UNIVERSITAT DE BARCELONA

Infrastructure and economic growth in Spain: 1845-1935

Alfonso Herranz Loncán

UNIVERSITAT DE BARCELONA

DEPARTAMENT D'HISTÒRIA I INSTITUCIONS ECONÒMIQUES

PROGRAMA DE DOCTORADO EN HISTORIA ECONÓMICA

INFRASTRUCTURE AND ECONOMIC GROWTH IN SPAIN, 1845-1935

Tesis Doctoral dirigida por el Dr. Carles Sudrià Triay
y presentada por Alfonso Herranz Loncán
para optar al título de Doctor en Economía

Barcelona, Octubre de 2002

Però solament els més joves, els infants, oblidarien completament: una part de la memòria dels altres romandria agarrada com una arrel sota les aigües del Segre i de l'Ebre. A les cambres noves, entre els mobles encara olorosos de vernís, sentirien sovint velles paraules; de les boires hivernals els arribarien clamors d'antigues tripulacions i crits d'unes altres gavines.
(…) Poc abans del tancament de les comportes del pantà de Riba-roja, la pluja va despenjar-se amb violència sobre la vila demolida i deserta.

Jesús Moncada, *Camí de sirga*, 1988

TABLE OF CONTENTS

List of Maps

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEE	Anuario Estadístico de España
AFT	Anuario de Ferrocarriles de D. Enrique de la Torre
AVT	Compañía de los Caminos de Hierro de Almansa a Valencia y Tarragona
CTNE	Compañía Telefónica Nacional de España
EACI	Estadística Administrativa de la Contribución Industrial
IVIE	Instituto Valenciano de Investigaciones Económicas
MAEOP	Memoria(s), Anuario(s) and Estadística(s) de Obras Públicas
MCPO	Compañía de los Caminos de Hierro de Madrid a Cáceres y Portugal (y del Oeste de España)
MZA	Compañía de los Caminos de Hierro de Madrid a Zaragoza y a Alicante
MZOV	Compañía de los Caminos de Hierro de Medina del Campo a Zamora y de Orense a Vigo
RENFE	Red Nacional de los Ferrocarriles Españoles
TBF	Compañía de los Caminos de Hierro de Tarragona a Barcelona y Francia

ACKNOWLEDGEMENTS

This project has been possible thanks to the support of a number of institutions, which provided financial resources during several stays in Madrid and London. I want especially to thank the British Council, *"La Caixa"*, the Economic and Social Research Council of the United Kingdom, the *Centro de Formación* of the *Banco de España*, the *Generalitat de Catalunya*, the *Ministerio de Educación y Cultura* (DGCYT projects PB94-0853, PB97-0940 and PB98-1187) and the Economic History Department of the University of Barcelona for their assistance.

My supervisor, Carles Sudrià, has been a permanent source of encouragement, intellectual challenge and enrichment, constructive criticism, support in all areas and reliability. Working with him has been an inestimable opportunity and a privilege. Thanks also to Jordi Nadal for his constant trust and support to my work, and to Germà Bel, Violeta Calderón, Albert Carreras, Jordi Catalan, Luis Germán, Antonio Gómez Mendoza, Miquel Gutiérrez, Antonio Linares, Ernest Lluch, Vicente Pinilla, Jordi Pons, Marc Prat and Enric Tello for his academic and personal help. I wish also to thank Isabel Bartolomé, Ángel Calvo, Eloy Fernández Clemente, Pere Pascual, Leandro Prados de la Escosura, Javier Silvestre and Margarita Vilar for offering me the results of their research before publication. I am especially grateful to Ramon Ramon and Daniel Tirado, who have spent long hours reading my papers and whose friendship has made a huge difference to the final result of this research.

Part of this research was carried out at the London School of Economics and Political Science. During the time I stayed there I could benefit from the support of many people. I want especially to thank Óscar Calvo González, Larry Epstein, Mary Morgan, Patrick O'Brien, Mar Rubio, Linda Sampson and Max-Stephan Schulze for their help. I am especially grateful to Nicholas Crafts and Dudley Baines for their permanent support and encouragement. All of them made the Economic History Department at LSE an exceptional environment to carry out my research.

Some of the papers that make up this thesis have already been presented in the seminars of the Economic History Departments of the London School of Economics and Political Science, and at the Universities of Barcelona, Zaragoza and Valencia, and also at the II Economic History Meeting (held in Valencia in April 1997) and the Seminar "New

Interpretations in Spanish Economic History" (held in Cuenca in July 2001). I thank the participants in those events for their comments on my research. I am also grateful to the staff of the Libraries of the *Ministerio de Fomento*, the *Ministerio de Hacienda*, the *Fundación de los Ferrocarriles Españoles*, the *Compañía Telefónica Nacional de España* and to Gaspar Martínez Lorente, director of the Library of the *Museo Postal y de Telecomunicaciones* for their assistance.

The personal support of a number of friends has been crucial during the elaboration of the thesis. Thanks to Nuria Arnal, Diana Espinosa, Antón García, Miguel Ángel González, Regina Grafe, Toby Kenyon, Elena Martínez, Mónica Martínez, Eva Rosa Muñío, José Núñez, Nacho Pascual, Isabel Sanz, Oriol Serra and, especially, to Ricard Font, for their generosity and for coming with me during this long journey.

Hidden behind the numbers of the thesis there are real people, such as my family, whose home has remained under the water of a reservoir in the Pyrenees since the 1960's, when the Francoist Dictatorship sacrificed their past to an ambiguous economic progress. This thesis is dedicated to my parents and my best teachers, Eloy Fernández, Domingo Gallego, Cristina Román and Carmelo Romero. All of them taught me that history is made, above all, of human living and suffering, and this is what makes it worth studying. I would have never embarked in postgraduate research without the stimulus of their teaching.

INTRODUCTION

This research is part of the attempts to understand the determinants of the long-run evolution of the Spanish economy during the first long stage of the industrialisation of the country. Those attempts have been aimed so far at explaining the difficulties of the Spanish economy to converge with the core European countries before 1936. As is shown by the most recent international estimates of income per capita, by the eve of the Civil War the country was probably as far from the richest European economies as it was in the central decades of the nineteenth century.[1]

In the early analyses of Spanish industrialisation, the lack of convergence with the core European countries was considered as a sign of the "failure of Spanish industrial revolution", as expressed in the title of Jordi Nadal's highly influential book. The idea of the anomalous behaviour of the Spanish economy before the Civil War, which was largely inherited from early twentieth century Spanish intellectuals (*regeneracionistas*), was based on the hypothesis that Spain was not the case of a "late joiner" but an anomalous failed attempt to be among the "first comer" industrial economies.[2] Unlike this view, further research has tended to stress the features that Spain shared with other peripheral economies, a perspective has been strongly reinforced by the recent availability of precise quantitative information about other European poor countries, which has allowed the definition of different "convergence clubs" within the continent.[3]

[1] For instance, according to Maddison's international database, the Spanish GDP per capita was slightly below 60 per cent of the average income per capita of France and the UK both by 1850 and by 1929; see Maddison (1995b). A similar picture, although at a higher percentage (ca. 70 per cent), is offered by Prados de la Escosura's alternative estimates; see Prados de la Escosura (2000). By contrast, Bairoch's previous estimates had provided a more pessimistic picture, in which Spain would gradually have lost ground with respect to the core European countries between those two dates; see Bairoch (1976). On the high degree of uncertainty regarding the level of Spanish income per capita in the middle of the nineteenth century, see Reis (2000). Nevertheless, this author's recent alternative estimate for 1850 would not change very much the picture coming from Maddison's data.

[2] Nadal Oller (1975); see especially p. 226. The idea of the "failure" of the Spanish economy was also present in Gabriel Tortella's initial research, in Tortella Casares (1973), pp. 3-4.

[3] An early attempt to include the Spanish industrialisation in a wider context can be seen, for instance, in Tortella's suggestions about the existence of a specific "Latin" or "south-western European" pattern of industrialisation, in Tortella Casares (1981b), pp. 11-15, a hypothesis that was later developed in detail in Tortella Casares (1994b). Later on, the idea of the Spanish exceptionality has been fiercely rejected by Fusi Aizpúrua and Palafox Gamir (1997), pp. 11-13, and, in the same direction, Pons Novell and Tirado Fabregat (2001) and Tirado Fabregat and Pons Novell (2001) have recently shown from a quantitative perspective that the long-term performance of the Spanish economy was not exceptional in the European context; see also Williamson (2000). A partially different view, in which the idea of exceptionality reappears, can be seen in Molinas and Prados de la Escosura (1989), and Prados de la Escosura (1992), where the lack of convergence between the Spanish economy and the "early starters", the Latin countries or the Third World is stressed.

In that context, either from a single-country point of view or from an international perspective the debate about the reasons for Spain's lack of convergence has probably constituted the most important focus of research on Spanish economic history. The central place of the debate has always been given to the attempts to explain the inability of the Spanish industry to grow and to attract active population from an agrarian sector of very low productivity, in a context in which the development of a modern industrial sector was essential to grow and converge.[4] Some interpretations, which were linked to a large extent with Jordi Nadal's early research, have insisted in a number of exogenous determinants that constrained the growth of productivity in Spanish industry and limited its development. According to that interpretation, factors such as Spanish climate and natural resources, or the highly uneven land distribution of the country, would have been responsible for keeping agrarian productivity at very low levels and for retaining a large share of active population in a sector in which wages were very low.[5] Those problems would have substantially constrained the Spanish population demand for industrial products and, due to the presence of scale economies in industry, would have undermined international competitiveness of Spanish industrial producers and would have prevented them the access to foreign markets.[6] Under those conditions, the lack of cheap coal of good quality in the country would have further constrained productivity growth in the industrial sector.[7]

Under that interpretation, the Spanish public sector would have been one of the main determinants of the failure of the economy. Its fiscal insufficiency would have prevented it from developing policies that were conducive to economic development. For instance, the way in which disentailment of the Church's properties took place, which was mainly aimed at obtaining fiscal resources, would have been detrimental to the growth of agrarian productivity.[8] And the poverty of the State would have also prevented the growth

---

[4] The different interpretations on this subject have been summarised, for instance, in Prados de la Escosura (1997), pp. 85-86.
[5] See especially Nadal Oller (1975). The importance of exogenous factors to explain the underperformance of the Spanish economy has also been stressed by Tortella Casares (1973), pp. 3-9, (1981b), pp. 12-15, (1994a), pp. 1-17, and (1994b)
[6] See especially Nadal Oller and Sudrià Triay (1993), pp. 218-220.
[7] Nadal Oller (1975), pp. 123-154. See also Sudrià Triay (1997a).
[8] This argument is summarised in Nadal Oller (1975), pp. 226-227.

of Spanish human capital endowment and would have isolated the country from the international capital markets due to the absence of monetary discipline.[9]

Those hypotheses have been challenged by other historians, who have insisted that the underdevelopment of the Spanish industry was the result of the own sector's strategy, which was much more oriented to rent-seeking at the expense of the domestic market than to compete in the international economy. The resulting high level of tariff protection, especially from the 1890's, would have prevented industrial productivity from growing and, therefore, would have hindered industrial exports and constrained the sector's size to the dimensions of the rather narrow domestic demand.[10] At the same time, tariff protection in agriculture would have also hampered productivity growth in that sector, and would therefore have helped to maintain a high share of agrarian active population that, under different conditions, would have emigrate abroad.[11]

Interestingly enough, in this alternative explanation of the Spanish lack of convergence, the poverty of the State is also identified as one of the factors responsible for the problems of the economy. If the Spanish producers' rent-seeking strategy was successful it was, among other reasons, due to the State's fiscal underdevelopment, which led it to depend strongly on tariff revenues.[12] Therefore, regarding the role of the public sector, both historiographical perspectives have offered complementary, and non conflicting, interpretations. And this is especially relevant from the point of view of the role of infrastructure in Spanish economic growth.

