THE SPANISH INFRASTRUCTURE STOCK, 1844-1935

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JEL Codes: N73, H54

Keywords: infrastructure, Spain, economic growth, capital stock, railroads

ABSTRACT

This paper presents the first estimates of Spanish infrastructure stock and investment for the period 1845-1935. Several sources and techniques have been used in the estimation, and the new series are reasonably reliable to the standards of historical statistics. Two distinct periods may be distinguished in the series: the years before 1895 (characterized by the prominence of railroads) and the period 1895-1935 (when most investment was addressed to other assets). The new series allow a preliminary comparison of the Spanish infrastructure endowment with that of the most advanced countries, showing a gradual process of convergence before 1936.

I. INTRODUCTION

By the end of 1843, after half a century of successive wars and constant political turmoil and fiscal crisis, the Spanish infrastructure stock was meager and in very bad condition. It barely consisted of a network of paths that were unevenly distributed across the country. Of these paths only a small part was adapted to cart traffic, and an even smaller proportion actually deserved to be called roads. In addition, some small-scale ports and a few dams, canals and irrigation ditches completed the country's infrastructure endowment. Many of those structures were several centuries old by 1843, and some of them had their origin in former Roman works.[1]

Between the mid-1840's and Franco's *coup d'Ét*at of 18th July 1936, the scenery was completely altered. The old paths gradually disappeared under the surface of a real network of macadam roads, which, by the eve of the Civil War of 1936-1939, connected most population centers of the country and had started to be covered with the so-called "special" surface treatment. At the same time, the railroads, which would perform the principal role in the Spanish transport revolution, spread all over the territory. Finally, the most important ports were endowed with complex and large-scale structures, the number of dams and irrigation canals increased substantially, and cities were equipped with modern networks of lighting, water distribution and sewage systems.

Over ninety years, infrastructure had changed the face of the country and had become one of the most visible aspects of Spanish modernization. In fact, it constituted one of the factors that made economic growth possible. The slow but continuous rise of income per capita in Spain between the mid-nineteenth century and 1936 would have been stopped, or been constrained to some coastal areas, without the spectacular reduction in transport, communication and energy costs, brought about by the new infrastructure.

As economists have long insisted, this sort of cost reduction, its dynamic long-term consequences and, specifically, the changes in the structure of location incentives that it produces, are absolutely crucial for growth. Thanks to the increase in infrastructure endowments, economies are allowed to exploit fixed resources that would otherwise remain idle due to the high transport costs. In addition, infrastructure allows a large share of non-agrarian production activities to concentrate in a few industrial centers, in a process that is absolutely crucial for the growth of developing economies and the rise of technologically advanced sectors.[2]

It is not surprising therefore, that infrastructure has always received the attention of economic historians and, more concretely, has always been included among the factors that may explain the evolution of the Spanish economy between 1850 and 1936. During those years, Spain experienced a sustained process of growth, but was unable to converge with the most industrialized European economies,[3] and researchers have attempted to find out to what extent the shortage or inefficiency of infrastructure was one of the factors to blame for that relative failure.

Research on the role of infrastructure in Spanish economic growth before the Civil War of 1936-1939 has been characterized by two features. On the one hand, as is usual in international historiography, analyses on the subject have focused on the railroad system. On the other hand, opinions on the role that railroads performed in Spanish economic growth have been divergent, provoking an intense debate that still remains unresolved. Some historians have indicated that the State's mistakes in the regulation of railroad construction and operation prevented an intensive use of the railroad network and, as a consequence, substantially reduced the economic impact of the railroad system.[4] By contrast, other researchers have insisted that railroads had an enormous growth impact in Spain, which was in fact much higher than in other European economies due,

amongst other reasons, to the lack of opportunities for the development of inland waterways in the country.[5]

After those initial interpretations, research devoted to the analysis of different aspects of the railroad system has been abundant.[6] In addition, during the last few years, some studies on other parts of Spain's infrastructure have been published.[7] However, in spite of these recent research efforts, an aggregate and systematic approach to the whole Spanish infrastructure stock is still missing. Such an approach would allow a better knowledge of some essential aspects of the history of Spanish infrastructure, such as the distribution of investment efforts amongst different assets, the importance of infrastructure capital formation within the whole economy, or the relative degree of infrastructure shortage in Spain compared with other countries. In addition, it would provide a quantitative basis for the solution of the old debate on the economic impact of Spanish infrastructure.

These pages are aimed precisely at filling that gap, by providing an estimation of Spanish infrastructure investment and stock between 1845 and 1935. The text is organized in four parts. The next section offers a brief account of the methods that have been followed for the construction of the new series. Section III presents the main results of the estimation, and performs some sensitivity analyses. Finally, on the basis of the new figures, Section IV describes the main features of Spanish infrastructure investment and stock during the period under study. It is followed by a summary of the main conclusions, and an Appendix containing the complete series and the main sources that have been used to obtain them.

II. THE NEW SERIES OF SPANISH INFRASTRUCTURE STOCK AND INVESTMENT: ESTIMATION METHOD

Infrastructure is quite a tricky concept, since most people know what it is, but it is difficult to find a widely accepted definition in the literature.[8] From a very broad point of view, infrastructure might be described as the stock of structures and support services that are necessary for the economic development of an area. This preliminary definition, however, admits many possible interpretations, from very narrow views of the concept, such as Hirschman's (who limited the hard core of infrastructure to transport and energy distribution), to very wide perspectives, such as those which include within the concept, the so-called "civic" infrastructure, i.e. "the way in which business is done".[9]

Most empirical studies, however, tend to fall somewhere between these two extreme interpretations, and consider infrastructure as the stock of physical capital goods that are organized in networks and fixed to the territory, and provide services which show some of the typical features of public goods. In Diewert's words, infrastructure services are similar to public goods as far as: "(i) there is a substantial cost of providing the service to an area and a small marginal cost of adding an extra customer to the area service grid (...) and (ii) charging customers the marginal cost of providing the service once the area service has been established will not lead to an efficient allocation of resources".[10]

These features explain why Public Sector intervention is so frequent in infrastructure construction and management. However, infrastructure services are not *pure* public goods, as far as they use to be congestible and excludable to some extent.[11]

Infrastructure is usually divided into *economic* infrastructure (i.e. those assets that provide direct services to production, such as transport, communication or energy distribution networks),

and *social* infrastructure (i.e. those assets that enhance social welfare, such as education and health structures).[12] This is not a strict division, because some elements, such as universities, perform both economic and social functions. However, it is a useful distinction because the impact of each of those two categories on productivity is very different. Several empirical studies have shown that economic infrastructure is much more conducive to direct efficiency increases than social infrastructure.[13]

The differences between economic and social infrastructure make a separate study of each of those two categories advisable. In this context, this research focuses on economic infrastructure due, amongst other reasons, to the slow development of Spanish social infrastructure during the period under analysis, and also due to the fact that most information about its historical evolution is only available at a local level, and thus beyond the possibilities of an individual researcher. Accordingly, the assets that are considered here are the following:

- transport infrastructure (roads, railroads, urban transport, canals and ports).
- communication infrastructure (telegraph and telephone networks).
- energy distribution networks (gas and electricity).
- water infrastructure (dams and irrigation canals).
- urban and suburban infrastructure.

Within these sectors, only the assets that are usually considered as infrastructure are covered by the research. Therefore, the estimates do not measure the value of the total capital stock of sectors such as transport or electricity, but include only those elements that can be considered as infrastructure *strictu sensu*, i.e. which are fixed to the territory and have certain public character. For instance, within transport, railroad rolling stock, merchant ships or

motorcars are not encompassed by the series, since they are not fixed to the territory. Similarly, the value of land has also been excluded from the estimation, because it does not belong in the capital stock.

The starting point of the estimation is 1844. This was determined by the availability of information. In fact, a more comprehensive analysis of the Spanish industrialization process would have required starting the research fifteen or twenty years earlier. However, the available data on investment in infrastructure before 1844 is too scarce to allow the estimation of yearly series.

The estimates are net capital stock figures, which are intended to reflect the productive capacity of each asset, as well as its gradual decay over time. Several procedures are available to estimate net capital stock figures. Obviously, the optimal method is the direct measurement of the replacement cost of the stock in a series of benchmark years. However, the amount of information required to apply this estimation technique is enormous, making its use difficult even when analyzing economies today, and virtually impossible in historical research.

As a second best choice, most researchers use the perpetual inventory method, according to which the stock is estimated through the accumulation of investment flows over time, after establishing a number of assumptions about the pattern of survival and efficiency decay of the assets. Accordingly, the net capital stock at time *t* is estimated as:

$$K_t = \phi_0 I_t + \phi_1 I_{t-1} + \ldots + \phi_T I_{t-T} \qquad (1),$$

where I is the level of gross fixed capital formation in each year, the series of coefficients ϕ reflects the efficiency decay of capital over time, and T is the useful life of capital. In order to apply expression (1), it is necessary, therefore, to obtain sufficiently long gross investment series, and to make likely assumptions about the useful life and the efficiency decay of each

asset. The next few paragraphs describe the way in which these two aspects have been dealt with in this research.

a. The gross investment series

As far as investment data is concerned, most estimates of infrastructure stock for current economies are based on the use of public gross capital formation as a proxy for gross investment in infrastructure. This approach does not provide exact figures, because public investment includes some assets that do not belong in infrastructure and, at the same time, excludes a certain proportion of infrastructure because it is privately owned. However, the biases associated with these two problems are usually not very serious for recent times, and the use of public capital figures as representative of infrastructure is, to some extent, justified by the ease of their estimation.[14] For instance, in the case of Spain, the evolution of the infrastructure stock from 1955 onwards has been recently estimated by the *Instituto Valenciano de Investigaciones Económicas* (IVIE) on the basis of public investment data.[15]

With the objective of carrying the analysis back in time, the IVIE has also produced figures of the State's net capital stock for the years 1900-1990.[16] However, in the Spanish case, the use of public capital figures as representative for infrastructure is not appropriate for the pre-1936 period because a large number of assets, such as railroads, tramways, the telephone system, energy distribution networks and some hydraulic works (i.e., more than 50 per cent of the stock of infrastructure) were privately owned at the time. As a consequence, the estimation of infrastructure series for the period before 1936 needs to complement the available information about the State's capital stock with data on private infrastructure investment. In fact, this task has been recently initiated by the IVIE itself, with an estimation of the stock of Spanish railroad infrastructure since 1844.[17]

Unlike this sectoral approach, in this research I have adopted a wider perspective and present estimates for all (public and private) Spanish infrastructure during the period 1844-1935. Therefore, in order to carry out the estimation, I had to retrieve investment data for each type of infrastructure, regardless of its public or private character. To that purpose, I followed different procedures. In a few cases (broad gauge railroads, State roads and ports), I was able to find some information on the amounts that were invested each year, and had only to make some statistical or accounting adjustments. By contrast, for other types of infrastructure, I had to estimate the value of the "gross" capital stock (i.e., without accounting for the efficiency decay of the assets) in one or several benchmark years, on the basis of the available technical and accounting information, and had to use physical indicators of the evolution of the stock to transform the benchmark estimates into yearly series of gross stock. These were then first-differenced in order to get "new" yearly investment figures, i.e. data on the annual excess investment after replacing the assets that were retired each year. Each series of "new" investment was then added to a hypothetical series of replacement investment, which was estimated according to the assumptions on the useful life of each asset. Finally, I took the sum of "new" and replacement investment as a gross investment series for each type of infrastructure.[18]

All investment series are presented in Table A1 of the Appendix.[19] Figures always refer to the end of the year and are expressed in constant pesetas of the mid-point year of the period under analysis (1890). The price index that has been used to deflate the available investment series (in the cases of broad gauge railroads, State's roads and ports), or to express in 1890 pesetas the stock and investment indices estimated on the basis of physical indicators (in all other cases) is the deflator for "Other construction" investment, which has recently been estimated by Leandro Prados de la Escosura.[20]

b. Assumptions on the useful life and efficiency decay of infrastructure

In the context of capital stock estimates, the absence of adequate information often makes it necessary to establish assumptions on the useful life and the efficiency decay patterns of the assets. These assumptions use to be too simple, especially when compared with the complexity of the technological and structural changes of the economic system which have a direct influence on the process of effective capital destruction.[21] As a consequence, assumptions on these two issues tend to introduce biases in the final series that are very difficult to make up for, especially in a historical estimation exercise for which data is much scarcer than for present times. In this research I tried to choose those assumptions that seemed most likely, on the basis of the available information, but in the next section I make an approach to the potential size of the biases associated with these aspects, by analyzing the sensitivity of the estimates to the establishment of different assumptions.

The useful life figures that I finally adopted in the estimation are shown in Table 1, and are similar to those applied in other estimations of capital stock for the late nineteenth and early twentieth century. In a few cases (narrow gauge railroads and tramways) I was able to get information on assets that were retired before the end of their useful life due to their obsolescence or lack of profitability, and I subtracted their value from the net stock at the time of their retirement, and not at the end of their useful life.

Table 1. Useful life assumptions

Assets	Years of useful life
Railroads:	
Grading, works and stations	100
Track and accessories	18/30*
Tramways	25
Roads	80
Ports	80
Telegraph and Telephone	30
Energy distribution networks	25
Urban infrastructure	25
Hydraulic works	80

Note: (*) Change in 1872.
Sources: Feinstein (1988), Groote (1996) and, for railroad track, Gómez Mendoza (1982) and (1989a).

Assuming the useful life figures in Table 1 made it necessary to exclude the oldest infrastructure from the estimation, i.e. those tracks that were in use before the construction of the road network, and a number of dams, canals and irrigation ditches that had been build before the eighteenth century. By 1844, all of them had long reached the end of their useful life, and their valuation in net terms at the end of that year would have required information of their state of repair. According to some contemporary indications, they seem to have been in a very precarious condition, especially in the case of tracks.[22] As a consequence, they would have amounted to a very tiny share of the total stock in 1844, and this would have gradually become negligible with the construction of new assets. This is shown in more detail in the next section, which includes an analysis of the sensitivity of the estimates to the exclusion of the oldest infrastructure.

As far as the efficiency decay of the assets is concerned, the most usual patterns in the literature are the one-hoss shay, the straight-line and the geometric decay. According to the first one, assets would maintain full efficiency until their retirement. In other words, it would be assumed that $\phi_0 = \phi_1 = \ldots = \phi_{T-1} = 1$, and $\phi_T = 0$ in expression (1). The straight-line pattern involves an identical loss of efficiency during the whole useful life of assets, i.e. it is assumed

that $\phi_0 = 1$, $\phi_1 = 1\text{-}1/T$, $\phi_2 = 1\text{-}2/T$, …, $\phi_{T-1} = 1\text{-}(T\text{-}1)/T$, and $\phi_T = 0$. Finally, the geometric decay pattern assumes that the productive capacity of assets decreases at a constant rate δ or, in other words, that $(\phi_{t-1} - \phi_t)/\phi_{t-1} = \delta$ for all $t<T$.

