	4.12. Rubber products and plastics
	4.13. Wood, cork and other manufactures
5.	Construction
6.	Dwelling
7.	Services
	7.1. Hotel and restaurant services
	7.2. Transport services
	7.3. Communication services
	7.4. Credit institutions and insurance
	7.5. Other services

different private sectors since 1964, the PIM cannot be applied in the same way as has been done in the estimation of public capital, except in those sectors in which a sufficiently long investment series was available, as in the communications sector.

Due to the difficulty mentioned, in this case the permanent inventory method has been applied on the basis of an initial capital stock. For this calculation, the research has rested on the study of the *National Wealth of Spain* available for 1964.[17] According to this procedure, to an initial capital stock are accumulated the investment flows corresponding to the subsequent years. In order to apply the PIM to these sectors, it is necessary to have available annual fixed capital consumption rates for each one of them. The OECD compiles and offers, for those countries that make this type of estimations, investment and capital series (in both gross and net terms) with the sector disaggregation mentioned in the text. Behind these series lie assumptions regarding the average life of the capital goods and structures in which each of these sectors invests, as well as the composition of the investment in each of them. In general, the average lives used by the different countries do not coincide.[18] On the basis of the information provided by the OECD we have estimated the implicit series of proportional rates of fixed capital consumption of the manufacturing sector as a whole. Observe that these rates include both depreciation and the withdrawal of capital goods. Next we

[17]University of Deusto (1968).

[18]See Ward (1976), Keese, Richardson and Salon (1991), OECD (1993).

have obtained the average rates for all countries, rates which have been considered to be a good approximation of those which may have held in the Spanish manufacturing sector in the course of time. The average rates corresponding to the 14 sectors that make it up have been derived by maintaining the ratio between the rate estimated for the Spanish case by Martín and Moreno (1991) for each branch and its estimation for the sector as a whole. In the "Other services" sector we have used the implicit average rates observed by the OECD, excluding dwellings. The rate of fixed capital consumption used can be seen in Table 3.

TABLE 3

FIXED CAPITAL CONSUMPTION RATES

Sectors	Average Rate Used
Energy products	6.4
Metallic minerals and metal production	6.4
Non-metallic minerals and products	8.5
Chemical products	8.8
Metal products	9.0
Industrial and agricultural machinery	10.3
Office machinery and computers	9.0
Electric material and accessories	9.4
Transport material	10.6
Food products, drinks and tobacco	9.3
Textiles, leather and footwear, clothing	9.7
Paper, paper articles, printing	7.8
Rubber products and plastics	6.7
Wood, cork and other manufactures	8.8
Leasing	8.5

III. RESULTS

From the estimates described in the previous sections, it has been possible to substantially advance knowledge of the process of capitalization and growth of the Spanish economy. It is also of interest to illustrate the situation of the Spanish endowments of capital in the international context. In Table 4 the capital/output ratio in all the countries considered by the OECD International Sectoral Data Base (ISDB) appears together with the Spanish data. This information allows us to conclude that the Spanish ratio is similar to most of the European countries, though in the inferior range, and that it has increased in the course of time.

The wealth of information can be exploited in many ways, from both aggregate and regional viewpoints. Some features now available from this series appear in Table 5. The data refer to the Spanish total but are also available at regional level, and those referring to public capital also at provincial level.

Table 5 reflects the intense process of capitalization of the Spanish economy in the last twenty-seven years, especially intense in the first part of the period, as the accumulated stock was multiplied practically by three (column 1). This growth was the result of an important participation, with the corresponding cyclical profile, of investment in GVA. For most of the period, with the exception of the