As is generally accepted, a sufficient endowment of physical infrastructure is one of the main prerequisites that must be available for a country to experience sustained economic growth and structural change. In the context of nineteenth and early twentieth century Spanish economy, infrastructure increases would have been absolutely essential to

[9] On the role of the Spanish State in the shortage of human capital in the country see, for instance, Tortella Casares (1994b). The negative impact of the monetary policy of the Spanish State during the gold-standard years has often been stressed by Pablo Martín Aceña; see, for instance, Martín Aceña (1981) or (1993).

[10] See, among others, Prados de la Escosura (1988), p. 175, and (1997), p. 93. That interpretation was fiercely criticised in Nadal Oller and Sudrià Triay (1993).

[11] This is one of the main hypothesis of Sánchez Alonso (1995); see also Prados de la Escosura (1997), p. 94. Recently, however, Blanca Sánchez Alonso has offered an alternative perspective, according to which agrarian tariff protection would have fostered emigration, but the income constraint of the Spanish population, which became worse at the end of the nineteenth century due to monetary depreciation, would have prevented Spanish workers from moving abroad; see Sánchez Alonso (2000c).

[12] See, especially, Fraile Balbín (1991), p. 204. By contrast, tariff protection has been seen as an second-best alternative way to promote industrial growth by Nadal Oller and Sudrià Triay (1993), p. 224. See also Carreras (1997), pp. 54-56.

unlock productivity improvements in the industrial sector. However, infrastructure growth depended to a large extent on the activity of the public sector and, as has been indicated, there seems to be unanimity on the inability of the Spanish State to perform adequate development policies during the period under study.

Accordingly, as could be expected, most interpretations on the role of infrastructure in Spanish economic growth have been highly pessimistic.[13] As is usual in international historiography, analysis on the subject have focused on railways, which was the main infrastructure asset during the period. Regarding this aspect, most historians have indicated that the poverty of the Spanish public sector was an obstacle for the establishment of an adequate railway system in Spain, and that such a failure had negative consequences on Spanish economic growth. The State's poverty and inefficiency would have resulted, firstly, in the virtual absence of backward linkages of railway construction in Spain and, most importantly, in the underperformance of the railway system once in operation. In spite of the high expectations that had risen around railway construction in the central decades of the nineteenth century, the economic impact of the railway system would have been much lower than expected due to the inadequate public regulation, and the main proof of that failure would be the low financial returns of the railway companies.

However, pessimism on the role of railways was challenged since the early 1980's by the outcomes of Gómez Mendoza's quantitative research, which is so far the most complete historical approach to the Spanish railway system. Unlike most previous interpretations on the subject, he indicated, on the basis of sound empirical evidence, that railways had a much more positive impact in Spain than in other European countries. That outcome was openly in conflict with the most extended interpretations on the subject and, accordingly, in spite of his methodological rigour, historians have been rather reluctant to accept Gómez Mendoza's main conclusions. As a consequence, the conflict between the prevailing perspectives on the issue and the quantitative evidence provided by this researcher has given rise to a historiographical paradox that remains unresolved.

In that context, this thesis is aimed at providing a new interpretation of the impact of infrastructure on Spain's economic growth during the period 1845-1935, which may be helpful both to get a better understanding of the reasons of Spanish difficulty to grow and industrialise, and also to throw some light on the debate on the economic role of Spanish

[13] See references on the subject below, in Section 1.4.

railways. The contributions of the thesis may be summarised into two main aspects. Firstly, in its first chapters the thesis adopts an aggregate approach to the subject, which has been absent from most of the historiography so far. The evolution of the whole Spanish infrastructure stock during the period previous to the Civil War of 1936-1939 is described in detail and compared with other countries' infrastructure endowment, and the question of its economic impact is dealt with from an aggregate point of view. Secondly, the last part of the thesis addresses the so-called "paradox of the Spanish railways" from a comparative perspective and offers a number of possible answers to the alleged conflicts among different interpretations, as well as a new assessment of the role of railways in the Spanish economy before 1936.

The thesis is organised as follows. Firstly, Chapter 1 discusses the major theoretical aspects of the relationship between infrastructure and economic growth, and summarises the main contributions of the historiography on the subject. In Chapter 2, new yearly series of Spanish infrastructure stock and investment for the years 1845-1935 are presented, which provide a broad picture of the evolution and characteristics of infrastructure capital formation during the period under study, and allow the measurement of its importance within the whole Spanish economy. Chapter 3 completes that description by analysing the geographical distribution of infrastructure among the Spanish regions and by researching into its main determinants. In Chapter 4, the Spanish infrastructure endowment is compared with that of other countries for which similar data is available, and a preliminary view of the Spanish relative shortage of infrastructure is offered. Chapter 5 applies econometric techniques to the estimation of the impact of infrastructure investment on Spanish economic growth. Finally, Chapters 6 and 7 focus on the role played by railways in the nineteenth and early-twentieth Spanish economy and raise several issues that have been discussed in the ongoing historiographical debate. Whereas Chapter 6 offers a new approach to the impact of railways on the Spanish economic growth during the period under study, in Chapter 7 the evidence that has been presented by some Spanish historians as proof of the failure of the Spanish railway system is analysed and re-interpreted from a comparative point of view. Chapter 8 contains the overall conclusions of the thesis.

CHAPTER ONE

THEORETICAL AND HISTORIOGRAPHICAL BACKGROUND

1.1 The concept of infrastructure

It is difficult to find a precise and generally accepted definition of infrastructure.[14] From a very broad point of view, "infrastructure" or "social overhead capital" may be defined as the structures and support services that are necessary for the economic development of an area.[15] Such a wide concept, however, admits numerous different interpretations. Some authors have given it a rather narrow scope. For instance, from Hirschman's point of view, "*the hard core of the concept can probably be restricted to transportation and power*".[16] On the contrary, other scholars have included within infrastructure not only transport, energy distribution networks and other similar assets, but also investment in human resources, institutions or, more generally speaking, what might be called "civic" infrastructure, i.e. "*the way in which business is done*".[17]

---

[14] On the difficulties to obtain an acceptable definition of infrastructure, see Groote (1996), pp. 22-26, or Button (1996), p. 148, who considers that providing an exact definition of infrastructure is just impossible, and ends up considering infrastructure simply as: "*what most people consider it to be*". As Groote has indicated (op. cit., pp. 24-25), part of the problem lies in the fact that the concept of infrastructure is not formally included in the UN system of national accounts, but its components are distributed among the categories "other construction" and "land improvement". On the other hand, the concept "non-residential structures", which is also widely used in capital stock estimates, is much more comprehensive than infrastructure; see Maddison (1995a) or Hofman (1992).

[15] See, for instance, Draper and Herce (1994), p. 130. "Infrastructure" and "Social Overhead Capital" are treated here as synonyms, as they have been in most economic literature. See an exception in Hansen (1965), p. 5.

[16] Hirschman (1958), p. 83.

[17] Stern (1991), p. 128; see also Hansen (1965), p. 5, and Bergman and Sun (1996), p. 18.

Most empirical studies, however, tend to fall somewhere between those two extreme interpretations, and consider infrastructure as a series of physical capital goods that are fixed to the territory and provide services which show some of the typical features of public goods.[18] Nevertheless, this description is still vague enough to allow the inclusion within the concept of a wide variety of elements and, in fact, the problems of definition have led most researchers to enumerate the assets that they consider in their analyses.[19] The most usual categories that are embraced by empirical analyses of infrastructure are the following:

- transportation
- communication
- energy supply
- water infrastructure
- education infrastructure
- health infrastructure
- urban infrastructure
- cultural, sports and tourist facilities
- social services
- natural endowment.[20]

Those elements are normally distributed into *economic* infrastructure (i.e., assets that provide direct services to production) and *social* infrastructure (i.e., assets that enhance social welfare).[21] The main rationale for that division is the fact that, as has been shown by empirical studies, the impact of each of those two categories on productivity is

[18] Broadly speaking, 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*"; Diewert (1986), pp. 3-4. However, infrastructure services are not usually seen as *pure* public goods, because they may show some degree of rivalry and/or excludability; see a discussion on this issue in Button (1996), p. 148-151.

[19] Alternatively, some authors have chosen a different definition strategy, namely to consider "infrastructureness" as an economic quality, which may be present in different degrees in each physical capital good. An example is Youngson (1967), p. 68, who defines infrastructure not as a set of assets but as "*a set of properties. Capital instruments may possess none, or some, or all of these properties in varying degrees*". In the same direction, Biehl (1984), pp. 100-105, indicates that different assets show different levels of "infrastructureness".

[20] See, for instance, Biehl (1984), pp. 102-108, or Diamond and Spence (1989), p. 38.