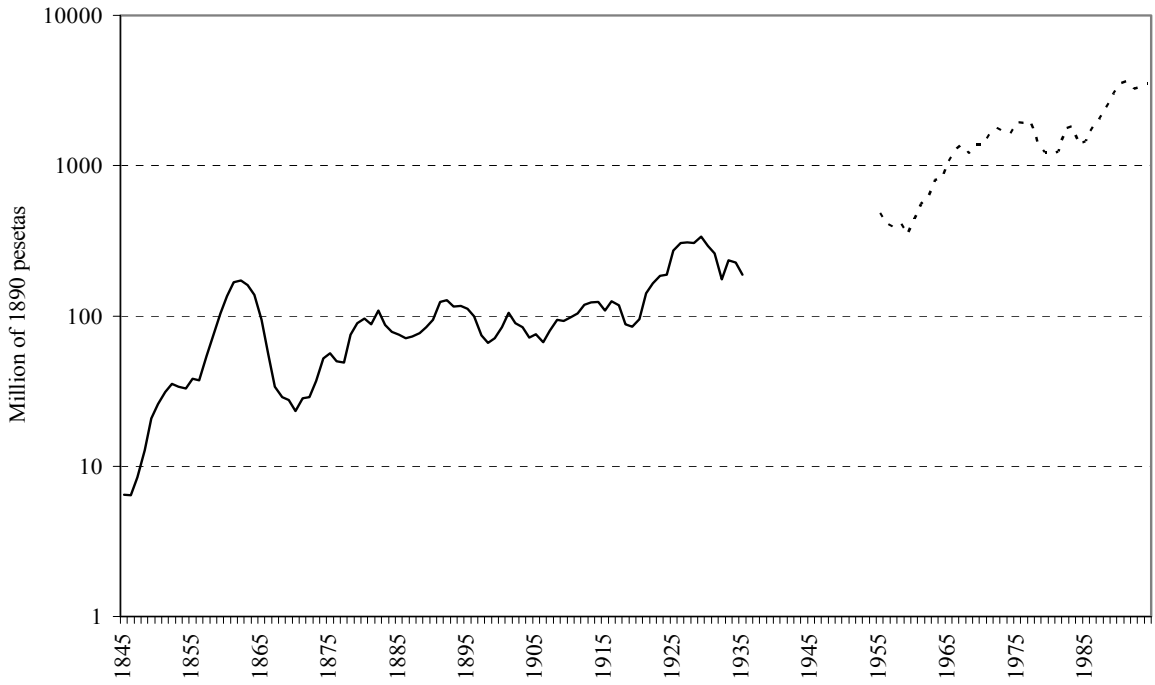
The geometric decay pattern has received more empirical support than the rest, the depreciation rate usually being calculated as $\delta=2/T$. On the basis of a detailed econometric analysis of second-hand asset prices, Hulten and Wykoff have suggested a modification of this expression for different types of capital. In the case of non-residential structures, they have estimated a depreciation rate of 0.91/T, which has been used here to obtain the infrastructure stock series.[23]

The final figures of net stock for each type of infrastructure are presented in Table A2 of the Appendix. As in the case of investment, figures always refer to the end of the year and are expressed in constant pesetas of the mid-point year of the period under analysis (1890).

III. ESTIMATION OUTCOMES AND SENSITIVITY ANALYSIS

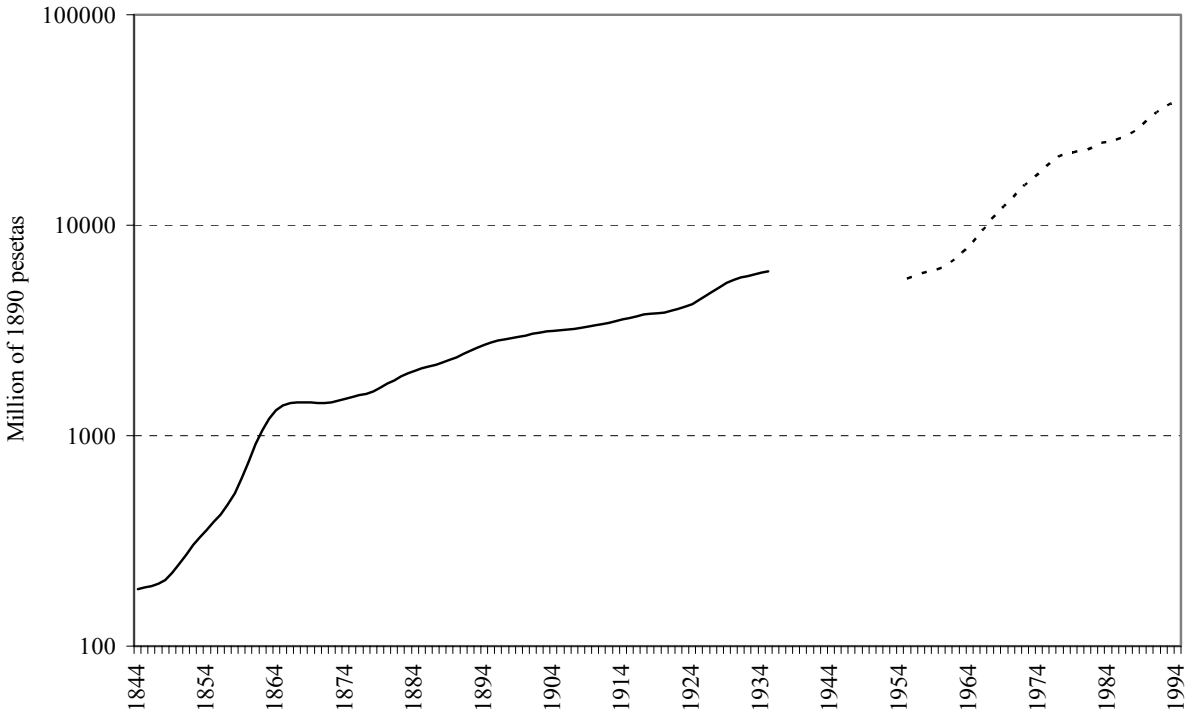
Figures 1 and 2 show Spanish infrastructure gross investment and net stock series during the period 1844-1935. In order to provide a more complete image of the historical process of Spanish infrastructure construction, they also include the IVIE estimates for the years 1955-1994.[24]

Fig. 1. Spanish Gross Infrastructure Investment (1845-1994).



Sources : for 1845-1935, my own figures; for 1955-1994, Mas et al. (1998).

Fig. 2. Spanish Net Infrastructure Stock (1844-1994).



Source : for 1844-1935, my own figures and, for 1955-1994, Mas et al. (1998).

Despite the gap of the Civil War and the post-war, and the coverage differences between figures for the period before 1936 and after 1954, the graphs offer a consistent picture of the evolution of Spanish infrastructure from the mid-nineteenth century onwards. They clearly show the four periods of maximum growth of the stock, i.e. the railroad mania of the last years of Queen Isabel II's reign (1855-1866), the 1920s, the end of the Francoist dictatorship (late 1960s and early 1970s) and the period 1986-1992.[25] Between those conjunctures, a series of stagnation periods appear in the graphs that correspond to the depression of the late nineteenth century, the Civil War and the beginning of the Francoist rule, and the crisis of 1973.

Despite the likelihood of the global trends, the accuracy of the new estimates is only relative, as is usual with historical statistics, and, although the overall process of Spanish

infrastructure construction seems to be adequately described by the series, inferences drawn from minor details or from short-term variations must be taken with extreme caution. The series have been estimated on the basis of limited information, and it has been necessary to establish a number of assumptions to make up for the lack of data. This may have introduced several biases in the final figures, which may be assumed to be larger at the beginning of the period than at the end of it, in the partial series than in the aggregate, and in the short term rather than in the long term.

The potential biases may have different origins. Firstly, some assets have been excluded from the series due to the absence of information. For instance, it has not been possible to include airport infrastructure in the estimates due to the lack of adequate investment data, although this exclusion seems to be of minor importance in the period before 1936.[26] As has already been indicated, the assets that were constructed before the eighteenth century have also been excluded from the series, due to the lack of information on their construction costs and state of repair by 1844. As far as they were still being used at that time, the stock estimates of the first decades would contain a downward bias. In order to approach the maximum size of that bias, I have made an optimistic valuation of those assets, by assuming for them similar construction costs to those of the eighteenth and nineteenth century, and a ratio between net and gross stock of 50 percent by 1844. Under these assumptions, ancient infrastructure would amount to 9 percent of the stock in 1844, and just 1 percent twenty years later.

A second source of potential bias is the poor quality of the empirical information that has been used to estimate some of the sectoral series. The most serious problems arise in the case of urban infrastructure, for which I have been unable to obtain reliable systematic data, and I merely suggest a correction of the aggregate figures on the basis of very insufficient evidence. But empirical

information is also scarce and of very poor quality in other sectors, such as non-public railroads, local roads, the telegraph network, gas distribution infrastructure and canals. Unlike the rest of the series, which are based on reliable data on the invested resources and the physical characteristics of the stock, information regarding these five sectors is indirect and incomplete, and estimates are a mere proxy of the actual figures and will contain a relatively high margin of error. Nonetheless, the importance of these assets within the whole infrastructure is rather small, as they only amounted to approximately 6 percent of the total stock, and 8 percent of the total investment during the period under study.

By contrast, for all other infrastructure the available information is acceptable, according to the usual standards of historical statistics, and the most important potential biases would be associated to the assumptions that have been applied to carry out the estimation process. Potential biases of this kind may be classified in three categories: i) those that result from the deflation procedure, ii) those that are a consequence of the individual assumptions that are applied in the estimation of sectoral series, and iii) those that are associated with the general assumptions that were established in the application of the perpetual inventory method.

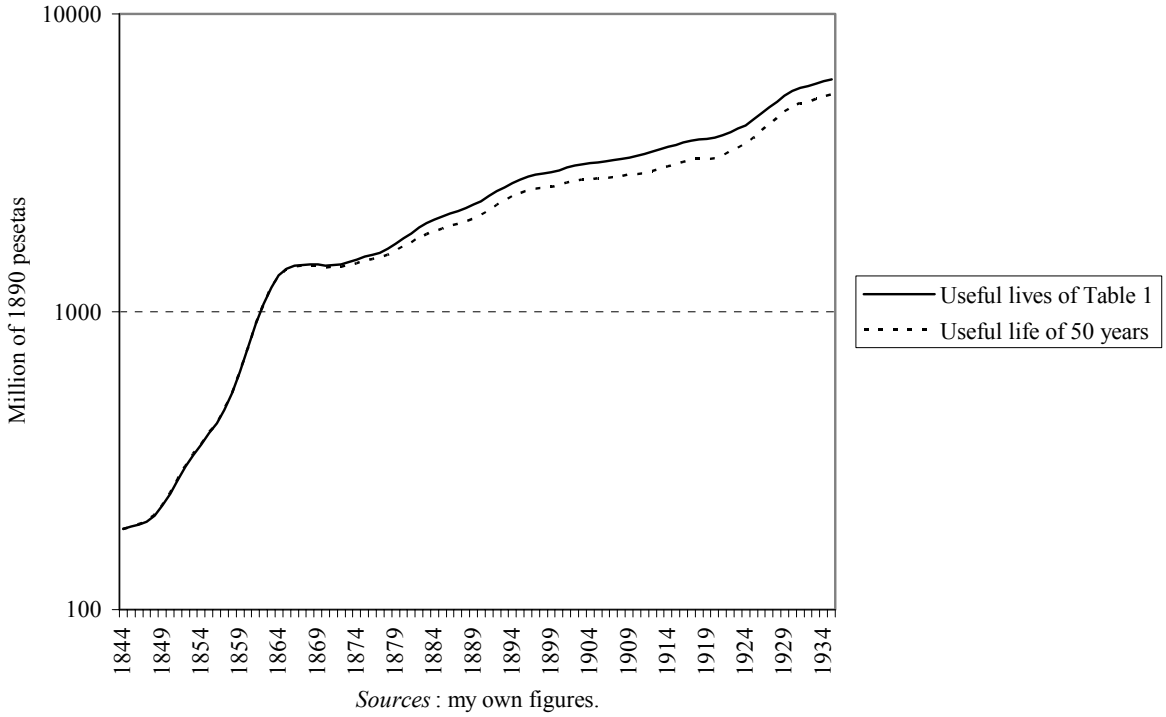
Regarding the first of these three potential sources of bias, the use of an average deflator that is the same for all series removes the "index number problem" associated with the combination of several sectoral series into an aggregate one.[27] However, as single price indices for each type of infrastructure are missing, the mismatch between the average deflator and the evolution of the price of each individual asset may have introduced biases into the final figures of unknown magnitude and sign. In fact, as far as the deflator that has been used is an average, biases may be assumed to cancel each other in the aggregate series. However, they may have reduced the accuracy of the individual estimates.

The second category of problems is associated with the assumptions that have been applied to estimate each individual series. For example, in those cases in which no investment data was available, physical indicators have been accepted as proxies for the evolution of the gross stock and, as a consequence, the potential increases in the technical complexity of the assets or in the quality of materials that were used in its construction may have introduced downward biases in the growth rate of the series. By contrast, upward biases may result from increases in the productivity of construction of each network, and can also arise as a consequence of the poor conservation of the assets. Although changes in quality and in the technical characteristics of infrastructure have been allowed for as far as possible, sometimes the lack of information has prevented adjustments, and some individual series may contain biases of unknown sign and magnitude. Nevertheless, as in the case of the deflation process, although those biases may be important for the sectoral series, they are probably much less relevant in the aggregate figures.

Finally, it is also necessary to analyze the consequences of the basic assumptions associated to the application of the perpetual inventory method and, more concretely, those regarding the useful lives and the efficiency decay of the assets. As far as the first of these two aspects is concerned, I have tried to keep the same useful lives as in other historical analyses of infrastructure. However, the accuracy of this choice is uncertain, since there is a total lack of information about the retirement and renewal practices that were followed at the time. In order to illustrate the size of the potential biases that would be associated with this problem, Figure 3 shows the difference between my infrastructure stock series and the estimates that would result from applying a homogeneous useful life of 50 years for all assets. This useful life figure has often been assumed for buildings and structures in capital stock estimates.[28] The gap between both series is rather small, amounting, on average, to 3 percent in 1844-1890 and to 12 percent in

1890-1935. Accordingly, the influence of the useful life assumption on the final series seems to be rather low, something that may be explained by the fact that estimates in Figure 3 are not based on the pure application of the perpetual inventory method to investment series, but on the combination of investment data with physical indicators of the evolution of the stock.