TABLE 4

CAPITAL OUTPUT RATIO: INTERNATIONAL COMPARISON

	1970–75	1975–80	1980–85	1985–90	1970–90
Australia	3.68	3.92	4.11	4.04	3.93
Belgium	3.30	3.57	3.76	3.84	3.61
Canada	3.97	4.07	4.43	4.47	4.24
Denmark	5.71	5.94	5.91	5.67	5.79
Finland	5.39	5.92	5.93	5.91	5.79
France	2.89	3.01	3.13	3.13	3.03
Italy	3.67	3.66	3.78	3.89	3.75
Japan	1.91	2.45	2.77	2.98	2.52
Netherlands	3.61	3.65	3.80	3.73	3.70
Norway	4.53	4.76	5.10	5.26	4.92
Spain	2.77	2.97	3.31	3.24	3.07
Sweden	4.16	4.35	4.52	4.54	4.40
United Kingdom	3.13	3.27	3.50	3.38	3.31
U.S.A.	3.52	3.64	3.78	3.65	3.64
West Germany	3.57	3.75	3.98	4.01	3.82

Source: ISDB (OECD) (1999). Spain: Fundación BBV/IVIE.

TABLE 5

INDICATORS OF THE PROCESS OF CAPITALIZATION

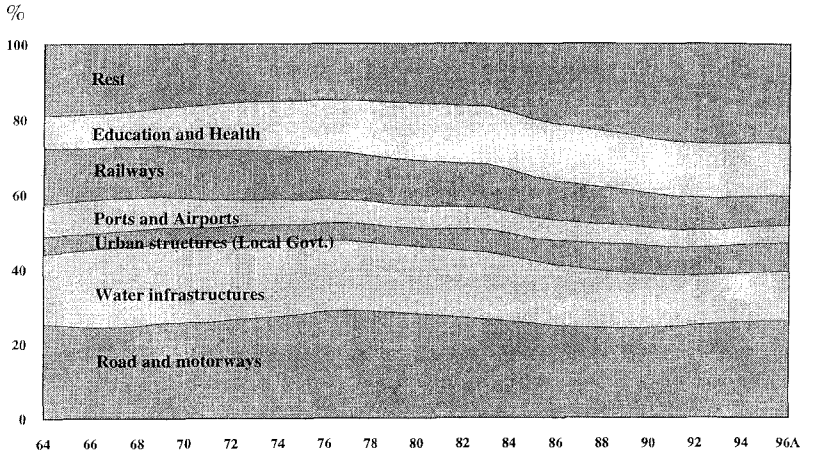
	Total Capital (1970 = 100) (1)	Total Gross Investment/ GVA (2)	Total Capital/ GVA (3)	Public Capital (1970 = 100) (4)	Private Capital (1970 = 100) (5)	Private Capital/ Total Capital (6)	Private Capital/ Private Employment (7)
1970	100.00	25.02	2.83	100.00	100.00	87.37	100.00
1971	105.87	23.17	2.82	109.30	105.37	86.96	104.73
1972	112.87	24.52	2.75	118.51	112.05	86.74	108.63
1973	121.00	25.72	2.70	126.82	120.16	86.76	115.04
1974	129.50	25.95	2.71	134.57	128.77	86.88	122.73
1975	137.05	24.68	2.83	144.56	135.96	86.68	132.58
1976	144.11	23.75	2.87	153.57	142.74	86.54	141.20
1977	150.68	22.85	2.90	163.36	148.85	86.31	148.48
1978	156.61	21.90	2.98	170.15	154.65	86.28	158.27
1979	161.67	20.98	3.08	174.86	159.76	86.34	167.69
1980	166.53	20.92	3.18	178.89	164.75	86.43	181.52
1981	170.77	20.44	3.27	182.87	169.01	86.47	193.44
1982	175.04	20.62	3.32	190.78	172.76	86.23	201.99
1983	178.79	19.70	3.34	197.97	176.02	86.02	208.70
1984	181.49	18.09	3.37	205.49	178.02	85.70	216.47
1985	184.61	18.70	3.36	214.96	180.23	85.29	223.06
1986	188.72	19.91	3.32	225.29	183.43	84.92	223.65
1987	194.31	21.56	3.24	236.31	188.24	84.64	217.67
1988	201.52	23.39	3.19	250.17	194.49	84.32	217.24
1989	210.40	25.40	3.16	268.49	202.00	83.88	217.99
1990	219.89	26.09	3.16	292.32	209.42	83.21	221.03
1991	229.19	25.94	3.23	316.76	216.53	82.54	229.37
1992	237.05	24.63	3.34	334.75	222.92	82.16	241.98
1993	242.37	22.24	3.48	351.72	226.56	81.67	257.67
1994	247.82	22.25	3.51	366.99	230.59	81.30	264.53
1995	254.39	23.34	3.51	380.36	236.18	81.12	263.18
1996	260.91	22.98	3.52	393.52	241.74	80.95	263.37
1997	267.99	23.27	3.50	406.43	247.98	80.84	262.91