[21] See, for instance, Batten (1990), p. 88. This is not a strict division, because some elements, such as universities, perform both economic and social functions.

very different, economic infrastructure being much more conducive to direct efficiency increases.[22]

This research focuses on economic infrastructure. The reason for that choice is twofold. On the one hand, the aforementioned difference in the relationships that link economic growth with social and economic infrastructure makes a separate study of each of those two categories convenient. And, on the other hand, most information about the historical evolution of the Spanish social infrastructure is only locally available and its analysis is therefore beyond the possibilities of an individual researcher. Accordingly, the assets that have been considered in this study are the following:

- transport infrastructure (roads, railways, canals, harbours and airports).
- communication infrastructure (telegraph and telephone networks).
- energy distribution networks.
- water infrastructure (dams and irrigation canals).
- urban and suburban infrastructure.

1.2 Infrastructure and economic growth: an overview

The analysis of the impact of infrastructure on economic growth may be traced back to the origins of modern economics. The link established by Adam Smith between market size (which he considered largely determined by transport possibilities) and the specialisation of production,[23] as well as the reflections of Von Thünen, Weber, Lösch and other nineteenth and early twentieth century economists on the impact of transport costs on location,[24] are representative examples of that early concern. However, the first comprehensive analysis of the impact of infrastructure on economic growth was offered in the 1950's and 1960's by development economists. Infrastructure was then given a central

[22] See, for example, Aschauer (1989), pp. 193-194, who stresses the higher growth impact of economic or, as he calls it, "core" infrastructure; see also Hansen (1965), pp. 7-12, Looney and Frederiksen (1981), p. 293, Canning (2000), p. 3, and, for the Spanish case during the last few decades, Mas et al (1996), p. 647.

[23] "*As it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market*"; Smith (1930), p. 19; see also pp. 20-23.

[24] On the theoretical contributions of those early location economists, see Ponsard (1983) or Fujita et al (2000), pp. 15-41.

position among the factors explaining economic progress, and was considered a necessary condition for an economy to initiate a process of sustained growth.[25]

The technical problems of dealing with increasing returns and non-linearities prevented the contributions of Development Economics to reach a wholly mathematical expression. However, they contained most of the ideas that were to be formalised a few decades later. For instance, the potential of infrastructure to help the economy to overcome low-level disequilibrium traps, its quality of being a necessary but non-sufficient condition for economic growth, the importance of network effects, or the link between infrastructure investment and the growth of the technologically advanced sectors of the economy, are ideas that were already present in the reflections of mid-twentieth century development theorists.[26]

Since the late 1980's a renewed interest in infrastructure has spread among mainstream economists, and numerous questions that had been raised by development economics a few decades earlier have again been paid close attention. That revived interest has resulted in two main lines of research. On the one hand, in the context of the attempts to explain the contemporary slowdown in Western economies' productivity growth, an overwhelming amount of analyses have been carried out to measure the elasticity of aggregate production with respect to infrastructure increases. Many of those works have concluded that infrastructure has a clearly positive and significant impact on productivity, and have proposed a policy of high public investment for the economy to enjoy again high rates of growth.[27] On the other hand, New Growth Theory and New Economic Geography have provided a theoretical basis for the analysis of the link between infrastructure and

---

[25] For instance, in Rosenstein-Rodan and Rostow's works, infrastructure was included among the essential preconditions for, respectively, the "big push" and the "take-off" of industrialisation; see Rosenstein-Rodan (1943), p. 208, and Rostow (1960), pp. 17-18; on Rosenstein-Rodan's approach see also Weitzman (1970), p. 569. The same prominence of infrastructure may be found in the writings of other development economists, such as Hansen (1965), Heyman (1965), Hirschman (1958), Kindleberger (1965), Nurkse (1953), Tinbergen (1967) or Youngson (1967).

[26] The threshold effect of infrastructure investment is analysed, for instance, in Nurkse (1953), p. 152, Hirschman (1958), p. 86, Youngson (1967), p. 68, or Maizels (1968), p. 124. The risk of infrastructure investment to be helpless in certain contexts was already stressed by Heyman (1965), p. 31, and Hirschman (1958), pp. 89-96. This author, among others, defended, as a consequence, the need to follow unbalanced growth strategies, which were in turn criticised in Kindleberger (1965), pp. 196-198. Finally, the relationship between infrastructure investment and the growth of the technologically advanced sectors of the economy was already present in Youngson's idea that "*overhead capital is facilitating investment which promotes innovation*"; see Youngson (1967), p. 71.

[27] The earliest examples of this kind of research are Mera (1973), Looney and Frederiksen (1981), Eberts (1986), Costa et al (1987) and Aschauer (1989). Further measurement exercises are so abundant that constitute, in Gramlich's words, "*a flurry of work all out of proportion*"; Gramlich (1994), p. 1176. A survey can be found in Sturm et al (1998); see also Section 5.3 of this thesis.

economic growth. Thanks to the contributions of these two bodies of research, it is now possible to study the economic role of infrastructure from a rather consistent position.

There are two main ways in which infrastructure may affect the evolution of a specific economy. On the one hand, from the point of view of the demand for other sectors' output, infrastructure construction has a direct impact on the level of production of certain activities. On the other hand, from the point of view of the supply of infrastructure services, increases in infrastructure endowment change the cost structure of firms. The first of those two effects (which is usually referred to as the "backward linkage" of infrastructure investment) has been a classical concern of economic policy, and the basis for the use of public investment as a countercyclical instrument. The demand effects of infrastructure construction may be positive or negative (for instance, if it crowds out private investment) and, under certain circumstances, may have long-term consequences. This may happen, for instance, if the supplier industries are able to exploit scale economies and apply new technologies thanks to the demand associated with infrastructure investment. Demand effects, however, more often have a short-term character and tend to disappear in the medium term. Accordingly, they are usually paid less attention in analyses focusing on long-run economic growth.[28]

From the point of view of the supply of services, an improvement in infrastructure endowment has substantial cost-saving effects at the firm level in the short term. Those effects take place, on the one hand, through direct reductions in the price of some inputs, such as energy or water, and, on the other hand, through decreases in the prices of both the rest of the inputs and the output, thanks to the general reduction in transport and distribution costs.[29] But, unlike the "backward linkages" of infrastructure construction that have been described before, the consequences of the cost reductions brought about by infrastructure use to go beyond their pure short-term impact. In fact, the economic importance of infrastructure improvement lies to a great extent in the dynamic long-term consequences of those cost reductions and, more concretely, in the changes in the structure of location incentives that they produce through the removal of location constraints.

[28] The "backward effects" of infrastructure construction are dealt with, for instance, in Diamond and Spence (1989), p. 57, Bruinsma et al (1990), p. 224, Kessides (1996), pp. 222-223, or Nijkamp and Rienstra (1998), p. 185.
[29] See Diamond and Spence (1989), pp. 53-54.

More concretely, as a consequence of the reduction in transport and distribution costs brought about by infrastructure, production is allowed to move away from input or output markets, and freely choose an optimal location.[30] That process has two main effects. Firstly, the economy is allowed to exploit fixed resources that had remained idle so far due to high transport costs. And, secondly, a large share of non-agrarian production activities may concentrate in a few industrial centres. This is possible not only because it is no longer necessary for producers to be close to input or output markets, but also because infrastructure reduces the problem of congestion of cities and industrial districts.[31]

Geographical concentration of the activity is crucial for the growth of developing economies, because it substantially fosters the development of the technologically advanced sectors. As new economic geographers have stressed, during the early stages of economic development, the growth of those sectors takes place to a large extent through their concentration in industrial districts and urban centres which, at the same time, become increasingly specialised.[32] In that context, the specialisation of regions and the localisation of economic activities turn out to be self-reproducing phenomena, which are motivated and sustained by the advantages that firms get from the process, through the exploitation of scale economies, comparative advantages and agglomeration externalities.[33]

New Growth Theory has pointed out that the development of technologically advanced sectors is essential for an economy to enjoy increasing returns to scale (IRS) in production and, therefore, to undertake a sustained process of growth.[34] In other words, those sectors play a leading role in an economy's progression towards a cumulative

---

[30] On the influence of infrastructure endowment on the level of transport costs in different countries, see Bougheas et al (1999) and, specially, Limão and Venables (2000).

[31] The two limits to the concentration of the activity (i.e. transport costs and congestion) are described by Puga (1996), p. 3, who indicates that, during the early stages of Western industrialisation, the first of these two problems was much more influential than the latter.

[32] Actually, the process of concentration of the activity tends to show an inverted U shape and, accordingly, starts decreasing at a certain point of time; see, for instance, Ottaviano and Puga (1997), pp. 26 and 29-30, or, for the US case, Kim (1995).

[33] Out of these three factors, agglomeration externalities are probably the most difficult to deal with. They have been a classical concern of economic theory, whose origins can be traced back to Marshall (1916), pp. 271-273, and, later on, to the works of Perroux (1955), p. 317, and Pred (1966), pp. 24-46; see a recent survey on the subject in Fujita and Thisse (1996). Problems mainly arise in the empirical analysis of the subject, due to the difficulties to measure agglomeration externalities in practice, and the results of the existing studies are not completely straightforward on their relevance. Glaeser et al (1992) and Henderson et al (1995), for instance, have identified different types of agglomeration externalities in the recent experience of US cities, but Kim (1995), on the contrary, has found no clear evidence of externalities in the long run trends of US industry specialisation and localisation, and has indicated that scale economies and comparative advantage seem to be much more relevant for explaining these processes.

[34] See especially Romer (1986) and (1990), and Lucas (1988).

development process and towards overcoming decreasing returns to scale (DRS) and underdevelopment traps.[35] Therefore, as far as infrastructure contributes to the development of the most advanced sectors of the economy, it plays a central role in the process of long-term economic growth of a country.[36]

However, the described dynamics are far from automatic. On the one hand, the economy must incur substantial adjustment costs in the short term in order to adapt to the new conditions created by infrastructure.[37] And, on the other hand, and more importantly, there are many intermediate factors that interfere with the final economic impact of infrastructure improvement. As Holtz-Eakin and Lovely warn in their model of infrastructure impact, the actual relocation effects of infrastructure depend on both the characteristics of the existing technology and the structure of markets. Where industrial sectors that experience either low scale economies, weak intersectoral linkages or a high degree of market power at the firm level are dominant, the economy is unlikely to react to cost reductions brought about by infrastructure improvements.[38] In those cases, no strong trend towards the relocation of the activity is to be found and, therefore, the long-term impact of infrastructure is much less intense.