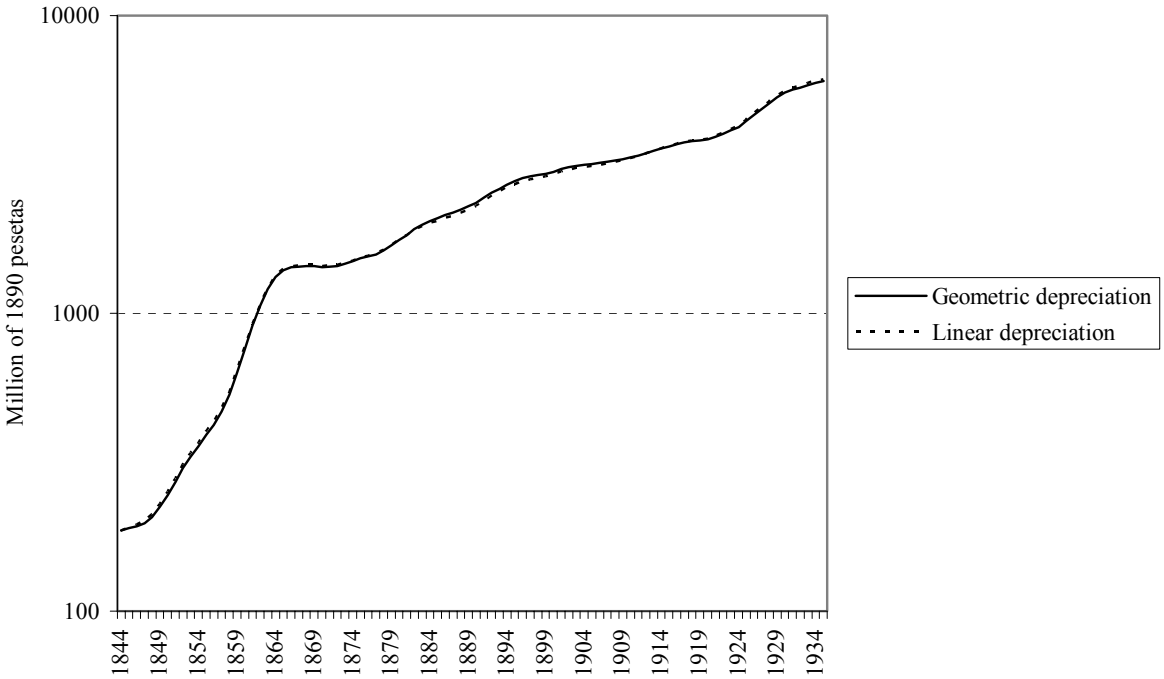
Fig. 3. The Spanish infrastructure stock: alternative estimates under different assumptions on the useful life of the assets



Sources : my own figures.

Figure 4 compares the infrastructure stock series that has been estimated under the assumption of a geometric depreciation pattern (with δ=0.91/T), against the series that would result from the assumption of a straight-line process. Gaps in the series are negligible, due to the similarity of these two depreciation patterns in the case of non-residential structures. The average difference is 1.4 percent and the maximum gap is only 2.9 percent.

Fig. 4. The Spanish infrastructure stock: alternative estimates under different assumptions on the efficiency decay pattern



Sources : my own figures.

To summarize, it may be useful to remember Charles Feinstein's considerations on his own estimation of the British capital stock in the late nineteenth century. He suggested that a 10 percent average margin of error might be assumed in his aggregate series. In the case of the sectoral estimates, this bias should be increased up to 25 percent.[29] Given the differences between the UK and Spain as far as the quality of the available information is concerned, and given the outcomes of the different sensitivity analyses that have been carried out in this section, the infrastructure series that are presented here should be allowed, at least, the same margin of error as the British ones. In fact, it would be reasonable to assume larger biases in the five series for which information is scarcer and of poorer quality (non-public railroads, local roads, telegraph networks, gas distribution infrastructure and canals). It is necessary, therefore, to insist

that the figures that are reproduced in the Appendix must be considered carefully. As Feinstein himself stated, it is necessary to warn the researcher against the spurious air of precision conveyed by long runs of estimates systematically arrayed in neat tables.[30] Keeping this *caveat* in mind, the next section describes the main features of the process of construction of Spanish infrastructure before the Civil War that may be inferred from the new series.

IV. THE EVOLUTION OF SPANISH INFRASTRUCTURE BEFORE THE CIVIL WAR

a. Infrastructure investment, 1845-1935

As may be observed in Figure 1, Spanish investment in infrastructure showed an underlying positive growth trend, as well as very intense fluctuations throughout the period under study. A complete understanding of the dynamics of the series requires an analysis of any possible structural breaks that could have provoked a movement or alteration in the growth trend. For that purpose, the Vogelsang test has been applied to the series. This aims to contrast the existence of one-time breaks in time series in the presence of serial correlation, regardless of whether a unit root or a linear trend is present or not.[31] I have applied the version of the test that was developed by Ben-David and Papell (2000) for finite series that are not I(1), because it allows testing for the presence of more than one break in the variables. The use of that version is justified in this case because, according to the ADF and the Phillips-Perron tests, the infrastructure investment series does not contain a unit root (see Table 2).

Table 2. Unit root tests. Gross Investment in infrastructure (1845-1935)

ADF t-stat.	-4.21**
PP t-stat.	-3.00*

H_0: Presence of a unit root.
* Rejection of the null hypothesis at the 5 percent significance level.
** Rejection of the null hypothesis at the 1 percent significance level.

The presence of a structural break has been contrasted for all years between 1850 and 1930, after excluding the extreme points of the series according to the test specification. The test statistic for the rejection of the null hypothesis of no structural break reaches its maximum F-statistic in 1854, at a level of 16.60, which is lower than the critical value of the test (17.85 at the 5 percent significance level).[32] Therefore, Spanish investment in infrastructure can be accepted to have followed a constant structural growth trend with no significant structural breaks during the country's first long wave of industrialization.

The lack of structural breaks is a common characteristic of most Spanish economic variables between the middle of the nineteenth century and the Civil War. In fact, the structural stability of investment in infrastructure reinforces the impression of continuity of that long historical period, in spite of the violent fluctuations that took place in the meantime.[33] In the case of the new infrastructure series, neither the profound changes in its composition that are described below, nor the substantial cyclical instability that may be seen in Figure 1, were able to alter its structural growth trend.

Table 3 presents the composition of infrastructure investment, and figures 5 and 6 show the percentage that gross investment in infrastructure accounted for within the GDP and total investment. This information provides a complete characterization of the process of infrastructure construction in Spain during the years under analysis.

Table 3. Spanish gross investment in infrastructure (1845-1935)

A) Composition of investment (annual average, %)

	Railroads	Urban transport	Roads	Ports	Telecom.	Energy distrib.	Hydr. Works	Total
1845/55	43.71	0.00	40.42	3.51	0.16	0.57	11.63	100
1856/65	74.92	0.00	17.23	4.00	0.52	0.20	3.14	100
1866/75	54.72	0.00	32.73	9.11	0.27	1.10	2.07	100
1876/85	65.39	0.33	28.05	2.00	0.49	1.81	1.93	100
1886/95	63.08	0.98	21.45	7.82	1.48	2.33	2.85	100
1896/1905	44.49	7.27	21.09	15.26	0.54	5.86	5.49	100
1906/15	31.67	3.73	21.46	16.90	2.12	14.45	9.66	100
1916/25	21.05	11.70	18.54	7.17	3.52	29.64	8.38	100
1926/35	15.88	4.56	30.92	8.74	9.53	18.38	12.00	100
1845/1895	*64.67*	*0.15*	*25.76*	*4.20*	*0.67*	*1.06*	*3.50*	*100*
1895/1935	*28.57*	*5.90*	*24.05*	*10.50*	*5.09*	*16.85*	*9.02*	*100*
1845/1935	**39.77**	**4.10**	**24.65**	**8.54**	**3.71**	**11.92**	**7.31**	**100**

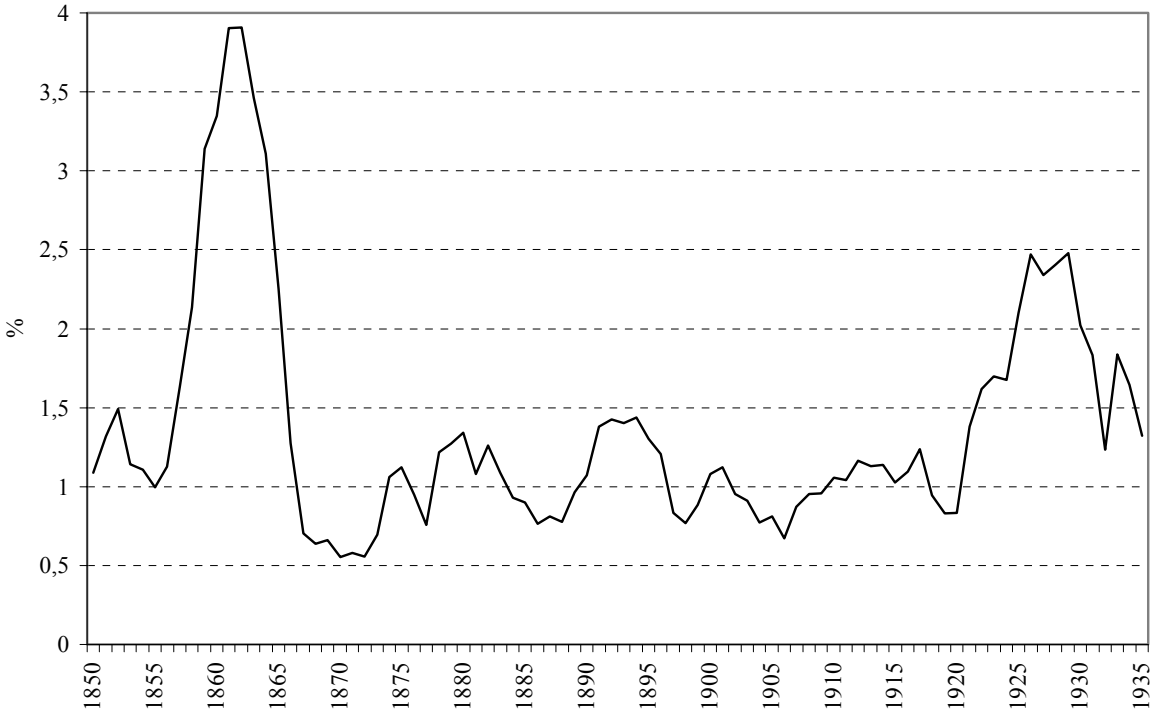
B) Yearly growth rate of investment (%)

	Railroads	Urban transport	Roads	Ports	Telecom.	Energy distrib.	Hydr. Works	Total
1845/1890	*4.23*		*2.75*	*2.78*		*8.27*	*-1.31*	*3.33*
1890/1935	*-1.64*	*5.20*	*3.59*	*1.12*	*8.46*	*8.00*	*6.17*	*3.36*
1845/1935	**0.68**		**1.81**	**3.70**		**7.94**	**3.25**	**2.33**

Sources: see the Appendix.

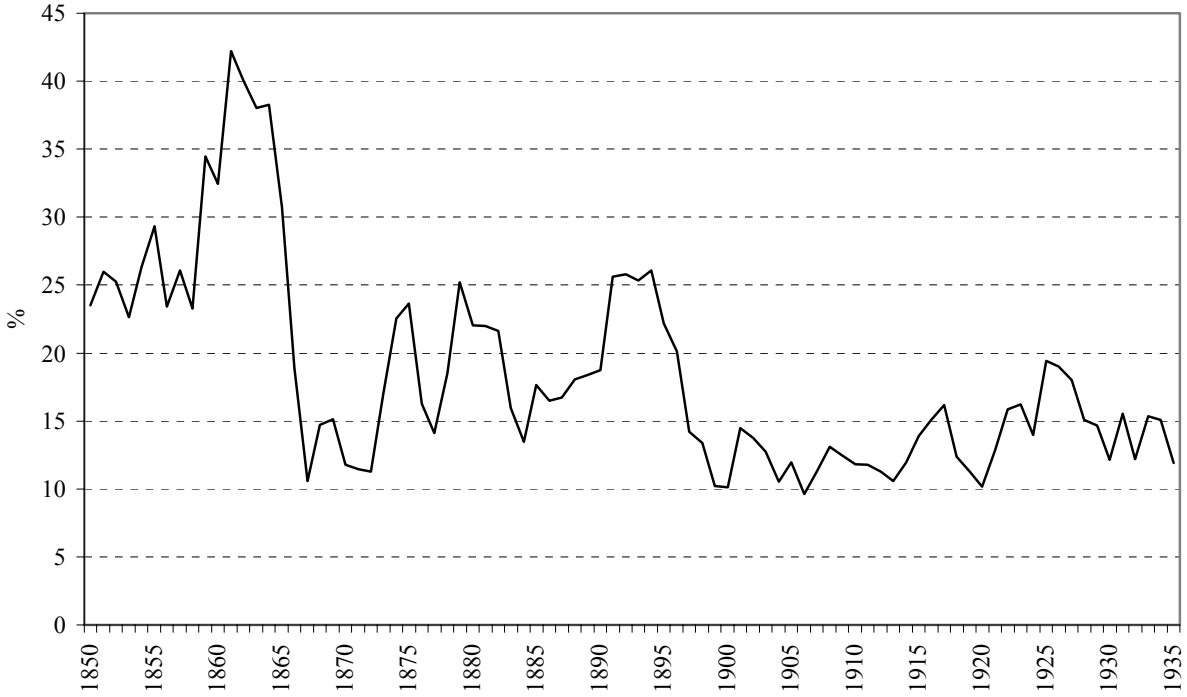
Note: Investment growth is expressed in annual accumulative rates, adjusted to a log trend. As a consequence, rates for the whole period are not the average of those for shorter periods.

Fig. 5. Spanish Gross Infrastructure Investment/GDP (1850-1935)



Sources : Prados de la Escosura (2003) and my own estimates.

Fig. 6. Spanish Gross Infrastructure Investment/Gross Total Investment (1850-1935)



Sources : Prados de la Escosura (2003) and my own figures.