years of serious economic crisis 1981–86, investment was over 20 percent, and even over 25 percent in the periods of expansion (column 2). Consequently, the capital/product ratio rose from 2.83 to 3.50 (column 3).

The growth of public capital (column 4) was more intense than that of private capital (column 5) over most of the period. The accumulated result of the respective rates of accumulation is that public infrastructures were multiplied by 4 and private capital by 2.5. The latter rate is a fundamental determinant of the evolution of total capital stock, because the greater part of it is private capital.

The breakdown of total capital into public and private enables us to observe that the second represents more than 80 percent of total capital, although as can be appreciated in column (6) it has progressively lost importance, especially since the establishment of democracy in Spain (1977) and the expansion of public services of the last twenty years.

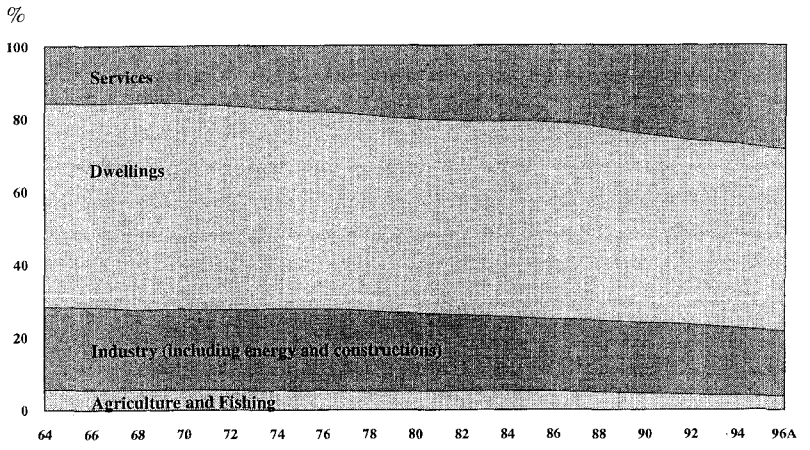
The rapid rate of growth of public capital was accompanied by changes in its structure, outstanding among them being the expansion of social infrastructures (education and health) and urban ones, and the loss of relative importance of railways and water structures.



Graph 1. Composition of Public Capital

Private capital, though growing more slowly, did so at a rate that caused the capital/labor ratio to be notably intensified (column 7) and allowed notable improvements in productivity. Nevertheless, the serious problem of unemployment suffered by Spain poses the question of whether in order to relieve it, it would be necessary to achieve even higher rates of accumulation of private capital.

Graph 2 indicates that the process of private accumulation was oriented in the same direction as the structural change in productive activity: loss of relative weight of agriculture and industry and the advance of private services (which complement the growth of public services). The graph also enables us to appreciate the importance in Spain—as in other countries—of the residential sector as the destination of investment and capital accumulation.



Graph 2. Composition of Private Capital

IV. Applications

The analysis of the capital series from different viewpoints has improved the knowledge of the process of the growth of the economy of Spain and its regions. As examples of these possibilities, we list below some of the results of studies already made on the basis of the estimates mentioned.

(a) The economic growth of Spain and its regions has practically all been due to the contributions of two factors: the process of capitalization and technical progress; on the other hand the contribution of employment is close to zero [Mas, Maudos, Pérez, and Uriel (1998)].

(b) The improvements in efficiency were driven by the change in the productive structure and the expansion in the endowments of infrastructures and human capital, both favoured by the development of public policies [Pérez, Goerlich, and Mas (1996), and Pérez and Serrano (1998)].