In addition, the impact of infrastructure is also determined by factors outside the most directly affected sectors. Actually, according to "new economic geographers", the relocation of activity is a process that involves the whole economy, since it is the result of the interaction of four factors: i) the characteristics of the existing technology, (as has already been indicated), ii) the mobility of factors among sectors and across regions, iii) the size of the available markets, and iv) the level of transport costs (which is the result of

[35] On the presence of both DRS and IRS sectors in backward economies and the existence of low-level disequilibrium traps, see Murphy et al (1989), Azariadis and Drazen (1990) and Boldrin (1992).

[36] Apart from the "New Economic Geography", other authors have provided complementary perspectives of the link between infrastructure and the technological level of an area. For instance, Suárez-Villa (1996), pp. 254-255, indicates that infrastructure may increase the quality and the access to education, and may facilitate the migration of highly skilled professionals, and Barro and Sala-i-Martin (1995), p. 34, include infrastructure among the factors that "*are ultimately key determinants of an area's attractiveness for production and research*".

[37] See, for instance, Lakshmanan (1989), p. 245.

[38] Holtz-Eakin and Lovely (1996). See also Takahashi (1998), p. 215, who indicates that the optimal level of infrastructure endowment increases with the importance of IRS in private production. In fact, those considerations may be related to the widespread characterisation of infrastructure as a necessary but non-sufficient condition for growth, which can be found, among others, in Diamond and Spence (1989), p. 34, Krugman (1991), p. 486, Capello and Gillespie (1993), p. 44, Krugman and Venables (1995), Venables and Gasiorek (1998), pp. 17-18, or Duggal et al (1999), p. 72. Similarly, Johansson (1993), p. 131, consider infrastructure just as a "potential", which may or may not be exploited by the economy and Biehl insists that infrastructure may be useless if the level of urbanisation and industrialisation of the country and the closeness to core economies are too low; see Biehl (1984).

infrastructure improvement, but also of other factors, such as geography and trade policy).[39] Therefore, infrastructure improvement is only one among several factors determining the relocation of activity. Some global features of the economy under study, such as the size of markets and the mobility of resources, are crucial for the process to advance. A low level of consumption of industrial products, or an immobile labour force, may act as absolute constraints to the process and, therefore, may prevent infrastructure from exerting all its potential impact.

Obviously, market size and factor mobility themselves depend on a wide range of characteristics of the economy. Among them, the level of GDP per capita, income distribution, the productivity of the traditional sectors, the human capital endowment and the State's policies may be mentioned.[40] In fact, all those elements are interconnected, and whereas all of them affect the impact of infrastructure on the economy, infrastructure itself may also modify them. For instance, in the early stages of development of an economy, infrastructure may ease the commercialisation of traditional products and, as a consequence, may stimulate productivity growth in the traditional sectors, in a process that enlarges both market size (through the level of income) and factor mobility (since productivity increases in those sectors allow the release of labour).

As a consequence, the relationship between infrastructure and economic growth offers a picture of extreme complexity and, in fact, the impact of infrastructure may be largely eroded if a number of other essential factors are absent. Under certain conditions, infrastructure improvement may be irrelevant or even harmful for the economy. This may be the case, for instance, if a decrease in transportation costs and the subsequent increase in accessibility result in the substitution of more competitive foreign products for domestic ones in the national market, due to the lack of response by internal production.[41]

---

[39] See, among others, Krugman (1991), Fujita and Thisse (1996), pp. 368-372, Venables (1996), Puga (1996), pp. 23-24, or Puga and Venables (1999).

[40] See, for instance, Krugman (1995), p. 50, or Puga and Venables (1999), pp. 303. As has been indicated by Humplick (1996), p. 129, among others, a higher level of development or a better designed economic policy increase the potential impact of infrastructure not only through the factors that determine that impact (such as market size or resources mobility), but also by improving efficiency in the management of infrastructure services.

[41] See Bergman and Sun (1996), pp. 17 and 30, and Vickerman (1991b) and (1995b). In the same vain, Dugonji (1989) and Martin and Rogers (1995) stress the need to distinguish between large scale and local infrastructure, and warn that the former may have a negative impact on the economic performance of peripheral regions if it is not accompanied by the latter. Similarly, Comfort (1988) insists on the need to complement infrastructure investment with other types of policy to foster development in lagging areas.

But there are other additional facts that further complicate the link between infrastructure and growth. Firstly, the actual impact of infrastructure depends not only on the existing physical endowment, but also on the efficiency with which it is designed and managed.[42] Secondly, geography may make infrastructure development much more expensive in some countries than in others and, accordingly, may reduce the returns to the invested resources.[43] And, thirdly, as has already been indicated, most infrastructure investment must be provided in large units, sometimes ahead of demand. Lumpiness means, on the one hand, that the full long-term impact of infrastructure may take a long time to be effective and, on the other hand, that a great deal of infrastructure investment comes in the form of large networks, which completely change the conditions under which an economy operates. As a consequence, construction of major networks may yield much higher returns than incremental additions to these networks, and the growth impact of infrastructure investment is therefore characterised by discontinuities closely associated with the development of new technology.[44]

It is therefore difficult to exaggerate the complexity of the relationship between infrastructure and economic growth. This relationship depends on a wide range of elements, such as geography, the quality of infrastructure itself, the features of the existing technology and a large series of factors determining the size of markets and the mobility of resources. All these aspects must be taken into account to achieve a meaningful explanation of the impact of infrastructure investment on a country's economic performance. The next section describes the way in which this question has been addressed in the context of the study of nineteenth and early twentieth century industrialisation.

[42] See, for instance, Hulten and Schwab (1993), pp. 270-271, Gramlich (1994), pp. 1189-1193, Vickerman (1995a), p. 39, Kessides (1996), pp. 226-227, Vickerman et al (1999), p. 3, or Frybourg and Nijkamp (1998), pp. 17-19 and 30, who indicate that infrastructure "hardware" (i.e. the tangible material element of infrastructure) must be paid the same attention as infrastructure "orgware", "finware" and "ecoware" (i.e. its organisational, financial and environmental aspects).

[43] For the problems of landlocked countries, see Gallup et al (1999), p. 184, and Overman et al (2001), p. 8; for low populated countries, Chu (1997) and Gallup et al (1999), and for ill-situated and poorly endowed countries, see Bougheas et al (1999), pp. 176-177.

[44] See, for instance, Murphy et al (1989), p. 1024, Biehl (1991), p. 15, Hulten and Schwab (1993), p. 269, Nijkamp and Rienstra (1998), pp. 192-193, Bougheas et al (1999), p. 173, or Fernald (1999).

1.3 The role of infrastructure in nineteenth and early twentieth century industrialisation

In the Western economies, the process of industrialisation during the nineteenth and early twentieth centuries was accompanied by a sustained increase in the available physical infrastructure. The continuous reduction in transport, communication and urban congestion costs constituted an essential condition for technological change and productivity growth to spread across Europe and overseas. In fact, there was a process of mutual influence, since the main infrastructure improvements depended to a large extent on the application of new technology (such as steam, electricity, new materials, and advances in civil engineering) to the fields of transport and communication.[45]

Until the mid-twentieth century, historians' attention focused to a large extent on the role that railways played within that process. As a massive investment, which changed the image of Europe at least as much as the factory system, they were long considered the "hero" of nineteenth century industrialisation, other infrastructure investment being paid much less attention.[46] Unanimity, however, was broken when Robert Fogel estimated the "social saving" that railways had afforded to the American economy during the nineteenth century, on the basis of a comparison of railway transport costs with the next best available alternative. His counterfactual exercise led him to reject the indispensability of railways for US economic growth.[47]

Fogel's conclusions challenged the generally accepted ideas about the impact of railways on nineteenth century economies and, therefore, provoked many different reactions. Whereas some scholars raised a number of technical *caveats* to his estimation methods, another group of historians devoted their research efforts to replicating Fogel's procedures for other countries, obtaining a very diverse set of results.[48] However, as Paul David stressed:

[45] O'Brien (1983b), pp. 1-2; Freeman and Aldcroft (1988); Andersson and Strömquist (1989), p. 30.
[46] The "hero" theory of railways is well represented by authors such as Jenks (1944), Rostow (1960), Gerschenkron (1962) or Woodruff (1966).
[47] Fogel (1964). "Social saving" estimates are considered to provide an upper bound measure of the resource saving brought about by railways; see Fogel (1979), p. 5, and also Section 6.2 below.
[48] Fogel (1979) is a summary of the controversy about the social saving model. A survey of the social saving estimates that were produced in the wake of Fogel can be seen in O'Brien (1983b), p. 10, although, as this author indicates elsewhere, "*there are differences in the content of the construct as used by Fogel and other new economic historians of railways, differences which turn largely upon the* ceteris paribus *conditions deemed to pertain in the counterfactual economy deprived of railways*"; O'Brien (1977), p. 23.

> *"the central idea in Fogel's book is really not especially concerned with the role railroads played in US economic growth. It touches that question only by implication and by way of illustration. For, most simply stated, Fogel's main thesis is that «no single innovation was vital for economic growth during the nineteenth century»".*[49]

Fogel himself recognised that his model could not encompass the question of the global impact of railways on economic growth, which would have required research to move from the static "social saving" approach to a dynamic and general-equilibrium-oriented perspective.[50] Instead, what Fogel considered to be one of the most important contributions of the social saving literature was the idea that the analysis of the economic impact of railways only made sense if it was integrated in the whole study of the transportation system. In his own words:

> "*[i]t is a misleading oversimplification to identify wagons, waterways and railroads with a sequence of temporal stages in which each was predominant (...). The transportation system that evolved during the nineteenth century embraced all three modes*".[51]

In that context, the attention had to be shifted from railways to the total increase in transportation productivity during industrialisation.

When Fogel was stressing the importance of the complementarities between different transport means, the outcomes of some researchers on the role of roads or waterways during industrialisation provided additional support to his suggestions. Transport historians observed that, before the birth of the railways, the existing transport means had serviced the needs of some of the growing European economies without serious problems.[52] And even after the arrival of the railways, the alternative transportation modes

---

[49] David (1969), p. 507. In the same vain, Fishlow insisted at the time on the need to reject the idea of "*unequivocal primer movers*" in the process of economic development; see Fishlow (1965), p. 204.

[50] Fogel (1979), pp. 5 and 45. See also O'Brien (1977), pp. 39 and 100.

[51] Fogel (1979), p. 49.