The most striking feature of the graphs is the abnormally high investment rates of the years 1855-1866, during which railroads were predominant within total investment. Those years correspond to the earliest and most intense Spanish railroad construction mania, which coincided in Spain with a substantial growth of the State's capital formation in other infrastructure and, particularly, in the road network, ports and the telegraph system. The violence of the cycle of 1855-1866 is illustrated by the fact that the maximum level of investment, which was reached in 1862, was not regained in absolute terms until six decades later, and the maximum ratios between infrastructure investment and the GDP (3.9 percent), and between infrastructure investment and total investment (42.2 percent) were probably never reached again. Nevertheless, those percentages were not abnormal in the international context. Situations in which railroad

investment accounted for 3 percent or more of GDP and 30 percent or more of total investment may be found, for instance, in Britain in 1847, the US in 1854, Germany in the 1850s and the 1860s, Hungary in the late 1860s and early 1870s, or Sweden in the 1870s.[34] Railroad investment manias were a widespread phenomenon in the Western economies at the time, and the Spanish case fits perfectly with other such experiences.[35]

The railroad mania ended in a deep investment crisis that started in 1866. Infrastructure construction resumed by the mid-1870s at much lower rates. Between 1875 and 1935, the average ratios between infrastructure investment and the GDP (1.2 percent) and total investment (15.8 percent), were similar or slightly lower than figures available for other economies during the period. For instance, investment in infrastructure was 2.7 percent of the GDP in Italy in 1890-1935, 2.2 percent in the UK in 1830-1913, 2.0 percent in Germany in 1850-1913, 1.9 percent in France in 1848-1913, and 1.2 percent in the Netherlands in 1800-1913.[36] As for investment in infrastructure as a percentage of total investment, it was, for instance, 15.2 percent in Germany in 1850-1913, 14.4 percent in France in 1848-1913 and 22.1 percent in Italy in 1890-1935.[37]

Several periods may be distinguished in the evolution of investment in infrastructure between 1875 and the outbreak of the Spanish Civil War. As may be observed in Table 3, the most important threshold is to be found around 1895. Before that year, the main feature of Spanish investment in infrastructure was the absolute prominence of railroads, since they absorbed nearly two thirds of the resources that were invested in the improvement and growth of Spanish infrastructure stock. By contrast, with the exception of the road network, investment in other types of infrastructure received extremely small proportions of the total resources. This situation gradually changed after the mid-1890s, when a process of intense diversification of

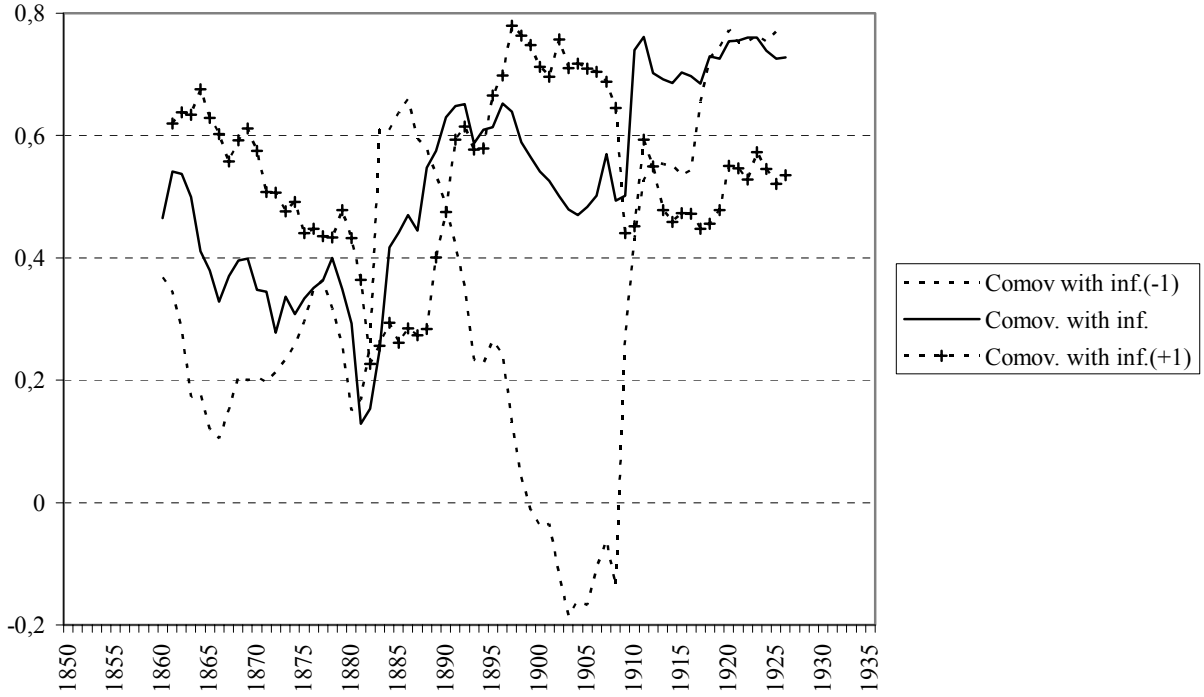
investment started. The reduction in the importance of railroads firstly benefited ports and urban and suburban transport, although the shares of those assets in total investment were later taken over by irrigation infrastructure, the telephone system and, especially, energy distribution networks.[38]

These changes in composition had a substantial impact on the fluctuations of investment in infrastructure. This impact has been analyzed by isolating the cyclical component of the series through the application of the Hodrick-Prescott Filter to its logarithm, and by comparing it with the cyclical component of Spanish GDP and industrial production during the period 1850-1935. Figures 7 and 8 show the 20-years moving correlation coefficients between the cyclical components of the two output variables and that of investment in infrastructure one year before, over the same year and one year later.

Fig. 7. Comovements of GDP and infrastructure investment (1850-1935)

Source : Prados de la Escosura (2003) and my own figures.

Fig. 8. Comovements of industrial production and infrastructure investment (1850-1935)



Source : Prados de la Escosura (2003) and my own figures.

According to the graphs, the association between the cyclical component of investment in infrastructure and production is always higher when the infrastructure variable is taken one year later than the output variable. The strong association between the main variables of the economy and gross investment in infrastructure in the following year indicates that fluctuations of the latter followed the movements of the rest of the economy with some time lag. Apparently, during the period of study, episodes of high economic growth fostered investment in infrastructure. This situation might have been the result of Wagner's Law, i.e. the impact on infrastructure of the increase in the financial capacity of investors (and, especially, of the public sector) due to economic growth, and also might reflect reactions to the upsurge of bottlenecks, resulting as well from the growth of the economy.

The described relationship was especially intense from the 1890s onwards. By contrast, investment in infrastructure was much more independent of the fluctuations of the rest of the economy between the late 1870s and the early 1890s. This would be consistent with the extreme importance of railroad investment during those years. Unlike other sorts of infrastructure, railroads were large-scale projects of inter-regional scope and, therefore, their degree of accommodation to the short-term fluctuations of the economy was relatively low. The construction of railroads took a relatively long time, and the bottlenecks that they were intended to break up had a much more structural and long-term nature than in the case of other types of infrastructure. As a consequence, railroad construction cycles were to some extent self-sustained and did not adapt well to the global fluctuations of the economy. The peculiar behavior of railroad investment fluctuations has been pointed out for numerous countries, and has been explained on the basis of technology, but also because of political factors and the railroad companies' strategic behavior within the railroad oligopoly.[39]

By contrast, during the first third of the twentieth century, the change in the composition of investment in infrastructure and the decline in the importance of the railroads meant a better adaptation of infrastructure capital formation to the immediate needs of the economy. After the mid 1890's, the amounts involved in each project were much smaller, and the link between infrastructure assets and production activities was much closer than in the previous period.

The diversification of investment from the 1890's onwards was the consequence of several factors, such as: the virtual completion of the railroad network;[40] the Spanish State's growing economic activity as reflected in the increase of public work construction; and a number of technological changes, such as technical advances in the long distance transmission of electricity, or in telecommunications. In fact, the maximum development of these three aspects arrived in

the last investment cycle of the period under study, i.e. under Primo de Rivera's Dictatorship and the Second Republic (1923-1936). During those years, diversification of investment reached its zenith, both in the case of public capital formation (with increasing resources devoted to roads, ports and hydraulic works) and private investment (in particular energy distribution, urban transport and telecommunications). The coincidence of the State's activism with the dynamism of private investment resulted in very high percentages of the GDP being spent on infrastructure capital formation, up to a level of 2.5 percent in 1929.

The exceedingly high volume of resources invested in infrastructure during the 1920's may explain a unique feature of the cyclical behavior of gross investment in infrastructure during those decades. As may be seen in Figures 7 and 8, the correlation between production and lagged investment in infrastructure before the 1920's was rarely significant, which might be interpreted as evidence of the minor influence of the elimination of bottlenecks by infrastructure, and of the irrelevance of its short-term "backward effects" on the evolution of the Spanish economy. However, during the 1920's and 1930's, fluctuations of infrastructure preceded fluctuations of industrial production. This change would be consistent with the considerations of some historians on the importance of public investment in the evolution of the Spanish industrial sector during those years. Jordi Palafox, for instance, has indicated that the military regime established in the country in 1923 was very sensitive to the interests of heavy industry, which had suffered an intense oligopolisation process in the previous period. As a consequence, during the dictatorship of 1923-1930, public investment in certain sorts of infrastructure (such as the railroad and road systems and hydraulic works) was four times as large as in the years between 1917 and 1923, and became essential for the growth of the machinery, steel and concrete industries, for example. These would otherwise have stagnated during the period, since the deep

structural problems of the Spanish agrarian sector substantially reduced the growth prospects of domestic markets. [41]

b. The Spanish infrastructure stock

As a consequence of the process of investment that has just been described, the Spanish endowment of infrastructure experienced a substantial growth during the period under analysis, which can be seen in Figure 2. The infrastructure stock grew at a yearly rate of 3.3 percent and, as a result, in 1935 it was 32 times larger than it had been in 1845. Figure 2 also shows that periods of intense growth of the stock, which were associated with episodes of high investment (such as the railroad mania of 1855-1866, or the 1920's), alternated with long periods of slow growth.

Table 4 shows the changes in the composition of Spanish infrastructure stock between 1845 and 1935. These changes are the direct result of the evolution of investment. Concretely, they reflect the concentration of investment efforts in railroads and roads up to 1895. By contrast, after that year, and due to the diversification of investment in infrastructure, railroads gradually lost importance within the total stock, to the advantage of ports, energy distribution networks, hydraulic works, telecommunications and urban transport, which had absorbed negligible amounts of resources during the second half of the nineteenth century.

Table 4. Spanish net infrastructure stock (1845-1935)

A) Composition of the stock (%)

	Railroads	Urban Transport	Roads	Ports	Telecom.	Energy Distribution	Hydraulic Works	Total
1845	1.16	0.00	82.17	5.79	0.00	0.10	10.78	100
1855	26.75	0.00	57.20	4.40	0.10	0.34	11.21	100
1865	63.18	0.00	26.92	4.20	0.38	0.20	5.13	100
1875	60.53	0.00	28.76	5.47	0.31	0.35	4.58	100
1885	62.71	0.08	28.22	4.28	0.32	0.73	3.66	100
1895	63.02	0.35	26.09	5.52	0.55	1.08	3.38	100
1905	58.58	1.68	25.65	7.89	0.47	1.80	3.93	100
1915	51.36	1.77	25.51	10.51	0.78	4.50	5.57	100
1925	42.98	4.10	24.81	9.98	1.31	10.37	6.46	100
1935	33.41	3.63	28.31	10.04	4.18	11.40	9.02	100

B) Yearly growth rates of the stock (%)

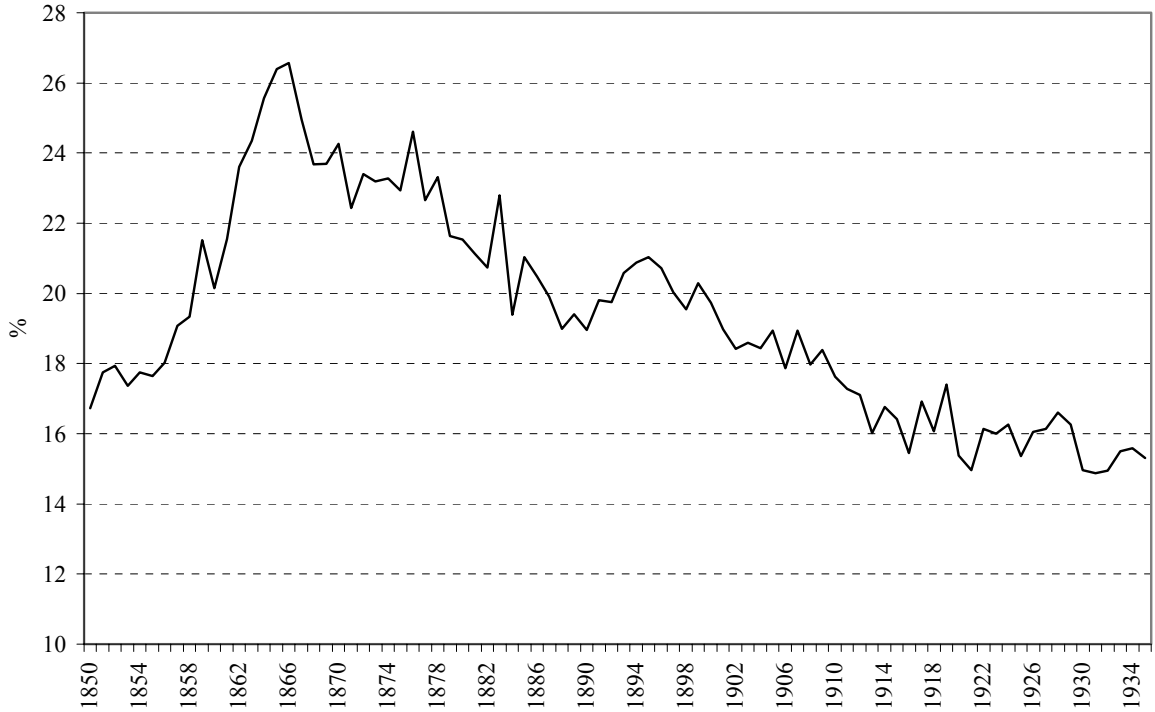
	Railways	Urban Transport	Roads	Ports	Telecom.	Electricity	Hydraulic Works	Total
1845/95	11.14		3.35	5.66		9.35	2.60	5.82
1895/1935	0.37	7.91	1.81	3.38	6.80	8.67	3.97	1.87
1845/1935	**4.25**		**2.32**	**4.39**		**8.45**	**2.73**	**3.25**

Sources: see the Appendix.

Note: Stock growth is expressed in annual accumulative rates, adjusted to a log trend. As a consequence, rates for the whole period are not the same as the average of those for shorter periods.