(c) The endowments of public capital are shown to be of importance in explaining the gains in productivity of the Spanish economy. This result, first found for the U.S. economy by Aschauer (1989), is maintained irrespective of the area of analysis selected. Mas, Maudos, Pérez and Uriel considered the industrial sector (1993) and the whole private sector of the economy (1994a). In both we found that public capital has a significant positive effect on labor productivity. This result is maintained when the variable being studied is total factor productivity [Mas, Maudos, Pérez and Uriel (1998)].

(d) Breaking down public capital by functions, it can be seen that the infrastructures most directly related to the productive process (roads, water infrastructures, urban structures and ports) are those which positively affect productivity, the effect of infrastructures of a social nature (education and health) being insignificant in practically all estimations (1994a and 1996).

(e) The estimations of time series on which the above conclusions are based pose the problem of overestimating the role of public capital when projecting into

the future the importance that they had in the past. The hypothesis that the positive effects of public capital are greatest in the first stages of development, when the first parts of the network of infrastructures are installed, is tested in Mas, Maudos, Pérez and Uriel (1996). The recursive estimation of the elasticity of labor productivity with respect to productive public capital allows us to conclude that it gradually decreases as the economy advances in development.

(f) The network characteristic of many productive infrastructures makes the public capital endowments of both a particular region and of its neighbors important in the explanation of gains in productivity. The spillover effects of public capital are tested in Mas, Maudos, Pérez and Uriel (1996).

(g) The endowments of public capital have tended over time to become uniform from region to region. Mas, Maudos, Pérez and Uriel (1994b) and Pérez, Goerlich and Mas (1996) describe this process from two viewpoints: (i) reduction of regional inequalities of endowment as indicated by dispersion statistics, and (ii) higher growth rate of the capital stock of those regions that initially started from most unfavorable positions. Conditioned convergence equations are also estimated, enabling the testing of the positive effect of endowments of public capital on convergence of *per capita* incomes of the Spanish regions, although this effect disappears as the endowments become equalized among regions.

(h) The effect of public capital on efficiency gains is analysed in Mas, Maudos, Pérez and Uriel (1998), distinguishing between total factor productivity (Solow's residual) and a stricter measurement of efficiency which discounts the effect of the use of public capital.

V. Conclusions

The statistical series of the endowments of capital stock of an economy constitute information of great interest for the analysis of long run economic processes, the factors behind economic growth, and advances in productivity, technical progress and efficiency. The public and private capital stock series for the Spanish economy presented in this paper offer a wealth of data with many possibilities of use, thanks to its territorial, functional and regional disaggregation.

The number of analyses made since the publication of the series, both by the group who compiled them and by many other researchers, is indicative of their interest, and allow appreciation of the decisive role that capital accumulation has played in the modernization of the Spanish economy in recent decades.[19]

References

Aschauer, D. A., Is Public Expenditure Productive? *Journal of Monetary Economics*, 23, 177–200, March 1989.

Bean, Ch., The Impact of the Cohesion Fund Spending on Regional Output and Employment in the Presence of Interregional Spillovers, Mimeo, The European Institute London School of Economics, 1996.

[19]For example, Cuadrado and García Greciano (1995); Villaverde and Pérez (1996); de Rus (1996); Ezquiaga and Perelli (1998); Bean (1996); Pissarides and Wasmer (1996); Quah (1996); Venables and Gasiorek (1996); González-Páramo, (1995); de la Fuente and Vives (1995).