[52] See especially, for Britain, Mitchell (1964), p. 316, and Albert (1972), pp. 186-187, and, for Belgium, Genicot (1946), p. 508. The positive growth impact of the pre-railway transport system on the British and Dutch economies has also been stressed, among others, by Freeman (1983), pp. 18-19, Ville (1990), pp. 13-29, Szostak (1991), De Jong (1992), p. 20, and Barker and Gerhold (1993), pp. 33-34. In the case of communications, Kaukiainen (2001) has also described very intense improvements in the speed of information transmission before the telegraph. On the other hand, historians have been much more pessimistic about the pre-railway situation in France or Spain, due to the geographical features of those two countries and their high dependence on animal power for transport; on the French case see Price (1975), p. 18, and (1983), pp. 36 and 45; on Spain, see below, Section 1.4.

continued to play playing an indispensable role in the most developed economies of the continent.[53]

In fact, during the second half of the nineteenth century the displacement of road and water transport by railways was quite limited. Roads, waterways and coastal navigation were specially adapted to certain sectors of the transport market for which railways could not compete. On the one hand, roads provided competitive transport services in the shortest hauls, among other reasons because they avoided transhipping costs and made the supply of door-to-door services possible. On the other hand, waterways and coastal shipping remained competitive in the transport of bulky, low-value commodities as well as in a great proportion of those longest haul services in which speed and precision were not crucial. Railways only had a clear advantage over the two other means in medium-to-long hauls and, especially, in passenger and high-value freight transport.[54]

Accordingly, during the second half of the nineteenth century efforts towards infrastructure improvement were distributed among all these different modes. The bulk of investment was indeed devoted to railway construction. But investment efforts were not at all confined to railways. On the contrary, the availability and quality of roads were increased in all countries,[55] new waterways were constructed and the old ones were

[53] See, for instance, Vamplew (1972), pp. 140-143, Berend and Ranki (1982), pp. 92-93, Fremdling (1983), p. 137, Laffut (1983), p. 217, Armstrong (1987), pp. 176-177, Bagwell and Armstrong (1988), pp. 173-175, Ville (1990), pp. 42-43 and 159, or Kunz (1994), pp. 197-198. The Netherlands was the country in which alternative transport means played the most prominent role during the railway era, due to the high quality of the existing networks; see De Jong (1992), p. 20.

[54] On the complementary nature of different transport means, Armstrong has indicated that: "*Instead of a simple view of successive eras dominated by the current champion as it supersedes the previous favourite, we have a much more complex picture in which multiple modes of transport coexist, each offering different strengths which appealed to different types of customer, depending on a variety of characteristics among which price was only one consideration. Speed, reliability, frequency, the minimum quantity, the precise origin and destination, as also the quality of the service, were important and had to be matched to the specific characteristics of the commodity to be moved and the customer served*"; Armstrong (1998), p. 166. An early defence of the need to see the history of the different transport means as an integrated whole, in Sherrington (1969) [1934], p. 8.; see also Girard (1966), pp. 213 and 243, Albert (1972), p. 196, Krantz (1972), pp. 23-27, Barker and Savage (1974), pp. 47 and 63, Price (1975), p. 12, and (1983), pp. 287-288, Tilly (1978), pp. 412-413, Fogel (1979), pp. 30-34, Laffut (1992), p. 87, Ville (1990), p. 22-23, and (1994), p. 197, and Barker and Gerhold (1993), pp. 43-46. The advantages of waterways in the transportation of bulky product have been dealt with, for instance, by Léon (1904), pp. 580-586, Merger (1990) and Armstrong (1995). The advantages of railways in passenger transport have been described, for instance, by Vamplew (1972), pp. 135-137, Barker and Savage (1974), p. 63, or O'Brien (1983b), p. 3. The situation that is described in the text was subject to changes associated to the evolution of technology. For instance, after the First World War traffic switched again from railways to roads, specially in short-to-medium distances; this process is described in detail, for instance, in Barker and Savage (1974), pp. 154-155, Barker and Gerhold (1993) or Butterfield (1995), p. 182.

[55] On road improvement during the nineteenth century in different countries, see, for instance, Léon (1904), pp. 579-580, Blum (1943), pp. 26-27, Tilly (1978), p. 412, Laffut (1983), pp. 218-219, De Jong (1992), p. 10, Price (1983), pp. 259-271, and also Ville (1990), pp. 13-29.

improved,[56] and a large amount of resources was devoted to the enlargement of port infrastructure, which was adapted for the development of coastal and deep-sea shipping.[57] In addition, the construction of transport infrastructure was complemented during the nineteenth and early twentieth century by investment in communication networks. In a context of progressive market integration, the telegraph and telephone systems provided an additional instrument for the development of interregional and international economic relations, having no superior in the rapid transmission of information.[58] At the same time, as urbanisation proceeded, the expansion of urban infrastructure reduced congestion costs and made large cities viable. Streets, urban transport, energy and water distribution, public lighting and sewer systems represented in that context a necessary addition to the large transport and communication networks.[59]

In this context, the initial excessive attention paid to railways by historians has been replaced by a much richer perspective, which stresses the internal complexity of infrastructure. And, at the same time, the analysis of the impact of infrastructure on growth has gradually shifted from both the “hero” theories and the purely static social-saving approaches to a dynamic and general equilibrium oriented perspective.[60] Just after Fogel’s contribution, Williamson’s general equilibrium exercise constituted a pioneering attempt to advance towards such an approach.[61] However, the amount of assumptions that are necessary in general equilibrium analysis has discouraged historians from following Williamson’s methods, and an increasing effort has instead been devoted to the separate description of each long-term economic consequence of infrastructure investment. In the process, this change of focus has led to the return of some of the old ideas of the “pre-social-savings” pioneers in the historiography of infrastructure.

The fields covered by recent historical research have been very diverse. Firstly, railway “backward linkages” have been analysed for several economies, paying attention to their long-term technological impact, which appears to have been very different among

[56] On the improvement of inland waterways in different countries during the second half of the nineteenth century, see Milward and Saul (1977), p. 43, Hadfield (1986), pp. 145-173, Kunz (1992) and (1995), p. 31, or Kunz and Armstrong (1995b), p. 8.
[57] See, for instance, Pounds (1985), pp. 463-465, or Jackson (1988), pp. 226 and 245.
[58] See, for instance, Flynn and Preston (1999), p. 438.
[59] The relationship between urban growth and urban infrastructure has been analysed, for instance, by Barker (1988) or Núñez Romero-Balmas (1996a), and its crucial role in nineteenth century US economic growth is stressed in Abramovitz (1993), p. 226.
[60] On the importance of this change see Carreras (1995).
[61] See Williamson (1974), p. 191.

countries.[62] Secondly, the relocation effects of infrastructure have been explored for several countries and regions. Researchers have insisted on the importance of transport cost reductions in increasing the size of markets for industry, in allowing certain previously isolated regions to access external markets, and in eliminating the problems of food supply to some areas. All those effects were crucial for economic growth, since they facilitated the relocation of activity and the exploitation of scale, specialisation and agglomeration economies.[63] However, in line with the ideas of New Economic Geography, historians have recognised that the final impact of infrastructure investment on location during industrialisation varied according to a wide range of characteristics of the economy. They have even indicated that, in some cases, infrastructure improvement could be irrelevant or damaging for an area, as might happen if the decrease in transport costs resulted in the substitution of more competitive foreign products for domestic ones in the national market.[64]

A number of studies have tried to test quantitatively, from an aggregate point of view, the link between infrastructure improvement and the long-term process of reorganisation of economic activity. Firstly, some researchers have estimated the impact of infrastructure investment on the level of urbanisation of the European countries, with significant and positive results. Nevertheless, they have indicated that the reduction of transport costs was a necessary but non-sufficient condition for urban growth, in line with the predictions of economic theory.[65]

---

[62] Considerations on this subject are indebted to the classical analyses by Rostow (1960) and Fogel (1964), and surveys for different countries can be seen in Ville (1990), pp. 145-153, and (1994), pp. 200-205, and, especially, in O'Brien (1983b), pp. 18-22. All these authors insist on the importance of railway "backward linkages" in the cases of the iron and electric industries. However, O'Brien indicates that for the "backward linkages" of infrastructure to have had a long-term impact, a sufficient endowment of other resources (such as human capital) and a relatively high level of autonomous demand must have been present in the economy. In other words, the range of economies in which the "backward linkages" of infrastructure can have made a difference seems to be quite narrow. Similar considerations are made by Fogel (1979), p. 39, n. 77. Actually, the fields in which the long-term "backward linkages" of infrastructure investment seem to have been most widespread among countries during industrialisation are not the industrial sectors but the financial markets, the organisation of business and the State's economic policy.

[63] For the US case, see Fishlow (1965), p. 311, Kim (1995) and Cain (1997), pp. 132-134; for Britain before and during the industrial revolution, Albert (1972), p. 113, and Szostak (1991), p. 31; for the Netherlands, Griffiths (1982); and for the specific relocation impact of inland navigation infrastructure, Niemeijer (1995) and Armstrong (1995), pp. 307-308. See also, from a general point of view, O'Brien (1983b), pp. 20-22, Pounds (1985), pp. 488-489, Bairoch (1990), pp. 148-149, and Ville (1990), pp. 154-166, and (1994), pp. 204-212.

[64] See, for instance, O'Brien (1983b), pp. 20-22, and Hart (1983), pp. 15-18.

[65] See Bairoch (1990), who indicates that the effect of infrastructure improvement on urbanisation would have been negligible without the increase in agricultural productivity that took place after 1800.