Figure 9 shows the evolution of the ratio between infrastructure stock and the total Spanish capital stock during the period under study. It clearly shows the effects of the huge investment efforts of the years between 1855 and 1866, which increased the percentage from around 18 percent to more than 25 percent. Later on, this percentage started to decrease, in a process that would continue until the Civil War. At the beginning, the reduction in the importance of infrastructure within the whole Spanish capital stock that took place after 1866, just reflected the return to normality after the excess investment of the railroad mania. However, once the stock reached the percentage level of the years before 1855 the decline did not stop. In fact, from the final years of the nineteenth century onwards, the reduction in the ratio seems to be a consequence of the diversification of the Spanish total investment and the increasing use of machinery and equipment in a growing number of sectors.

Fig. 9. Spanish infrastructure stock/total capital stock (1850-1935)



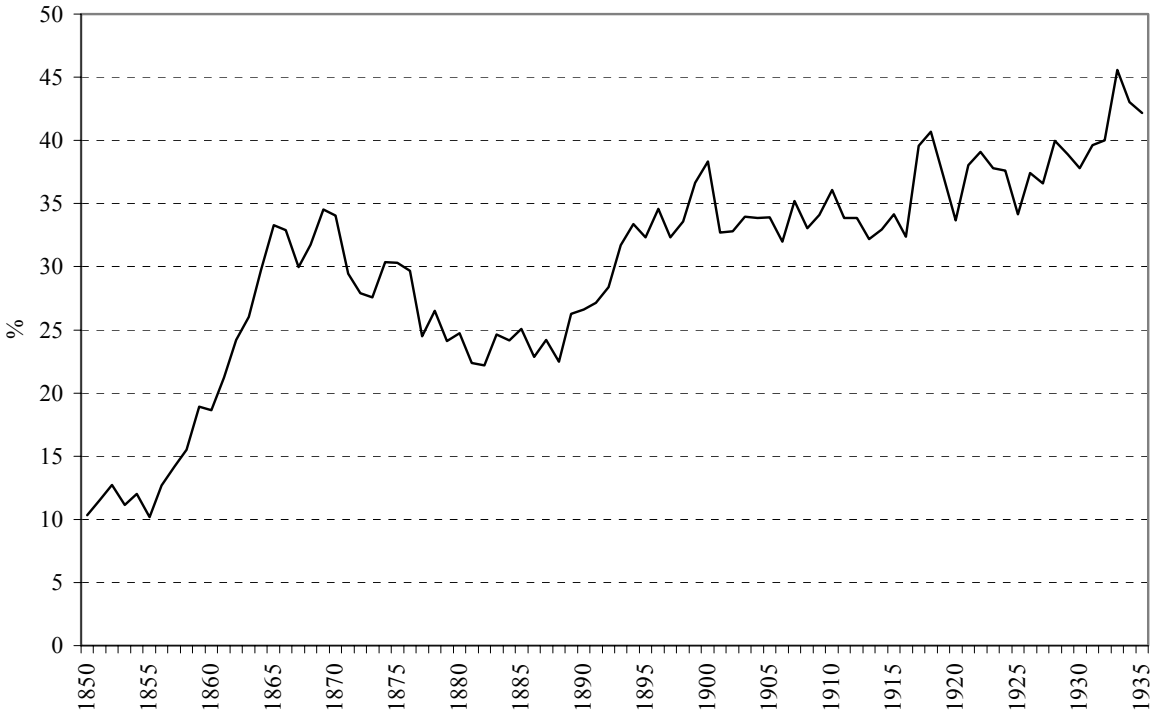
Source : Prados de la Escosura and Rosés (2003) and my own figures.

From a comparative point of view, the percentages that are reproduced in Figure 9 are similar to those of other economies during the period, such as Germany (between 1850 and 1930) or Japan and the Soviet Union (in the Inter-war period), where they fluctuated between 14 and 20 percent. By contrast, the Spanish percentages were lower than those of the UK (20-25 percent) or Italy (26-29 percent) during the same period.[42]

The relationship between infrastructure stock and GDP provides a first approximation to the relative abundance or shortage of infrastructure in Spain during the period under study. The evolution of this percentage is reported in Figure 10, which shows its gradual growth from levels of about 10 percent in the mid-nineteenth century to levels above 40 percent on the eve of the Civil War of 1936. However, this increase was not a steady one. As could be expected, growth

was steep during the years of the railroad mania, reaching levels close to 35 percent, but it was abruptly interrupted in 1866, and from this date to the mid-1890's, percentages fluctuated between levels of 20 to 35 percent. Growth only resumed in the last decades of the period, and during the 1930's the ratio reached levels of over 40 percent.

Fig. 10. Spanish net infrastructure stock/GDP (1850-1935)



Source : Prados de la Escosura and Rosés (2003) and my own figures.

How do these percentages look in an international context? It is difficult to answer this question, since the comparison among historical infrastructure endowments of different countries is rather difficult. This is due to the extreme paucity of infrastructure stock estimates, and the fact that the available figures are hardly comparable because of differences in definitions and in estimation techniques. In this context, Table 5 is just a preliminary attempt to carry out that comparison for a few economies for which appropriate information is available.

Table 5. Net Infrastructure Stock/GDP in different countries (1850-1930, %)

	1850	1860	1870	1880	1890	1900	1910	1920	1930
Spain	**10.33**	**18.65**	**34.07**	**24.75**	**26.61**	**38.31**	**36.06**	**33.68**	**37.80**
Netherlands	29.11	29.34	37.86	38.72	39.32	31.72	30.27	na	na
UK	43.50	44.90	46.30	47.94	49.33	46.74	48.21	44.89	38.93
Japan	na	na	na	na	19.41	25.26	30.51	32.50	42.75
Italy	na	na	na	na	71.63	74.68	72.21	64.40	65.55
USSR	na	na	na	na	Na	na	na	na	17.15[a]
US	na	na	na	na	Na	na	na	na	68.62[b]

Sources:
Spain: GDP from Prados de la Escosura (2003) and my own infrastructure stock figures.
Netherlands: Groote (1996), Maddison (1995) and Centraal Bureau voor de Statistiek (1994).
UK: Capital stock from Feinstein (1965), (1972) and (1988), and GDP from Deane (1968) and Maddison (1995).
Japan: Capital stock from Ohkawa et al (1966) and GDP from Ohkawa et al (1974).
Italy: Rossi et al (1993).
US: Bureau of Economic Analysis, in *http://www.bea.doc.gov*.
USSR: Moorsteen and Powell (1966, p. 50).
Notes: na: not available; (a) in 1928; (b) in 1929.

According to the table, the endowment of infrastructure in industrialized countries stood between 30 and 50 percent of GDP during the second half of the nineteenth century and the first decades of the twentieth century, although, in a few cases, such as Italy and the US, it might have reached even higher levels. In this context, the growth of the Spanish infrastructure as a percentage of GDP constituted a process of convergence with the situation in more advanced economies. However, that convergence process, as has been said, was not continuous, but experienced a one-time boost in 1855-1866 and, later on, a long stagnation until the last few years of the nineteenth century, when it gradually resumed.

As a result of this convergence process, by the end of 1935 Spain had an infrastructure endowment that was acceptable from a comparative point of view, and had been obtained through several decades of substantial investment efforts. The country, however, still suffered from serious shortages in certain areas. For instance, it still lacked a national electricity network, suffered from a serious scarcity of secondary roads, and the density of its railroad network was

rather low in the European context.[43] However, its endowment of social fixed capital was relatively acceptable in many other areas. Unfortunately, the Civil War and the post-war period introduced a violent break in the previous convergence trend, which would open up a huge gap between Spain and the advanced economies. Afterwards, several decades would again be necessary to reduce the distance.

V. CONCLUSIONS

This paper presents new estimates of Spanish infrastructure stock and investment for the period 1845-1935. The new series are intended to provide quantitative information about one of the key factors in Spanish economic growth during the first stages of industrialization. Although some measurement of State capital stock had already been undertaken by other scholars, this research is the first systematic attempt to estimate the value of the entire Spanish infrastructure. A variety of sources and techniques has been used in the estimation, and the new series may be accepted as reasonably reliable to the standards of historical statistics, with the possible exceptions of some minor infrastructure sectors, such as non-public railroads, the telegraph and gas distribution networks, the stock of Spanish canals and urban infrastructure. Thanks to the new series, a nearly complete picture of the process of development of Spanish infrastructure between the mid-nineteenth century and the present is available.

The new quantitative evidence reflects a constant and sustained effort of improvement and enlargement of the Spanish infrastructure endowment throughout the 1845-1935 period. Although investment in infrastructure was characterized by intense fluctuations, especially during the early and final years of the period under study, it is not possible to confirm the presence of structural breaks in the series that could have interrupted or substantially altered its

long-term growth. Broadly speaking, two distinct periods may be distinguished in the evolution of Spanish infrastructure. On the one hand, the second half of the nineteenth century was characterized by the prominent role of railroads, which accounted for exceedingly high shares of total infrastructure investment. On the other hand, from the last few years of the nineteenth century onwards, railroad capital formation stagnated due to the virtual completion of the main network, and the majority of investment in infrastructure was then addressed to other assets such as roads, ports, electricity distribution and hydraulic works.

The new series allow a very preliminary comparison of Spanish infrastructure endowment with that of other advanced economies of the time. Between the mid- nineteenth century and the eve of Spain's Civil War, the ratio between Spanish infrastructure stock and the GDP undertook a substantial growth process, and converged with the levels experienced in other industrialized countries. That convergence, however, was highly concentrated in certain periods, such as the railroad mania of 1855-1866, and the Inter-war years. The next question to answer in this context, is to what extent the relative shortage of infrastructure during most of the period under study might have been one of the factors to blame for Spain's lack of convergence before the Civil War. Although this problem has been considered by historians for decades, the new series allow for a more systematic approach and for the application of econometric techniques to address the issue. This task will indeed be undertaken in further research.

ACKNOWLEDGMENTS

I wish to thank Dudley Baines, Isabel Bartolomé, Ángel Calvo, Albert Carreras, Nicholas F. R. Crafts, Eloy Fernández Clemente, Pedro Pablo Ortúñez, Pere Pascual, Leandro Prados de la Escosura, Joan Ramon Rosés, Carles Sudrià and an anonymous referee for their generous help

and valuable contributions to this research. I gratefully acknowledge financial support by the British Council, the Economic and Social Research Council, and the Spanish *Banco de España*, *Ministerio de Educación y Cultura* (BEC2002-00423) and *Generalitat de Catalunya*.

APPENDIX

Table A1. Spanish Gross Infrastructure Investment, 1845-1935 (millions of 1890 pesetas)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1845	1.41					2.40	0.33	0.07	0.40			0.10		0.60	1.06	**6.37**	**6.47**
1846	1.95					2.40	0.33	0.07	0.34			0.09		0.11	1.06	**6.35**	**6.43**
1847	3.12					3.17	0.39	0.09	0.36			0.07		0.11	1.06	**8.37**	**8.44**
1848	4.92	0.25				5.13	0.55	0.12	0.44			0.06		0.15	1.06	**12.68**	**12.74**
1849	7.57	0.57				7.69	0.76	0.17	0.56			0.01		0.29	3.13	**20.74**	**20.74**
1850	10.36	0.64				9.46	0.90	0.20	0.75			0.07		0.29	3.13	**25.79**	**25.86**
1851	12.73	0.65				11.86	1.09	0.24	0.85	0.08		0.13		0.22	3.13	**30.98**	**31.11**
1852	14.11	0.67				14.13	1.28	0.28	1.10	0.08		0.20		0.22	3.13	**35.21**	**35.40**
1853	14.85	0.41				11.93	1.09	0.24	1.54	0.08		0.21		0.22	3.13	**33.71**	**33.91**
1854	16.68	0.09				9.80	0.93	0.20	1.22	0.08		0.23		0.40	3.13	**32.78**	**33.00**
1855	18.72	0.03				12.75	1.16	0.26	1.27	0.08		0.25		0.40	3.13	**38.06**	**38.30**
1856	19.96	0.01				9.35	0.99	0.21	2.12	0.77		0.23		0.40	3.17	**37.22**	**37.44**
1857	32.68					11.31	1.02	0.23	1.27	1.08		0.23		0.40	5.52	**53.73**	**53.95**
1858	48.99	0.04				14.25	1.06	0.26	1.63	1.09		0.19		0.40	5.52	**73.44**	**73.62**
1859	87.88	0.38				8.70	1.10	0.30	2.42	0.46		0.29		0.05	2.64	**104.21**	**104.49**
1860	113.53	0.69				13.43	1.14	0.21	2.80	0.31		0.28		0.05	2.64	**135.06**	**135.33**
1861	131.05	0.69				26.53	1.18	0.21	3.73	0.46		0.21		0.05	2.92	**167.02**	**167.22**
1862	133.48	0.69				27.93	1.23	0.22	4.66	0.59		0.13		0.05	2.92	**171.90**	**172.02**
1863	118.79	0.96				24.07	2.82	0.22	9.70	0.58		0.14		0.05	2.92	**160.24**	**160.37**
1864	97.30	1.33				23.02	3.08	0.23	9.74	0.39		0.27		0.05	2.92	**138.32**	**138.58**
1865	60.72	1.42				17.70	3.38	0.24	7.36	0.17		0.25		0.05	2.92	**94.18**	**94.42**
1866	30.01	1.45				11.57	3.70	0.26	4.87	0.01		0.29		0.05	2.88	**55.08**	**55.36**
1867	13.84	1.49				12.27	1.84	0.23	2.98	0.04		0.21		0.05	0.53	**33.49**	**33.69**
1868	5.97	1.19				14.92	1.92	0.24	3.47	0.06		0.31		0.05	0.53	**28.66**	**28.95**
1869	9.11	1.20				11.35	1.99	0.25	2.42	0.14		0.32		0.05	0.53	**27.37**	**27.68**
1870	9.57	1.80				8.15	0.42	0.25	1.73	0.11		0.33		0.05	0.53	**22.96**	**23.27**