Cuadrado, J. R. and B. García-Greciano, *La Economía Española en un escenario abierto*, Fundación Argentaria and Visor, S.A., 1995.
Elderton, W. P., *Frequency Curves and Correlation*, 2nd edition, Charles and Edwin Layton, London, 1927.
Ezquiaga, I. and O. Perelli (eds.), *Endeudamiento para el desarrollo*, Federación Gallega de Cajas de Ahorro, 1998.
De la Fuente, A. and X. Vives, Infrastructure and Education as Instruments of Regional Policy: Evidence from Spain, *Economic Policy*, 2, 13–51, 1995.
Fundación BBV/IVIE, (M. Mas, F. Pérez, and E. Uriel (eds.), *El "stock" de capital en España y sus Comunidades Autónomas*, Fundación BBV, Bilbao, 1995, 1996 and 1998.
González-Paramo, J. M., Infraestructuras, Productividad y Bienestar, *Investigaciones Económicas*, 19(1), 155–68, 1995.
INE, *Contabilidad Regional de España*, Instituto Nacional de Estadística, Madrid.
Keese, M., P. Richardson, and G. Salon, The Measurement of Output and Factors of Production for Business Sector in OECD countries (The OECD business sector database), WP-99, OECD, Paris, 1991.
Mairesse, J., L'évaluation del capital fixe productif. Méthodes et resultats, *Collections de L'INSEE*, Serie C, N. 18–19, November 1972.
Martín, C. and L. Moreno, Medidas del stock de capital a partir de datos contables, in *Valoración Económica del beneficio y del capital*, FEDEA, Madrid, 1991.
Mas, M., J. Maudos, F. Pérez, and E. Uriel, Competitividad, productividad industrial y dotaciones de capital público, *Papeles de Economía Española*, 56, 144–60, 1993.
———, Capital público y productividad en las regiones españolas, *Moneda y Crédito*, 1994a.
———, Disparidades regionales y convergencia de las CC.AA. españolas, *Revista de Economía Aplicada*, 4, 129–48, 1994b.
———, Infrastructures and Productivity in the Spanish Regions, *Regional Studies*, 30(7), 1996.
———, Public Capital, Productive Efficiency and Convergence in the Spanish Regions (1964–91), *The Review of Income and Wealth*, Series 44, No. 4, 383–96, September 1998.
Miller, E., Can a Perpetual Inventory Capital Stock be Used for Production Function Parameter Estimation? *Review of Income and Wealth*, Series 36, No. 1, March 1990.
Munnell, A., How Does Public Infrastructure Affect Regional Performance? *New England Economic Review*, Federal Reserve Bank of Boston, 1990.
———, Infrastructure Investment and Economic Growth, *Journal of Economic Perspective*, 4(4), 189–98, 1992.
OECD, *Flows and Stocks of Fixed Capital*, Paris, several years.
———, *Methods used by OECD Countries to Measure Stocks of Fixed Capital*, Paris, 1993.
———, ISDB, *International Sectoral Data Base*, Paris, 1999.
Paccoud, T., Stock of Fixed Assets in Industry in the Community Member States: Towards Greater Comparability, *Studies on National Accounts*, Statistical Office of the European Communities, No. 2, 1983.
Pérez, F., F. J. Goerlich, and M. Mas, *Capitalización y crecimiento en España y sus regiones 1955–95*, Fundación BBV, Bilbao, 1996.
Pérez, F. and L. Serrano, *Capital humano y desarrollo económico en España*, Fundación Bancaixa, Valencia, 1998.
Pissarides, Ch. and E. Wasmer, The Impact of the European Cohesion Fund Spending: Regional Labour Market Issues, Mimeo, The European Institute London School of Economics, 1996.
Quah, D.T., Regional Cohesion from Local Isolated Actions, Mimeo, The European Institute London School of Economics, 1996.
de Rus, F., Infraestructuras, Crecimiento Económico Regional y Evaluación Económica, *Papeles de Economía Española*, 67, 221–37, 1996.
Universidad Comercial de Deusto, *Riqueza Nacional de España*, Bilbao, 1968.
U.S. Bureau of Economic Analysis, *Fixed Reproducible Tangible Wealth in the United States*, Washington, DC, Government Printing Office, several years.
Venables, A. J. and M. Gasiorek, Evaluating Regional Infrastructure: A Computable Equilibrium Approach, Mimeo, The European Institute London School of Economics, 1996.
Villaverde, J. and P. Pérez, Los ejes del crecimiento de la economía española, *Papeles de Economía Española*, 67, 63–80, 1996.
Ward, M., *The Measurement of Capital. The Methodology of Capital Stock Estimates in OECD Countries*, OECD, París, 1976.
Winfrey, R., Statistical Analysis of Industrial Property Retirements, Bulletin 125, *Iowa Engineering Experimental Station*, Iowa State University, Ames, 1935.