Secondly, other authors have tried to explain a country's urban hierarchy by comparing the size of each city with its accessibility through the available infrastructure networks. However, they have not found any strong link between the two variables. Although the non-structural character of those pieces of research may explain the lack of positive results, failure to find a link between accessibility and urban hierarchy has also been interpreted as proof that "*creation of transport infrastructure was reflected more in a change to the operating mode of the urban network as a whole rather than by individual demographic effects measurable on the sum of its component towns*".[66]

Finally, two studies have tried to measure the whole long-term growth impact of infrastructure by using different econometric methods. On the one hand, from a single-country perspective, Groote, Jacobs and Sturm carried out a time-series analysis of Dutch economic growth, but the estimation outcomes could only capture a significant positive impact of infrastructure investment in the short term.[67] Secondly, in a recent research, Foreman-Peck and Lains included the level of infrastructure endowment (as measured by the size of the national railway networks) in a panel data model aimed at explaining the level of income per capita of a large sample of European countries during the period 1870-1910. However, their results are again disappointing, since they were unable to find any direct impact of infrastructure on economic growth.[68] Actually, the ambiguity of the outcomes of all those quantitative approaches shows the high complexity and variability of the relationship between infrastructure and economic progress, and points to the need to complement aggregate analyses with more detailed descriptions of particular processes.[69]

Spain, like every other country in Europe, was involved in an intense process of infrastructure improvement from the beginning of industrialisation, which completely

[66] Lepetit (1994), p. 348; this researcher analyses the impact of the road network on the French urban system in the period 1740-1840, with no significant results. Similarly, Pumain (1982) indicates that French railways did not make a difference in the growth of each individual city during the period 1836-1911, because the network just adapted to the existing urban hierarchy. Van der Knaap (1978), pp. 96-116, obtains slightly positive, but still inconclusive results on the impact of road, waterway and railway networks on the Dutch urban hierarchy during the period 1850-1970.
[67] Groote et al (1999); see a detailed description of that estimation exercise in Sections 5.3 and 5.4 of this thesis.
[68] Foreman-Peck and Lains (2000), p. 95. They, however, found a slight indirect impact of infrastructure on the levels of income per capita through the reduction of the share of active population involved in agriculture.
[69] Freeman (1983), pp. 18-19, indicates that the link between infrastructure improvement and economic performance should be expected to vary over space and through time, preventing generalisations. In the same vain, O'Brien (1983b) is rather sceptic on the feasibility of an aggregate analysis of the growth impact of railways. He indicates that "*even if models could be designed to capture the complex interconnections of railways to economic growth through time, empirically the task of quantification seems impossible.*" (p. 14). See also Fogel (1979), p. 48.

changed the conditions under which the economy operated. In Spain, as they did in other countries, the process of infrastructure construction and its impact on growth reflected Spanish geographic, demographic and economic features. The next section summarises the main contributions of the literature regarding the role that infrastructure played in Spanish industrialisation, and indicates the main questions that are nowadays under discussion.

1.4 Infrastructure and Spanish economic growth: historiography

Although the research on the historical evolution of Spanish infrastructure has a very long tradition, the first systematic approach to its impact on Spanish economic growth dates back to the 1970's and was produced in the context of Gabriel Tortella's analysis of nineteenth century Spanish industrialisation.[70] Unsurprisingly, this pioneer's interpretations had two features that were also present in the work of his US counterparts some years before. On the one hand, his research focused on railways, paying very little attention to other types of infrastructure. And, on the other hand, his deep pessimism on the subject largely reflected the opinions that were expressed by contemporaries in the late nineteenth and early twentieth centuries, as US historians' optimistic views had done before.[71] Therefore, in Spain, instead of being seen as the "hero" of industrialisation, railways were included among the explanatory factors of the underperformance of the economy during industrialisation.

In his research, Tortella stressed a number of shortcomings that had characterised the establishment of the railway system in Spain. Firstly, from his point of view, Spanish railways were constructed ahead of demand, without paying any serious attention to real

[70] Tortella Casares (1973). Before the mid-1970's, the study of the history of Spanish infrastructure had been either politically-oriented or purely descriptive. Examples of the first kind of works are Alzola y Minondo (1979) [1899] or Sánchez de Toca (1911), whereas Arrillaga (1930), Menéndez Pidal (1951), Wais San Martín (1987) [1967] or Cabezas (1974) are typical detailed descriptions of the historical evolution of Spanish railways, roads or communication networks. Casares Alonso (1973) constitutes an interesting although partially failed attempt to analyse the economic impact of Spanish railways, in which the effort to use sophisticated methods contrasted with the inability of the author to draw meaningful conclusions from the evidence.

[71] Dealing with US historiography on railways, Fogel (1964), p. 1, pointed out that: "*the prevailing interpretation of the influence of railroads on American economic growth during the nineteenth century is still dominated by hypothesis spawned during that era*". If nineteenth century opinion in the US was quite optimistic on the economic role of railways, Spanish views were, on the contrary, dominated by a deep pessimism, which was largely associated to the perception of the poor financial results of the Spanish private railway companies during most of their lives, and also to the high level of corruption that characterised the process of construction of the network. Contemporary declarations of pessimism about the performance and results of Spanish railways are abundant; some examples for different periods are Vega Armentero (1884), pp. 32-34, Boag (1923), p. 8, or Perpiñá (1952), pp. 308-309.

transport needs.[72] He pointed out that, after a long period of very little construction activity, the Spanish governments of the years 1854-1856 (the so-called "Progressive Biennium") subordinated all their other aims to the hasty construction of a national railway network. In that context, the development of the banking system was mainly oriented to the financing of railway construction and, as a consequence, domestic industry suffered from a shortage of financial resources during the period 1855-1865.[73] In addition, once the lines had been constructed, railway companies faced a situation of excess capacity which made them unprofitable during most of their lives. This was the origin of their financial collapse in the crisis of 1866, and also the reason for the slowdown of railway construction after that date.[74] To make things worse, the construction of Spanish railways was characterised by a complete lack of "backward linkages". Imports of materials for railway construction were given generous tariff exemptions, which deprived the Spanish iron industry of a crucial source of demand.[75]

Almost at the same time, Jordi Nadal's research offered a slightly different but equally pessimistic view of the subject. Reproducing to some extent the Gerschenkron-Romeo previous debate on the Italian railways, Nadal considered, unlike Tortella, that a fast process of construction was necessary due to the network features of railway investment. He also indicated that, given the foreign nature of a large share of the resources that were invested in the Spanish railways, it is unlikely that, had railway construction been slower, those resources would have been directed to the domestic industry.[76] On the other hand, Nadal added to Tortella's reasons for pessimism his own criticisms to the radial design of the Spanish railway network, which would not respond to the needs of the economy but to political factors and foreign interests.[77] But, apart from those considerations, he tended to share Tortella's views on other aspects, such as the importance of the lack of "backward linkages" of Spanish railway construction which

[72] Tortella Casares (1973), p. 169.
[73] Ibidem, p. 16.
[74] Ibidem, p. 193.
[75] Ibidem, p. 12 and 339. This criticism, as most expressions of "railway pessimism", had numerous precedents in the nineteenth century; see, for instance, Alzola y Minondo (1979) [1899], pp. 384-385 and 422, and Sánchez de Toca (1895), pp. 78-82.
[76] Nadal Oller (1975), pp. 38-42. By contrast, Tortella had stressed the role of domestic capital in the financing of railways; see Tortella Casares (1973), p. 337. Regarding the Italian case, see a summary of Gerschenkron's and Romeo's respective positions in Cafagna (1989), pp. 390-396.
[77] Nadal Oller (1975), pp. 48-50.

constituted, from his point of view, one of the main missed opportunities for the industrialisation of the country.[78]

All the problems stressed by those two researchers, which were closely associated with the way in which railway construction was regulated by Spanish governments, reduced the economic benefits of the development of the railway network to levels that were substantially lower than expected, and led Tortella and Nadal to include railways among the factors to blame for what the latter called the "failure of the Spanish Industrial Revolution". However, immediately after those authors' works were published, other historians offered slightly more positive pictures on the matter. On the one hand, Sánchez-Albornoz pointed out in the late 1970's that railways had been an essential factor of market integration for nineteenth century Spain.[79] And, on the other hand, an exhaustive collective study of the history of Spanish railways concluded that, although limited, the impact of railways on Spanish economic development had been crucial, and indicated that the establishment of the railway network was one of the main determinants of Spanish regional specialisation and urbanisation.[80]

But the real challenge to Nadal and Tortella's pessimistic views was to arrive a few years later. In the early 1980's, Gómez Mendoza's research opened up new perspectives on the issue. Firstly, this author offered a new interpretation of the lack of "backward linkages" of Spanish railway construction. He pointed out that the Spanish iron industry was too underdeveloped in the middle of the nineteenth century to meet the demand of railways and, as a consequence, a more protective tariff policy would have involved a substantial excess cost for the Spanish economy.[81]

Secondly, and more important, Gómez Mendoza applied Fogel's social saving model to Spain in the years 1878 and 1912. According to his estimation exercise, if all commodities carried by Spanish railways in 1878 had been transported by alternative means, the excess transport cost would have amounted to 11.8 per cent of Spanish GDP. That was a much higher figure than those obtained for countries such as England and Wales (4.1 per cent in 1865), US (3.7 per cent in 1859), France (5.8 per cent in 1872), or

[78] Ibidem, pp. 158-165.
[79] Sánchez Albornoz (1977), p. 20.
[80] See Artola (1978c), Vol. 2, p. 526.
[81] See Gómez Mendoza (1982), pp. 240-242. Nevertheless, although this author doubted that the Spanish iron economy could have been able to react to an all-embracing protective policy, he suggested that a different tariff structure, similar to the German one, which allowed the free import of cast iron and protected the most advanced stages of the rail production process, would have been appropriate in the Spanish case.

Belgium (2.5 per cent in 1865). The estimate for 1912 was an even more impressive figure, amounting to 18.5 to 23 per cent of the Spanish GDP in that year.[82] Therefore, contrary to the conclusions of previous studies, which included railways among the explanatory factors for the "failure of the Spanish Industrial Revolution", Gómez Mendoza stressed the indispensable role that railways performed in Spanish industrialisation during the second half of the nineteenth century.

The high level of the social saving of the Spanish railway system was mainly attributed to the fact that, in a counterfactual economy without railways, most freight would have been shifted to roads, due to the serious constraints that Spain's physical geography put on water transportation.[83] Gómez Mendoza's conclusions were consistent with the outcomes of Ringrose's research on the pre-industrial Spanish transport system, according to which, the lack of possibilities for water transport were already creating serious bottlenecks in the Spanish transportation sector at the end of the eighteenth century. The excessive dependence on the road system, apart from making transport too expensive for most commodities except for the shortest hauls, led to the gradual appearance of Malthusian traps. These were associated with the fact that, during periods of economic growth, population increases put additional pressure on the demand for land, which made the access of draught animals to pastures more expensive and, in some cases, impossible. As a consequence, transport was a factor of economic stagnation in Spain before the railway era.[84]

---

[82] See Gómez Mendoza (1981), pp. 25-114. Figures for other countries in O'Brien (1983b), p. 10. In his research, Gómez Mendoza offered an alternative social saving estimate for 1878 that allowed for the presence of idle resources in the economy and amounted to 7.5 per cent of Spanish GDP. That was still a high figure in comparative terms; see Gómez Mendoza (1981), p. 95, and Section 6.2 of this thesis. This author also calculated the acreage of arable land that would have been necessary to feed the animal population required to sustain economic growth at its 1878 actual level in the absence of railways. That amount was estimated to be 1.12 million hectares of land, i.e. 32 to 43 per cent of the wheat acreage in 1891, which reinforced the idea of the great importance of railways for the nineteenth century Spanish economy; ibidem, pp. 67-68.