Table A1. Spanish Gross Infrastructure Investment, 1845-1935 (millions of 1890 pesetas) (continued)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1871	10.59	2.06				10.23	0.42	0.26	3.29	0.10		0.52		0.05	0.26	**27.79**	**28.29**
1872	11.40	2.13	0.12			9.37	0.42	0.27	3.58	0.02		0.59		0.05	0.26	**28.23**	**28.79**
1873	20.58	2.68	0.24			7.78	2.66	0.33	1.13	0.01		0.54		0.19	0.26	**36.40**	**36.91**
1874	33.72	2.60	0.36			5.52	2.80	0.34	5.39	0.15		0.43		0.27	0.26	**51.83**	**52.24**
1875	37.04	1.78	0.47			7.40	2.94	0.35	4.64	0.33		0.52		0.47	0.26	**56.21**	**56.71**
1876	29.14	1.50	0.24			11.66	3.10	0.36	0.60	0.72		0.91		0.47	0.26	**48.96**	**49.83**
1877	25.20	1.73	0.01			13.60	3.26	0.37	0.64	0.67		1.35		0.47	0.26	**47.56**	**48.85**
1878	50.53	1.51	0.09			14.47	3.44	0.39	0.64	0.51		1.15		0.61	0.26	**73.61**	**74.70**
1879	61.97	1.73	0.28			17.05	3.62	0.40	0.81	0.23		0.83	0.70	0.68	0.26	**88.55**	**89.34**
1880	69.70	2.84	0.27			14.80	3.81	0.41	1.20	0.16		0.36	0.76	0.87	0.26	**95.46**	**95.80**
1881	57.48	3.84	0.09	0.36		16.69	4.01	0.43	1.06	0.24		0.76	0.83	0.87	0.82	**87.48**	**88.20**
1882	58.66	5.32	0.14	1.12		33.09	4.83	0.28	0.89	0.25		1.20	0.20	0.87	0.82	**107.67**	**108.82**
1883	51.65	6.67	0.28	0.36		19.09	3.47	0.02	1.14	0.29		1.48	0.21	0.62	0.82	**86.10**	**87.51**
1884	39.24	6.74	0.15	0.76		19.30	2.52	0.22	2.74	0.33		1.62	0.23	0.46	2.62	**76.93**	**78.47**
1885	30.59	6.32	0.05	0.03		17.20	7.95	0.64	6.01	0.37	0.05	1.40	0.25	0.10	2.72	**73.69**	**75.02**
1886	23.89	6.77	0.41	0.14		21.29	6.87	1.40	3.47	1.75	0.05	0.97	0.27	0.11	2.89	**70.26**	**71.19**
1887	25.27	7.23	0.76	0.16		25.28	2.07	0.26	4.18	2.04	0.21	1.15	0.30	0.18	2.81	**71.91**	**73.01**
1888	30.88	8.53	0.60	0.27		23.21	0.13	0.03	4.02	2.00	0.26	1.91	0.32	0.19	2.95	**75.31**	**77.12**
1889	39.97	11.52	0.61	0.39		19.28	0.13	0.03	3.73	0.83	0.21	1.99	0.35	0.19	2.85	**82.09**	**83.98**
1890	49.83	13.99	0.89	0.76		17.32	0.13	0.03	4.43	1.04	0.09	1.57	0.35	0.22	2.60	**93.25**	**94.75**
1891	64.76	15.87	1.08	2.38		15.43	4.19	0.43	13.64	1.15	0.07	1.36	0.52	0.25	2.05	**123.18**	**124.48**
1892	69.07	15.97	1.27	2.74		15.03	4.35	0.44	10.94	1.25	0.40	1.63	0.61	0.33	1.76	**125.78**	**127.33**
1893	65.25	13.62	1.49	0.32		15.96	1.13	0.72	9.54	0.91	0.33	1.63	1.24	0.36	1.91	**114.42**	**115.97**
1894	68.92	10.35	1.76	0.50		14.88	1.14	0.75	10.61	0.75	0.35	0.91	2.00	0.39	2.47	**115.79**	**116.27**
1895	59.14	7.82	2.07	1.97		17.13	1.16	0.50	12.26	0.36	0.44	0.98	2.87	0.37	3.08	**110.15**	**112.02**
1896	44.59	5.58	2.44	2.97		18.71	1.17	0.51	12.26	0.12	0.07	1.24	3.18	0.40	3.19	**96.42**	**99.25**
1897	16.47	4.41	2.28	4.11		18.39	0.60	0.06	16.01	0.09	0.08	1.30	2.99	0.25	3.25	**70.29**	**74.20**
1898	19.41	5.04	1.46	2.27		14.72	0.60	0.06	14.25	0.11	0.12	0.84	2.65	0.18	2.66	**64.37**	**66.53**

Table A1. Gross Infrastructure Investment, 1845-1935 (millions of 1890 pesetas) (continued)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1899	25.01	7.54	1.10	2.65		12.98	2.52	0.06	11.00	0.24	0.16	0.43	2.86	0.23	1.64	**68.42**	**70.95**
1900	25.99	11.99	1.26	7.72		9.21	2.57	0.06	9.33	0.21	0.25	0.52	4.49	0.34	2.81	**76.75**	**84.09**
1901	23.18	14.89	1.33	18.11		9.09	2.62	0.35	8.88	0.23	0.17	0.91	4.31	0.41	2.96	**87.44**	**104.69**
1902	23.65	15.27	1.33	6.86		13.04	2.67	0.36	10.30	0.13	0.20	1.35	3.14	0.44	4.47	**83.21**	**89.75**
1903	23.42	15.02	1.33	3.76		14.82	2.72	0.73	9.89	0.09	0.20	1.33	1.72	0.56	4.69	**80.29**	**83.87**
1904	14.70	12.89	1.33	2.45		10.06	2.78	0.75	11.69	0.22	0.41	1.73	3.68	1.00	5.77	**69.47**	**71.81**
1905	8.94	8.36	1.33	4.91		16.12	2.83	0.78	13.53	0.42	0.66	1.28	5.04	1.06	5.82	**71.11**	**75.79**
1906	6.92	5.38	1.39	3.46		12.16	2.89	0.81	16.39	0.87	0.52	1.96	4.83	1.64	4.54	**63.78**	**67.07**
1907	9.30	6.29	1.52	6.82		14.14	2.95	0.84	17.96	0.78	0.77	2.20	3.64	2.67	3.33	**73.21**	**79.70**
1908	14.00	7.42	1.66	8.71		15.32	3.00	0.76	20.67	0.77	1.00	2.81	3.16	2.86	3.80	**85.95**	**94.25**
1909	20.58	7.29	1.79	1.51		18.01	3.06	0.79	18.16	1.02	1.03	2.49	7.40	3.65	4.28	**91.06**	**92.50**
1910	22.81	11.43	1.53	2.51		21.21	0.92	0.81	16.26	0.98	1.04	1.75	6.95	3.54	3.58	**95.33**	**97.72**
1911	26.11	14.63	0.84	2.31		20.65	0.93	0.84	16.23	1.06	1.36	0.97	8.26	4.20	3.30	**101.68**	**103.88**
1912	36.13	12.61	0.49	4.61		20.12	0.63	0.87	16.95	0.64	2.01	1.31	5.43	5.42	6.72	**113.93**	**118.32**
1913	30.02	10.92	0.50	0.74		21.78	0.63	0.90	14.08	0.94	1.24	2.19	24.47	6.40	7.94	**122.76**	**123.46**
1914	27.63	9.88	0.50	1.72		21.09	0.63	0.93	15.75	0.89	1.32	2.98	25.71	5.72	7.41	**122.16**	**123.79**
1915	11.08	7.76	0.45	3.97		19.97	0.64	0.96	12.42	0.87	1.61	2.57	29.84	6.07	7.17	**105.37**	**109.15**
1916	21.54	5.61	0.33	11.84		19.45	0.64	0.99	7.83	2.08	4.37	2.23	25.63	5.85	5.39	**113.77**	**125.05**
1917	20.50	5.49	0.27	5.93	2.70	16.26	1.78	4.02	7.96	2.33	2.80	1.78	30.06	4.49	2.74	**109.12**	**117.34**
1918	2.47	6.38	0.27	1.71	5.41	11.46	4.39	1.83	6.97	2.33	3.16	1.63	26.81	5.60	0.76	**81.17**	**87.95**
1919	0.88	7.34	0.27	1.48	4.06	11.80	1.47	2.36	8.48	1.20	3.34	0.91	25.71	5.44	5.01	**79.74**	**85.02**
1920	2.04	9.42	0.27	3.79	2.72	13.84	1.48	2.51	8.93	1.57	1.38	0.98	28.12	6.27	5.49	**88.79**	**94.99**
1921	20.31	8.89	0.20	10.41	3.08	16.70	1.49	2.68	10.45	1.78	0.99	1.24	36.18	6.32	8.29	**129.00**	**141.85**
1922	27.63	6.51	0.12	12.91	8.40	19.59	1.50	2.85	9.67	1.87	1.37	1.30	39.64	7.46	4.35	**145.18**	**165.48**
1923	31.69	6.85	0.10	10.94	14.55	21.91	1.51	3.04	10.96	1.30	1.47	0.84	45.27	7.21	2.88	**160.51**	**184.78**
1924	37.52	7.45	0.15	8.00	13.64	19.36	1.53	3.24	11.35	0.96	0.97	0.43	48.73	13.02	0.91	**167.28**	**187.89**
1925	39.47	6.75	0.20	23.77	8.61	43.37	5.99	4.89	11.72	0.36	10.71	0.52	71.97	10.85	1.85	**241.04**	**271.88**
1926	43.80	4.87	0.10	19.27	2.84	84.47	6.19	5.34	9.70	0.12	20.54	0.91	70.54	11.83	3.60	**284.13**	**305.18**

Table A1. Spanish Gross Infrastructure Investment, 1845-1935 (millions of 1890 pesetas) (continued)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1927	52.55	8.18	0.01	11.30	2.41	76.78	6.46	5.85	28.26	0.24	18.72	1.35	67.19	12.83	4.84	**296.97**	**310.02**
1928	62.32	6.74	0.04	6.60	4.82	75.66	6.83	6.42	28.33	0.36	11.46	1.33	62.70	14.63	6.11	**294.34**	**305.21**
1929	57.69	1.24	0.12	2.76	2.41	74.65	7.26	7.06	30.25	0.64	73.77	2.06	51.81	15.23	6.61	**333.54**	**338.46**
1930	50.24	2.02	0.12	6.36	2.97	79.52	7.63	7.73	8.69	0.47	39.56	2.61	47.55	16.63	13.12	**285.22**	**294.10**
1931	38.03	2.38	0.04	5.63	6.48	72.82	8.06	8.48	8.23	0.41	50.14	4.24	12.73	15.80	16.52	**249.99**	**261.53**
1932	30.52	2.51	0.06	8.56	4.30	41.84	1.60	9.96	8.84	0.19	6.11	4.61	21.11	13.29	10.25	**163.73**	**175.98**
1933	18.52	2.44	0.12	11.78	1.06	47.53	16.45	9.49	30.45	0.18	1.70	4.60	31.49	11.13	36.06	**222.99**	**235.21**
1934	8.77	2.17	0.06	9.89	1.36	43.78	0.93	8.31	38.21	0.41	5.04	3.83	41.78	9.89	42.09	**216.53**	**227.25**
1935	4.71	1.56	0.02	2.51	2.20	44.36	2.76	8.71	30.27	0.66	10.44	2.32	30.63	6.92	36.34	**184.42**	**188.91**

Note: as is indicated in the text, for broad gauge railroads, State's roads and ports, investment figures have been estimated directly from information on capital formation flows. In all other cases, they have been calculated on the basis of gross stock estimates (see the estimation method in Section II above). The price index that has been used to deflate the available investment series (in the cases of broad gauge railroads, State's roads and ports), or to express in 1890 pesetas the stock and investment indices estimated on the basis of physical indicators (in all other cases) is the deflator for "Other construction" investment, which has recently been estimated by Leandro Prados de la Escosura (2003).

Sources:

a) For broad gauge railroads, the main source of information is a sample of capital accounts of railroad companies. Investment data has been collected for *Compañía de Caminos de Hierro del Norte de España*, from Tedde (1978, pp. 264-290); *Compañía de los Ferrocarriles de Madrid a Zaragoza y a Alicante (MZA)*, from the company's yearly accounts; most broad gauge Catalan companies (before their absorption by *MZA*), from Pascual (1999); *Compañía del Ferrocarril de Tudela a Bilbao*, from Ormaechea (1989, p. 18); and *Compañía de los Ferrocarriles Andaluces*, *Compañía de los Caminos de Hierro del Sur de España* and *Compañía de los Ferrocarriles de Madrid a Cáceres y Portugal (y del Oeste de España)*, from the companies' yearly accounts and Ortúñez (1999). The share of land and rolling stock within investment has been calculated from information in *MZA*'s yearly accounts, Alzola (1884/1885, 33, p. 228), Hernández (1983), Tedde (1978, pp. 264-290), and Pascual (1999). The average unit cost coming from this sample of companies (which accounted for more than 80 percent of the broad gauge network during most of the period under study) has been applied to the rest of the network, whose mileage has been taken from Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1860-1924) and Wais (1987).

b) For narrow gauge railroads, average unit cost per km of electrified and non-electrified line has been estimated on the basis of a large sample of companies' capital accounts in 1922 (corresponding to 89% of the network), which is available in Spain, Ministerio de Fomento, *Estadística de Obras Públicas* (1922). The share of land and rolling stock within investment has been estimated on the basis of Alzola (1884/1885). Unit cost figures have been applied to each year (electrified and non-electrified) mileage, which has been estimated from Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1860-1924), *Anuario de Ferrocarriles de D. Enrique de la Torre* (1922-1935), and Olaizola (2003, pp. 16-18).

c) For non-public railroads, yearly mileage in operation has been estimated on the basis of Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1874-1924) and *Anuario de Ferrocarriles de D. Enrique de la Torre* (1922-1935), and average unit cost has been taken from Alzola (1884/1885, 33, p. 228).

d) For tramways, average unit cost per km of horse, steam and electricity-drawn lines has been estimated on the basis of a large sample companies' capital accounts in 1907, which is available in Spain, Ministerio de Fomento, *Estadística de Obras Públicas* (1907). The share of rolling stock has been taken from Gil Carretero (1968, p.