[83] See Gómez Mendoza (1982), pp. 55-56, and O'Brien (1983b), pp. 7-14. The geographical constraints that limited the development of the Spanish transport system have been described, for instance, in Madrazo (1984), pp. 19-31, Gómez Mendoza (1995), pp. 137-139, or Gómez Mendoza (1999b), pp. 225-229. The main problems were, on the one hand, the shape of the country, which substantially diminished the scope of coastal shipping in spite of the length of the Spanish coast, and, on the other hand, the harsh relief and aridity of most of the territory and the irregularity of most Spanish rivers, which minimised the possibilities for canal construction and river navigation. As a result of those problems, at the beginning of railway construction only some 300 km of canals had been built, whereas river navigability was limited to the last stretches of the rivers Ebro and Guadalquivir.

[84] See Ringrose (1972), especially pp. 91 and 162. See also Gómez Mendoza (1983) and (1995), pp. 132-134. However, unlike Gómez Mendoza, Ringrose did not believe that railways sorted out the Spanish transport problems. On the contrary, he accepted Tortella's main conclusions and assumed that "*during the whole*

Since the publication of Gómez Mendoza's research, historians' knowledge of the evolution of Spanish infrastructure has greatly increased. However, the global approach of the first analyses, which included railways in broad explanations of Spanish industrialisation, has to some extent been replaced by two types of research. On the one hand, an increasing amount of effort has been diverted from railways to the study of the evolution of other types of infrastructure, which had previously been largely neglected. On the other hand, some pieces of research have been devoted to the analysis of the economic impact of railways and other types of infrastructure from a purely regional point of view.

The first type of works have described the long-term evolution of Spanish roads,[85] ports,[86] canals,[87] urban infrastructure,[88] telecommunications,[89] electricity infrastructure,[90] irrigation works[91] and, in some cases, the whole Spanish transport system.[92] Actually, a number of those sectoral studies have gone beyond the mere description and have analysed the growth impact of infrastructure. For instance, some research has stressed the limited capacity of most Spanish ports to stimulate industrial activities.[93] Several historians have also indicated that the few existing waterways had a much larger impact on the field of irrigation and power generation than on transport itself.[94] Other subjects, such as the role of urban transport infrastructure in the growth of Spanish cities, or the absence of significant "backward linkages" in the development of the Spanish telegraph and telephone systems, have also been explored.[95] And, finally, other authors have focused on the "backward

nineteenth century (…) transport problems continued raising limits to the Spanish possibilities to industrialise and develop"; see Ringrose (1974), p. 81 (my translation).

[85] Although dealing with the period immediately before the railway era, Madrazo (1984) offers a high quality approach to the evolution and the impact of the Spanish road network. For the period after 1850, see Gómez Mendoza (1999a) and Frax Rosales and Madrazo (2001).

[86] Alemany Llovera (1991), Sáenz Ridruejo (1994) and Guimerá Ravina (1996). Although not directly dealing with port infrastructure, Frax Rosales (1981), Frax Rosales and Matilla Quiza (1994) or Valdaliso Gago (1991) and (1997) are valuable analyses of the evolution of Spanish sea transport.

[87] See, for instance, Del Moral Ruiz (1981), Gómez Mendoza (1995) and Pérez Sarrión (1995).

[88] See, for instance, Costa Campí (1981), Monclús and Oyón (1996) and Núñez Romero-Balmas (1996b) and (1998).

[89] Bahamonde Magro (1993) and also, on the telegraph network, Capel Saéz and Tatjer (1994), González Peláez (1995), Olivé Roig (1995), Otero Carvajal (1995) and Calvo Calvo (2001), and, on the telephone system, Nadal Ariño (1995) and Calvo Calvo (1998).

[90] See, among others, Llorente Chala (1979), Hernández Andreu (1981) or Bartolomé Rodríguez (1995).

[91] See, for instance, Villanueva Larraya (1991), Al-Mudayna (1991), or Fernández Clemente (1998).

[92] See Frax Rosales and Matilla Quiza (1988), pp. 192-225, and Gómez Mendoza (1997) and (1999b).

[93] The main exception would have been Bilbao; on this subject see Alvargonzález Rodríguez (1996), p. 171, and De La Puerta Rueda (1994), pp. 292-293.

[94] See, for instance, Del Moral Ruiz (1981), Gómez Mendoza (1995), pp. 139-143, or Pérez Sarrión (1995), pp. 141-142.

[95] On the role of urban infrastructure, see Monclús and Oyón (1996); on the "backward linkages" of the Spanish telecommunication networks, see Calvo Calvo (1998), pp. 75-77, and (2001).

linkages" of public investment in infrastructure during the Inter-war period, and have offered conflicting conclusions on the subject.[96]

However, the largest amount of research effort on non-railway infrastructure has undoubtedly been devoted to the analysis of the economic impact of the Spanish electricity system. In this regard, some of the earlier assessments of the subject considered the development of hydroelectricity as one of the main determinants of the growth and diversification of Spanish industry during the first third of the twentieth century. Nevertheless, that enthusiastic view has later been replaced by a rather more moderate perspective on the matter.[97]

The overwhelming predominance (with very few exceptions)[98] of a sectoral approach in research at the national level is not to be found so clearly in regional studies. Although railways have been the main focus of attention of regional historians, their analysis has been accompanied by a substantial effort to study the joint impact of several types of transport infrastructure on regional economic growth.[99] In the last few years, a number of researchers have studied the effects of the reduction of transport costs on the development of the most dynamic regions of the country, such as Catalonia,[100] the Basque Country[101], Valencia[102] or some areas of Andalusia, and most of them have been rather optimistic on the subject. More concretely, they have insisted on matters such as the crucial role of transport improvements in the development of certain productions,[103] and their influence on the geographical concentration of population and activity since the middle of the nineteenth century.[104]

---

[96] See, on the one hand, Comín Comín and Martín Aceña (1984), pp. 249-258, who indicate that, although important, public investment was not decisive in the evolution of the Spanish heavy industries during the Inter-war period. On the contrary, Palafox Gamir (1980), p. 24, attributes a large share of the Spanish industrial growth during the 1920's to the demand effects of the State's activity.
[97] An example of the early highly optimistic analyses is Sudrià Triay (1987). However, the research of Bartolomé Rodríguez (1995) has recently indicated that the dynamic effects of the diffusion of electricity were rather low; see especially p. 113; and Sudrià Triay (1997a) himself has also offered a new perspective on the problem, which is much less enthusiastic than his earlier writings.
[98] The main exceptions of a sectoral approach in research at the national level are Comín Comín (1993) and, especially, Cubel Montesinos (1997), where infrastructure is said to have performed a crucial role in Spanish economic growth, and Gómez Mendoza (1991), which constitutes a first systematic quantitative approach to the evolution of the whole Spanish infrastructure during the process of industrialisation.
[99] See a survey of this type of research in Vidal Olivares (1999a).
[100] Pascual Domènech (1991).
[101] González Portilla et al (1995).
[102] Vidal Olivares (1992).
[103] See, for instance, Vidal Olivares (1992), pp. 183-270, and (1999a), pp. 385-387, Morilla Critz (1999), pp. 500-502, or Cuéllar Villar and Sánchez Picón (1999), p. 631.
[104] See, for instance, Macías (1999), pp. 461-474, Pascual Domènech (1999a), or Molina de Dios (2001).

Nevertheless, in spite of the huge increase in the available information on Spanish infrastructure during the last decade and the generalised optimism that has dominated regional literature, the contradictions that arose in the early analyses of the 1970's and 1980's have not disappeared from the historiography. And, in fact, those conflicts have returned to the forefront of the debate since 1998. That year, the 150th anniversary of the opening of the first Spanish railway line was commemorated with the publication of two collective works that summarised the results of the most recent research on the history of the Spanish railway system.[105] In those texts, the old conflict between a high social saving estimate and the poor performance of the Spanish railway system has still been considered a historiographical paradox, as is summarised in Gabriel Tortella's words:

> *"(...) all this* [Gómez Mendoza's] *reasoning is not consistent with the fact that the first stage of fast railway construction was followed by one of the deepest crises or depressions that the Spanish economy has suffered in Late Modern times (that of the years 1864-1874), nor with the fact that the Spanish railway companies turned out to be disastrous businesses, both during the crisis and thereafter, which led them to ask constantly for public subsidies and, during the first decades of the twentieth century, to be the most ferocious supporters of the nationalisation of the sector. (...) The question must be raised that, if transport was so badly needed and its shortage was constraining growth, why demand was so insufficient, traffic so scarce, and financial results so poor once railway lines and networks had been constructed."*[106]

In conclusion, two shortcomings may be highlighted in the most recent Spanish historiography on infrastructure and growth. Firstly, most research has been sectorally orientated and an aggregate perspective on the subject is still virtually missing. And, secondly, the conflicts that arose in the 1980's among different interpretations concerning the growth impact of Spanish railways remain unsolved. As was indicated in the introduction, this thesis is intended to shed some additional light on those two shortcomings. On the one hand, Chapters 2 to 5 offer an aggregate picture of the evolution of the whole Spanish infrastructure stock and its growth impact. And, on the other hand,

[105] Comín Comín et al (1998), and Muñoz Rubio et al (1999). Short surveys of the literature produced on the subject during the last twenty-five years have also been offered by Gómez Mendoza (1998) and Muñoz Rubio and Vidal Olivares (2001).
[106] Tortella Casares (1999), p. 250. See also Tortella Casares (1994a), pp. 111-114. Syntheses of the debate on the economic impact of Spanish railways can also be seen in Comín Comín et al (1998), Vol. 1, pp. 134-148, and Comín Comín (1999).