462). Unit cost figures have been applied to the yearly mileage of each type of traction, which has been estimated from Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1882-1924), *Anuario de Ferrocarriles de D. Enrique de la Torre* (1893-1935), and Ceballos (1932, vol. 7, p. 381).

e) For the subway, average unit cost per km of line comes from Gómez-Santos (1969, p. 40), and has been applied to each year's mileage, which comes from RENFE (1958, p. 122), and Comín et al. (1998, vol. 2, p. 307).

f) For State's roads, the investment series is based on the State's expenditure on the road network from 1859 onwards, which is available in Uriol (1968). Before 1859, the average construction cost, coming from Uriol (1968), p. 414, has been applied to each year's network mileage, which has been estimated from Uriol (1992, pp. 15-16, 25 and 67).

g) For provincial roads, the average construction cost has been estimated on the basis of information on bids for road construction at the expense of the provincial institutions in 1896-1899, which comes from the *Revista de Obras Públicas* (various years). The resulting figure has been applied to each year's network mileage, which comes from Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1862-1924), and *Anuario Estadístico de España* (1931-1935).

h) For local roads, the average construction cost has been estimated on the basis of information on the State's expenses in local roads in 1911-1924, which has been taken from Gómez Mendoza (1991, p. 192). The resulting figure has been applied to each year network mileage, which comes from Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1866-1924) and *Anuario Estadístico de España* (1931-1935).

i) For ports, the basis of the investment series until 1908 is the series of port construction expenditure that is provided by Cercos (1968). For the period 1908-1935, a comparison of the physical characteristics of the Spanish ports in 1908, 1925 and 1965, taken from Spain, Ministerio de Fomento, *Estadística de Obras Públicas* (1908), Junta Central de Puertos (n.d., pp. 204-213), and Cercos (1968, p. 624), has been complemented with information on the evolution of total port expenditure of the port *Juntas* in 1908-1925, taken from Junta Central de Puertos (n.d., pp. 214-222), and the amounts allocated to port investment in the State's budget in 1925-1965, coming from Suárez de Tangil (1954, pp. 50-51), and Cercos (1968, p. 605).

j) For the telegraph system, the value of the network in 1896 has been estimated on the basis of its physical description, which comes from the *Estadística Telegráfica de España* (1896) and the unit cost of each of its components, which has been taken from De Urquijo (1968, p. 694), and López Hernández (1968). The resulting gross value has been brought backward and forward according to the network mileage, which comes from the *Estadística Telegráfica de España* (1864-1934).

k) For the telephone system from 1924 onwards, data on the nearly monopolistic *Compañía Telefónica Nacional de España*'s assets, has been taken from its yearly accounts, and this has been applied unit value figures coming from López Hernández (1968). For small companies, information has been taken from the *Estadística Telegráfica de España* (1924-1934), the yearly accounts of the company *Red Provincial de Guipúzcoa* and Echaide (1929). Before 1924, the value of the gross stock in that year has been brought backward according to the evolution of the number of networks and their subscribers, coming from the *Estadística Telegráfica de España* (1885-1924).

l) For the gas distribution network, the gross value of the stock in 1900 has been estimated from information about the companies' capital accounts in Costa (1981, pp. 49-57), and brought forward and backward according to the evolution of production, which comes from Carreras (1983, vol. 1, pp. 72-73).

m) For the electricity distribution network, the gross value of the stock in 1943 has been estimated from the information on the companies' capital accounts that is provided in Becerril (1946), and brought forward and backward according to the evolution of production, which comes from Bartolomé (1999).

n) For hydraulic works, the construction cost of each individual reservoir has been estimated from information in Garrido (1968). For other hydraulic infrastructure after 1883, the value of the State's investment in hydraulic works (net of the value of State reservoirs) has been used as a lower bound of total investment. This information is available in Mas et al. (1995, vol. 4). Before 1883, the State's role in the construction of hydraulic works was marginal and a valuation of those canals for which data are available has been used as a lower bound of the gross stock. Information about individual canals has been obtained from Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1862-1924), Bello (1914), Alzola (1979), Ceballos (1932) and Fernández Ordóñez (1986).

o) No systematic information is available on urban infrastructure. The last column of the table is just a preliminary correction of the sum of all other infrastructure, in an attempt to reduce the potential bias associated with the exclusion of urban infrastructure from the series. A lower bound of the bias in 1900-1905 has been calculated from information on local public works in Núñez (1996, p. 400), and carried forward and backward according to the evolution of urban transport investment (between 1894 and 1935) and investment in gas distribution infrastructure (between 1845 and 1894).

Table A2. Spanish Net Infrastructure Stock, 1844-1935 (millions of 1890 pesetas)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1844	0.81					147.51	7.10	1.56	10.80			0.09		2.41	16.72	**187.00**	**187.00**
1845	2.21					147.12	7.29	1.60	10.99			0.19		2.97	17.50	**189.86**	**189.96**
1846	4.11					146.73	7.48	1.64	11.12			0.27		3.03	18.26	**192.65**	**192.83**
1847	7.16					147.11	7.74	1.70	11.28			0.33		3.08	19.02	**197.41**	**197.65**
1848	11.94	0.25				149.44	8.14	1.79	11.50			0.38		3.19	19.77	**206.41**	**206.69**
1849	19.28	0.82				154.32	8.75	1.92	11.85			0.36		3.42	22.59	**223.31**	**223.58**
1850	29.27	1.44				160.90	9.50	2.08	12.38			0.42		3.65	25.38	**245.02**	**245.35**
1851	41.44	2.07				169.80	10.43	2.29	13.00	0.08		0.53		3.81	28.13	**271.60**	**272.04**
1852	54.77	2.69				180.89	11.53	2.53	13.88	0.16		0.72		3.98	30.86	**302.00**	**302.61**
1853	68.58	3.05				189.64	12.44	2.73	15.17	0.23		0.90		4.14	33.55	**330.44**	**331.24**
1854	83.98	3.09				196.16	13.18	2.89	16.14	0.30		1.10		4.48	36.21	**357.53**	**358.52**
1855	101.14	3.06				205.56	14.14	3.10	17.14	0.38		1.31		4.81	38.85	**389.48**	**390.68**
1856	119.23	3.02				211.45	14.91	3.26	18.98	1.14		1.50		5.14	41.48	**420.11**	**421.48**
1857	149.71	2.96				219.24	15.71	3.44	19.95	2.18		1.67		5.47	46.43	**466.77**	**468.30**
1858	195.95	2.95				229.87	16.54	3.65	21.28	3.20		1.80		5.79	51.33	**532.36**	**534.02**
1859	280.21	3.28				234.83	17.40	3.90	23.37	3.56		2.03		5.76	53.30	**627.63**	**629.51**
1860	388.54	3.92				244.47	18.29	4.05	25.82	3.76		2.23		5.72	55.25	**752.03**	**754.10**
1861	512.37	4.54				267.09	19.21	4.20	29.17	4.10		2.36		5.68	57.45	**906.16**	**908.36**
1862	636.24	5.15				290.86	20.16	4.36	33.42	4.57		2.41		5.64	59.62	**1,062.42**	**1,064.67**
1863	743.10	6.02				310.50	22.69	4.52	42.66	5.01		2.45		5.61	61.76	**1,204.33**	**1,206.62**
1864	826.52	7.24				328.87	25.47	4.69	51.83	5.25		2.64		5.57	63.89	**1,321.95**	**1,324.42**
1865	871.82	8.53				341.71	28.50	4.86	58.51	5.26		2.79		5.53	65.99	**1,393.49**	**1,396.11**
1866	885.57	9.81				348.27	31.82	5.05	62.64	5.10		2.98		5.50	68.03	**1,424.76**	**1,427.56**
1867	882.86	11.07				355.46	33.24	5.21	64.82	4.99		3.08		5.46	67.70	**1,433.89**	**1,436.79**
1868	872.28	12.00				365.22	34.73	5.38	67.47	4.90		3.28		5.43	67.37	**1,438.05**	**1,441.13**
1869	865.01	12.92				371.30	36.27	5.55	69.04	4.89		3.44		5.40	67.05	**1,440.89**	**1,444.17**
1870	858.42	14.43				327.50	71.48	5.73	69.91	4.85		3.61		5.37	66.73	**1,428.04**	**1,431.48**
1871	853.09	16.19				332.41	71.44	5.92	72.32	4.81		3.97		5.35	66.14	**1,431.63**	**1,435.41**

Table A2. Spanish Net Infrastructure Stock, 1844-1935 (millions of 1890 pesetas) (continued)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1872	848.66	18.03	0.12			330.17	80.64	6.10	75.00	4.69		4.39		5.32	65.56	**1,438.68**	**1,442.86**
1873	855.11	20.41	0.30			332.63	91.95	6.35	75.20	4.56		4.74		5.43	64.99	**1,461.67**	**1,466.18**
1874	875.02	22.69	0.61			333.22	94.26	6.60	79.65	4.57		5.00		5.62	64.42	**1,491.64**	**1,496.40**
1875	897.22	24.14	1.02			335.38	96.01	6.87	83.30	4.76		5.31		6.00	63.86	**1,523.87**	**1,528.92**
1876	911.29	25.31	1.35			343.45	97.64	7.14	82.87	5.34		5.98		6.38	63.31	**1,550.05**	**1,555.75**
1877	919.44	26.68	1.43			350.23	101.37	7.42	82.49	5.85		7.03		6.75	62.76	**1,571.46**	**1,578.16**
1878	954.43	27.83	1.47			358.63	104.87	7.71	82.10	6.18		7.85		7.27	62.22	**1,620.56**	**1,628.04**
1879	1,001.46	29.23	1.65			369.51	108.36	8.01	81.90	6.22		8.30	0.70	7.85	61.68	**1,684.86**	**1,692.76**
1880	1,057.59	31.73	1.90			384.92	105.28	8.32	82.09	6.20		8.25	1.44	8.62	61.15	**1,757.48**	**1,765.34**
1881	1,103.03	35.19	2.04	0.36		397.55	104.85	8.64	82.14	6.22		8.62	2.21	9.37	61.19	**1,821.42**	**1,829.63**
1882	1,150.45	40.09	2.13	1.46		438.94	92.47	8.81	82.01	6.25		9.42	2.33	10.12	61.22	**1,905.71**	**1,914.68**
1883	1,192.30	46.33	2.32	1.77		458.83	86.67	8.72	82.13	6.32		10.49	2.46	10.61	61.25	**1,970.20**	**1,980.19**
1884	1,221.25	52.59	2.50	2.46		480.16	77.94	8.83	83.85	6.42		11.61	2.60	10.94	63.09	**2,024.24**	**2,035.30**
1885	1,240.29	58.39	2.56	1.65		493.88	82.19	9.36	88.82	6.56	0.05	12.48	2.76	10.90	65.00	**2,074.88**	**2,086.76**
1886	1,251.98	64.64	2.79	1.72		508.50	87.24	10.64	91.20	7.80	0.09	12.91	2.93	10.86	67.05	**2,120.37**	**2,132.67**
1887	1,264.17	71.29	3.36	1.83		527.21	87.81	10.77	94.27	9.19	0.30	13.54	3.12	10.90	69.01	**2,166.76**	**2,179.65**
1888	1,282.35	79.13	3.99	2.03		542.98	87.16	10.66	97.13	10.47	0.55	14.90	3.33	10.95	71.09	**2,216.71**	**2,230.89**
1889	1,309.59	89.95	4.54	2.35		555.51	86.30	10.56	99.67	10.81	0.75	16.23	3.56	11.00	73.04	**2,273.87**	**2,289.33**
1890	1,341.31	102.65	5.25	3.02		566.41	85.02	10.46	102.88	11.40	0.82	17.12	3.78	11.07	74.72	**2,335.91**	**2,352.21**
1891	1,387.59	117.05	6.18	5.29		576.54	86.92	10.75	115.27	12.02	0.86	17.75	4.16	11.18	75.83	**2,427.41**	**2,444.31**
1892	1,437.61	131.36	7.29	7.84		585.63	89.23	11.06	124.82	12.67	1.23	18.64	4.62	11.37	76.64	**2,519.99**	**2,537.74**
1893	1,483.18	143.11	8.59	7.87		595.90	89.32	11.64	132.86	12.97	1.52	19.47	5.69	11.58	77.58	**2,601.28**	**2,619.82**
1894	1,531.85	151.44	10.13	8.09		605.11	89.06	12.24	141.87	13.17	1.83	19.54	7.49	11.82	79.08	**2,682.73**	**2,700.95**
1895	1,570.14	157.12	11.94	9.75		618.57	88.79	12.59	152.44	13.07	2.22	19.67	10.08	12.04	81.17	**2,759.59**	**2,778.90**
1896	1,593.43	160.49	14.07	12.36		632.49	89.39	12.95	162.89	12.79	2.22	19.99	12.89	12.28	83.35	**2,821.58**	**2,842.82**
1897	1,588.37	162.66	16.24	15.43		645.77	88.94	12.85	176.97	12.48	2.23	20.32	15.42	12.37	85.56	**2,855.59**	**2,879.74**
1898	1,586.41	165.44	17.85	16.87		654.29	88.49	12.75	189.13	12.18	2.28	20.21	17.51	12.39	87.15	**2,882.94**	**2,908.17**
1899	1,590.18	170.69	18.87	18.64		661.67	89.97	12.66	197.90	12.00	2.38	19.73	19.73	12.46	87.71	**2,914.58**	**2,941.26**

Table A2. Spanish Net Infrastructure Stock, 1844-1935 (millions of 1890 pesetas) (continued)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1900	1,594.97	180.33	19.82	25.41		664.87	91.48	12.56	204.89	11.80	2.55	19.33	23.50	12.64	89.44	**2,953.60**	**2,986.45**
1901	1,596.97	192.74	20.87	42.00		665.54	93.02	12.76	211.36	11.63	2.64	19.18	26.96	12.88	91.29	**2,999.85**	**3,048.41**
1902	1,597.77	205.14	21.94	47.34		670.14	94.60	12.96	219.17	11.40	2.76	19.30	29.12	13.16	94.63	**3,039.42**	**3,092.23**
1903	1,597.45	217.07	22.99	49.37		676.46	96.82	13.53	226.49	11.13	2.88	19.47	29.78	13.55	98.16	**3,075.14**	**3,129.17**
1904	1,587.16	226.71	24.03	50.03		679.60	96.07	14.12	235.52	10.96	3.20	20.16	32.08	14.38	102.72	**3,096.73**	**3,150.83**
1905	1,570.99	231.78	25.06	52.48		687.72	97.75	14.73	246.29	10.92	3.76	20.57	35.63	15.26	107.29	**3,120.22**	**3,176.88**
1906	1,553.46	233.84	26.11	53.45		691.96	99.47	15.36	259.80	11.17	4.17	21.48	39.08	16.71	110.52	**3,136.57**	**3,194.18**
1907	1,538.11	236.73	27.24	57.29		698.14	101.23	16.02	274.72	11.34	4.81	22.42	41.22	19.17	112.50	**3,160.95**	**3,222.50**
1908	1,524.36	240.75	28.49	63.46		705.07	103.03	16.59	292.19	11.57	5.67	23.82	42.78	21.80	114.94	**3,194.50**	**3,261.55**
1909	1,516.06	244.57	29.87	62.36		714.61	104.87	17.18	306.94	12.15	6.53	24.80	48.53	25.17	117.82	**3,231.44**	**3,296.88**
1910	1,509.39	252.38	31.13	62.48		726.63	104.55	17.78	319.62	12.69	7.37	25.10	53.61	28.41	119.97	**3,271.11**	**3,336.03**
1911	1,507.82	263.15	31.87	62.43		737.96	104.23	18.41	332.13	13.27	8.51	24.77	59.80	32.27	121.81	**3,318.43**	**3,382.82**
1912	1,516.74	271.57	32.11	64.36		749.90	103.62	19.05	345.22	13.40	10.26	24.72	62.92	37.31	127.05	**3,378.25**	**3,444.25**
1913	1,521.10	278.05	32.19	62.65		763.36	103.02	19.72	355.29	13.82	11.19	25.26	84.96	43.27	133.46	**3,447.34**	**3,510.93**
1914	1,525.12	283.40	32.29	61.84		775.95	102.43	20.41	366.91	14.16	12.17	26.54	107.45	48.48	139.26	**3,516.42**	**3,578.57**
1915	1,513.82	286.61	32.35	63.24		787.28	101.85	21.12	375.08	14.45	13.39	27.51	133.17	53.97	144.75	**3,568.61**	**3,631.69**
1916	1,514.05	287.59	32.31	71.22		797.96	101.27	21.86	378.56	15.40	17.34	28.20	153.71	59.20	148.40	**3,627.08**	**3,698.63**
1917	1,513.03	288.39	32.20	73.40	2.70	807.77	101.85	25.62	382.13	16.46	19.54	28.31	177.68	63.00	149.37	**3,681.44**	**3,757.99**
1918	1,493.50	289.93	32.06	72.29	8.09	812.96	105.03	27.14	384.67	17.50	22.00	28.27	197.23	67.86	148.34	**3,706.85**	**3,786.78**
1919	1,472.00	292.11	31.92	70.92	12.08	815.94	105.25	29.17	388.69	17.83	24.59	27.79	214.62	72.52	151.57	**3,726.99**	**3,809.11**
1920	1,451.25	296.18	31.79	71.35	14.68	820.93	105.48	31.34	393.11	18.45	25.19	27.36	233.67	77.94	155.24	**3,753.96**	**3,838.54**
1921	1,447.87	299.46	31.62	77.86	17.63	828.73	105.71	33.65	399.01	19.20	25.39	27.12	260.16	83.36	160.70	**3,817.46**	**3,910.70**
1922	1,451.53	300.30	31.35	86.17	25.87	839.33	105.96	36.11	404.05	20.00	25.83	26.91	289.28	89.85	162.80	**3,895.34**	**4,003.93**
1923	1,459.67	301.70	31.01	92.03	40.18	852.12	106.21	38.72	410.34	20.33	26.39	26.44	322.88	96.02	163.41	**3,987.45**	**4,115.51**
1924	1,473.25	303.99	30.68	95.52	53.46	862.24	106.53	41.51	416.94	20.37	26.42	25.74	358.08	103.49	162.04	**4,080.28**	**4,223.28**
1925	1,489.61	305.78	30.39	112.61	61.58	896.64	111.18	45.90	423.75	19.44	36.15	25.11	415.31	112.92	161.63	**4,248.01**	**4,413.74**
1926	1,511.55	305.87	30.13	120.62	63.86	970.77	115.98	50.69	428.50	18.92	55.57	24.75	469.49	123.42	162.97	**4,453.07**	**4,627.00**
1927	1,544.77	309.37	29.81	124.76	65.69	1,036.36	120.96	55.92	451.74	18.55	72.57	24.67	518.91	134.81	165.53	**4,674.40**	**4,852.47**

Table A2. Spanish Net Infrastructure Stock, 1844-1935 (millions of 1890 pesetas) (continued)

	Broad gauge railrd.	Narrow gauge railrd.	Non-public railrd.	Tram-ways	Sub-way	State's roads	Prov. roads	Local roads	Ports	Telegraph network	Telephone network	Gas distrib. network	Electric. distrib. network	Reservoirs	Other hydr. works	**TOTAL**	**TOTAL corrected** (inc. urban inf.)
1928	1,587.01	311.24	29.43	125.29	69.91	1,099.80	126.19	61.66	474.75	18.31	81.79	24.57	561.26	147.84	169.33	**4,888.39**	**5,069.42**
1929	1,623.49	305.14	29.09	120.90	71.68	1,160.75	131.71	67.95	499.38	18.30	153.01	25.06	590.64	161.28	172.76	**5,131.13**	**5,309.57**
1930	1,651.93	301.57	28.79	120.91	74.00	1,224.86	137.48	74.83	502.09	18.13	187.83	26.25	614.78	175.96	182.66	**5,322.08**	**5,501.06**
1931	1,667.86	298.06	28.50	120.41	79.80	1,280.85	143.54	82.37	504.27	17.90	232.20	28.76	603.69	189.67	195.85	**5,473.73**	**5,656.43**
1932	1,675.83	294.63	28.17	121.57	83.38	1,303.64	143.00	91.27	506.93	17.50	231.19	31.45	601.57	200.71	202.61	**5,533.46**	**5,719.18**
1933	1,671.39	291.27	27.85	125.48	83.68	1,332.28	157.38	99.63	531.00	17.11	225.79	33.79	608.24	209.46	235.11	**5,649.46**	**5,837.36**
1934	1,657.93	284.99	27.57	129.39	84.29	1,356.28	156.15	106.72	562.68	16.92	223.82	35.41	625.12	216.81	273.27	**5,757.36**	**5,948.57**
1935	1,641.25	281.42	27.27	126.20	85.72	1,381.63	156.67	114.11	586.04	16.90	227.21	35.75	629.73	221.11	305.25	**5,836.24**	**6,024.04**

Sources: The stock figures are the result of applying the perpetual inventory method to the investment figures in Table A1. The value of the net stock at the end of 1844 in the cases of roads, ports and hydraulic works has been estimated on the basis of Uriol (1992), Spain, Ministerio de Fomento, *Memoria(s), Anuario(s)* and *Estadística(s) de Obras Públicas* (1862-1924), Bello (1914), Alzola (1979), Ceballos (1932), Fernández Ordóñez (1986) and Cunningham (1914).

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ENDNOTES

[1] The only serious attempt to endow the country with an extensive network of highways and canals took place in the last half of the 18th century. However, by 1840 the projected radial highway system was still incomplete and none of the critical junction of the projected canals had been finished. On this subject, see Ringrose (1970, pp. 14-17) and also Madrazo (1984, pp. 162-167).

[2] See, for example, Diamond and Spence (1989); Batten and Karlsson (1996); Holtz-Eakin and Lovely (1996); and Fujita et al. (2000).

[3] According to Maddison's international database, the Spanish GDP per capita was around 60 per cent of the average income per capita of the UK, France and Germany, both by 1850 and by 1929; see Maddison (1995). Recently, Prados de la Escosura has offered an image of the Spanish relative income per capita which is slightly different than Maddison's, showing a slow long-term decline from a higher starting point; see Prados de la Escosura (2003, pp. 179-181). On the high degree of uncertainty regarding the level of Spanish income per capita in the mid- nineteenth century, see Reis (2000). Nevertheless, this author's recent alternative estimate for 1850 would not change the picture that is offered by Maddison's data very much.

[4] See the classical works by Tortella (1972, pp 118-121) and Nadal (1976, pp. 551-553) and recent research by Comín *et al.* (1998, vol. 1, pp. 140-141).

[5] See, especially, Gómez Mendoza (1983).

[6] See, for instance, the proceedings of the three Conferences on Spanish Railroad History that have taken place in the last few years (Alicante, 1998, Aranjuez, 2001 and Gijón, 2003). A

survey of the research that was carried out on the Spanish railway system up to 1998 can be seen in Gómez Mendoza (1998).

[7] The main references are shortly surveyed in Herranz-Loncán (2002), Chapter 1.

[8] See, for instance, Groote (1996, pp. 22-26). As a consequence of these definition problems, some authors renounce to define infrastructure, and describe it as, "*what most people consider it to be*"; Button (1996, p. 148). Definition problems are probably associated with the fact that infrastructure does not correspond to any of the usual national account categories; within the UN System of National Accounts, the closest category would be "Other buildings and structures", but this also includes buildings devoted to industrial and commercial uses, which cannot be considered as infrastructure; see United Nations (1993).

[9] Hirschman (1958, p. 83); Stern (1991, p. 128).

[10] Diewert (1986, pp. 3-4).

[11] See a discussion on this issue in Button (1996, p. 148-151).

[12] See, for instance, Batten (1990, p. 88).

[13] See, for example, Hansen (1965, pp. 7-12) or Aschauer (1989, pp. 193-194) and, for the Spanish case during the last few decades, Mas et al. (1996, p. 647).

[14] Hulten and Schwab (1993, pp. 271-272); Gramlich (1994, p. 1177).

[15] Mas et al. (1998).

[16] Mas et al. (1995, vol. 4).

[17] Cucarella (1999).

[18] The process of estimation of gross investment figures on the basis of physical indicators is described by Ohkawa et al (1966, p. 135), and Groote (1996, p. 95). A similar procedure for machinery is applied by De Long and Summers (1994, pp. 13-14). The definition of "new" investment that is reproduced in the text comes from Feinstein and Pollard (1988, p. 2).

[19] The data sources can also be seen in the Appendix. Actually, in a lot of cases data search was facilitated to a great extent by the pioneering research efforts carried out by Gómez Mendoza in the field of transport and communications; see Gómez Mendoza (1989b).

[20] Prados de la Escosura (2003).

[21] Escribá-Pérez and Ruiz-Tamarit (1995). Actually, as has been stressed by Hulten (1990, p. 127), a more rigorous analysis of the capital stock should consider the coefficients ϕ of efficiency decay as endogenous.

[22] See, for instance, Madrazo (1984, p. 235), or Gómez Mendoza (1989a, p. 35).

[23] Hulten (1990, pp. 124-125 and 142).

[24] The IVIE estimates are available in Mas et al. (1998). They include the following infrastructure: railroads, roads and highways, ports, airports, hydraulic works and urban infrastructure. Their coverage is therefore different from my figures, which also include energy distribution networks and telecommunications, but exclude airports. The IVIE figures have been expressed in pesetas of 1890 by applying Prados de la Escosura's deflator for "Other construction" investment, which has been taken from Prados de la Escosura (2003).

[25] The importance of the periods 1855-1866 and 1922-1929 was already stressed, from the viewpoint of total capital formation, by Carreras (1990, pp. 124-126).

[26] Yearly figures of State non-military investment in air transport since the beginning of the twentieth century are available in Mas et al. (1995). However, two reasons prevent us from using this data to estimate infrastructure stock figures. Firstly, a large share of the Spanish airport investment was not financed by the State before 1936. And, secondly, the available data includes investment in land, which accounted for a very large share of total airport investment during the first stages of the history of air transport, and must not be included in infrastructure. On these issues, see AENA (1996). Nevertheless, the exclusion of those assets from the series is not very important. For instance, for the sake of illustration, if the value of the State-owned airport assets (including land) between 1928 and 1935 is calculated, it amounts to just 0.15 percent of the total infrastructure stock.

[27] As has already been indicated, the deflator that has been used in all cases is the series that was recently estimated by Prados de la Escosura (2003) for investment in "Other construction".

[28] For instance, it has been used to obtain Spanish capital stock estimates by Cubel and Palafox (1997) and Prados de la Escosura and Rosés (2003).

[29] Feinstein (1988, p. 264). Similar margins of error are assumed by Groote in his estimation of the Dutch infrastructure stock between 1800 and 1913; see Groote (1996, p. 49).

[30] Ibidem.

[31] Vogelsang (1997).

[32] The absence of a structural break around 1854 may be surprising, given the intensity of the fluctuations of the railroad era, which are dealt with in more detail below. However, if Figure 1 is examined, the overall long term structural trend of investment does not seem to have been altered by the railroad mania. Nevertheless, the proximity of the starting point of the series prevents from drawing a final conclusion on this issue.

[33] Cubel and Palafox (1998) have searched for the presence of structural breaks before 1936 in the series of Spanish GDP, industrial production and investment, with no positive results. Pons and Tirado (2001) have analyzed Spanish GDP and GDP per capita in 1870-1994, and the earliest structural break they have found is in 1935, which is obviously associated with the impact of the Civil War. Finally, the lack of structural breaks in the series of Spanish GDP and GDP per capita before 1936 has recently been confirmed by Prados de la Escosura (2003, pp. 145-146).

[34] For the UK and the US, see Mitchell (1964), Feinstein (1972, p. 40), and O'Brien (1977, p. 55); for Germany, Fremdling (1983, p. 124), and Tilly (1978, p. 414); for Hungary, Katus (1983, p. 191); for Sweden, Hedin (1967, p. 11), and Holgersson and Nicander (1968, p. 5).

[35] See, for instance, Fishlow (1965, pp. 105-106), or O'Brien (1977, p. 57).

[36] Groote (1996, pp. 76 and 85), except for the Italian figure, which has been calculated on the basis of Rossi et al. (1993).

[37] These percentages have been calculated from Hoffman (1965), Lévy-Leboyer and Bourguignon (1990) and Rossi et al. (1993).

[38] Actually, production and distribution of electricity constituted the most important destination of capital in Spain during the first third of the twentieth century, and the paid-up capital of the electricity companies reached the same level as the capital of the railroad companies by 1921; see Bartolomé (1995, p. 109).

[39] On the independent character of railroad investment fluctuations see, for Britain, Kenwood (1965, pp. 314-319), and Hawke (1970, pp. 363-379), for the US, Fishlow (1965, p. 179), for France, Caron (1983, p. 35), for Sweden, Hedin (1967, pp. 10-11), and, for Hungary, Katus (1983, p. 191). The role of political factors on this independent behavior has been stressed by Fenoaltea (1983, pp. 53-54), and Lévy-Leboyer (1978, pp. 249-250), and the importance of the railroad companies' strategic behavior within the railroad oligopoly, has been highlighted by Harley (1982, p. 797).

[40] In 1895, 86 percent of the pre-Civil War length of the main (broad gauge) railroad network had already been open to public service.

[41] Palafox (1980, pp. 23-33); see also Palafox (1991). However, unlike this author, Comín and Martín Aceña (1984, pp. 249-258), have pointed out that the small size of the public sector during the 1920's and 1930's prevented it from being decisive in the evolution of the Spanish industry.

[42] These percentages have been calculated from the following sources: for Germany, Hoffmann (1965), for Japan, Ohkawa et al. (1966), for the Soviet Union, Moorsten and Powell (1966, p. 50), for the UK, Feinstein (1965), (1972) and (1988), and, for Italy, Rossi et al. (1993). The German percentage refers to capital figures in gross terms.

[43] Herranz-Loncán (2002), Ch. 4 and, on the absence of a national electricity distribution network, Bartolomé (2003).