Chapters 6 and 7 address the so-called "paradox of Spanish railways" and suggest some possible answers for it. Starting with the first of those two tasks, the next chapter offers a detailed description of the process of construction of Spanish infrastructure between 1845 and 1935.

CHAPTER TWO

SPAIN'S INFRASTRUCTURE STOCK (1845-1935): A QUANTITATIVE ESTIMATE

2.1 Introduction

This chapter aims to describe the main features of the development of Spanish infrastructure stock and investment during the period 1845-1935. It is based on research into the available physical and monetary data on Spanish infrastructure, which has been undertaken on both a provincial and a national basis, and which has produced, as its main result, time series of infrastructure stock and investment for those years. This may be considered as the first exhaustive and systematic attempt to approach the long-term evolution to the whole Spanish infrastructure, and it joins other recent efforts to measure the total capital stock of the Spanish economy.[1]

As has been indicated in Chapter 1, the concept "infrastructure" has been confined here to the so-called "economic" infrastructure, i.e. those assets that provide direct services to production. The "social" infrastructure, which enhances social welfare but whose link with production is indirect, has been left aside. As has already been pointed out, there are two reasons for that choice. On the one hand, the links of economic and social infrastructure with economic growth are different, which makes a separate study of each type convenient. And, on the other hand, primary information about Spanish social

[1] The Spanish total capital stock in 1900-1990 has recently been estimated by Cubel Montesinos and Palafox Gamir (1997).

infrastructure is so scattered that its analysis is beyond the possibilities of an individual researcher.

Accordingly, the assets that have been included in this research are transport, communication and energy distribution networks, and hydraulic works. Some urban assets that are not embraced in those four categories (i.e. urban distribution of water, sewerage, lighting, streets and urban development) are also an essential part of economic infrastructure. However, it has not been possible to include them in this research, because a substantial share of the sources of information about their development are only locally available. As a consequence of their exclusion, the estimates that are presented in this chapter suffer from a downward bias of unknown magnitude.[2]

This research covers the first long run wave of Spanish industrialisation, which took place, approximately, from the first decades of the nineteenth century until the outbreak of the 1936-1939 Civil War.[3] The new estimates may be combined with the results of some recent pieces of research, which have focused on the evolution of Spanish infrastructure during the second half of the twentieth century, to obtain a nearly complete picture of the very long-run evolution of infrastructure during the whole process of Spain's industrialisation.[4]

---

[2] There is, however, some available evidence on the relative importance of the bias. On the one hand, Núñez Romero-Balmas (1996b), p. 400, has recently published data on bids for local public works and services at the expense of the Spanish local councils during the period 1900-1905. The cost estimates of the associated investment would amount to around 7 per cent of total gross infrastructure investment during those few years. This percentage is a lower bound of the investment excluded from my series, because some assets and, especially, urban development and street lighting, were, to a large extent, private undetakings and are not included in Núñez's figures. On the other hand, according to the earliest available data of the value of urban infrastructure in the second half of the twentieth century, in Mas et al (1995/1998), the assets that are excluded from my series amounted in 1955 to 6 per cent of the total infrastructure stock. This percentage might be assumed to be a higher bound of the magnitude of the bias throughout the period 1845-1935, because the growth of Spanish urban infrastructure seems to have been concentrated in the last few decades of the period. On the contrary, during the second half of the nineteenth century its growth would have been prevented by the slow progress of Spanish urbanisation and the weak fiscal capacity of the Local Councils. On the shortage of financial resources in the Spanish local public sector during the period (which, apart from reducing the endowment and quality of the Spanish local services, led to the generalisation of the concession regime), see Barthe (1919), p. 10, Del Moral Ruiz (1984), pp. 153-163, García García and Comín Comín (1995), pp. 90-100, Comín Comín (1996), pp. 201-206, or Núñez Romero-Balmas (1996b), pp. 417-419. Anyway, given the uncertainty on the level of the bias before 1900, it has not been made up for in the gross investment and net stock series that are presented here.

[3] The starting date of the analysis (1845) has been fixed according to the availability of information. If the research had covered a longer period, for example, from 1825 or 1830, it would have been more comprehensive. However, although some data is available for the years prior to 1845, its paucity does not allow the estimation of aggregate figures of infrastructure stock comparable with those presented here.

[4] The series available for the period 1955-1998 and the problems related to linking them with my estimates are described below. The impact of infrastructure on Spanish economic growth during the second half of the twentieth century has been the object of several recent pieces of research; see, among others, Argimón et al

This chapter describes the composition of infrastructure, the different stages that can be distinguished in the process of its construction, and the importance of infrastructure investment within the whole Spanish economy during the period under study, whereas Chapter 3 presents the distribution of infrastructure among the Spanish regions. In this chapter, Section 2.2 offers a brief account of the methods that have been followed for the construction of the new series. Section 2.3 describes the main features of the evolution and composition of the Spanish infrastructure stock and investment and, finally, Section 2.4 contains a summary of the main conclusions. The sources and the estimation methods used to obtain the infrastructure series are described in detail in the Appendix of this chapter.

2.2. The estimation of new series of Spanish infrastructure stock and investment

Spanish infrastructure stock and investment figures are available for the period 1955-1998 thanks to the recent research effort of the *Instituto Valenciano de Investigaciones Económicas* (from now on, *IVIE*).[5] As is usual in contemporary infrastructure estimates, they are essentially public capital stock figures. Therefore, they include some public assets that do not actually belong in infrastructure and, on the other hand, they exclude some share of infrastructure because it is privately owned. However, the biases associated with these problems are probably not very serious for the period after 1955, and the use of public capital figures as representative of infrastructure is, to some extent, justified by the ease of their estimation.[6]

The *IVIE* has also produced figures on the Spanish State's net capital stock for the years 1900-1990. However, the use of public capital figures as representative for infrastructure is not appropriate for the period before 1936, because railways, tramways and the telephone and electricity networks (i.e., more than 50 per cent of the stock of

(1994), González-Páramo (1995), Mas et al (1996), Moreno et al (1997) and (2002), Roca Sagalés and Pereira (1998), Boscà et al (1999) and (2002), and a comparison between the results of the research for the US and Spain, in Garcia-Milà (1994).

[5] *IVIE* data are available in Mas et al (1995/1998) and in http://bancoreg.fbbv.es. Before the *IVIE* series were produced, attempts to measure the Spanish capital stock were limited to a series of unreliable estimates that were published between 1914 and 1933 and are summarised in Cubel Montesinos and Palafox Gamir (1997), pp. 116-120, to the measurement of the Spanish "national wealth" at the end of 1965, which was published in Universidad Comercial de Deusto (1968) and to André Hofman's preliminary attempt to estimate time series of the Spanish capital stock; see Hofman (1993).

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

infrastructure) were privately owned at the time. As a consequence, in order to obtain infrastructure estimates for the period before the Spanish Civil War, information about the State's capital stock must be complemented with data on private investment in infrastructure. Actually, that task has recently been initiated by the *IVIE*, although from a purely sectoral perspective, with Cucarella's estimates of the Spanish stock of railway infrastructure since 1844.[7] In this research I adopt a wider perspective and try to obtain estimates for the whole (public and private) Spanish infrastructure during that period.

Several methods may be applied in the process of estimation of capital stock figures. Obviously, the optimal procedure is the direct measurement of the value of the replacement cost of the total stock in a series of benchmark years. However, the amount of information required for that estimation technique is usually beyond the possibilities of historical research. As a second best choice, most researchers use the perpetual inventory method, i.e. the accumulation of investment flows over time, after establishing a number of assumptions about the pattern of survival and decay of the assets. Finally, in those cases in which even investment figures are not available, the value of the stock in a benchmark year may be estimated by indirect means (for instance, by using the companies' accounts or by resorting to technical literature), and carried forward and backward according to indirect (usually physical) indicators of its evolution.

In this research, different approaches have been applied to the calculation of the stock of each type of infrastructure, according to the information available in each case.[8] The sources and the estimation methods that have been used for each category of assets, as well as the resulting figures and their comparison with the alternative available estimates, are described in detail in the Appendix of this chapter. The rest of this section offers a short summary of the general features of the estimation process.

The direct application of the perpetual inventory method has only been possible in those cases in which systematic information about investment flows was available, i.e. broad gauge railways, State roads and ports. For each of those three types of infrastructure, the usual perpetual inventory relationships have been applied to the investment figures

[7] Cucarella (1999). This author's estimates are compared with my own figures in the Appendix of this chapter.

[8] Obviously, the use of different techniques in the calculation of the stock may tend to bias the result. However, as Feinstein points out, in historical estimation of capital stock figures there is no alternative to the application of heterogeneous methods, due to the lack of appropriate primary information; see Feinstein (1972), pp. 39-42.

(after estimating the value of the gross and net stock at the end of 1844 on the basis of physical indicators) and, as a result, a series of net capital stock at the end of each year has been produced for the period 1845-1935.

For other types of infrastructure, the value of the gross capital stock in one or several benchmark years has been estimated according to the available accounting and/or technical information, and physical indicators of the evolution of the stock have then been used to transform the benchmark estimates into yearly series of gross stock. Those series have then been first-differenced in order to get yearly "new" investment figures, i.e. data on the annual excess investment after replacing the assets that were retired during the year. Each series of "new" investment has then been added to the series of replacement investment that resulted from the assumptions on the useful life of each asset. The sum of both series has been taken as gross investment in each type of infrastructure. Finally, the perpetual inventory relationships have been applied to those series of gross investment in order to get net stock figures.[9]

A rectangular retirement model has been applied in all cases, which assumes that each asset is retired at the end of its useful life. Depreciation has been assumed to be linear, as in the existing estimates for other countries.[10] In order to increase the international comparability of the estimate, the useful life figures, which are shown in Table 2.1, are also similar to other historical estimates, except in those few cases for which technical information was available.

---

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

[10] See Feinstein (1988), p. 261, or Groote (1996), p. 37. In spite of its widespread application in practice, these usual rigid assumptions on the retirement and depreciation of assets are not sufficient to grasp the complexity of the technological and structural changes experienced by the economic system, which influence the process of effective capital destruction. Therefore, these assumptions introduce biases in the final series that are very difficult to make up for, especially in a historical estimation exercise for which information is much scarcer than for present-times research. On this subject, see Escribá-Pérez and Ruiz-Tamarit (1995).

Table 2.1
Useful life assumptions

Assets	Years
Railways:	
Grading, works and stations	100
Track and accessories	18/30*
Tramways	25
Roads	80
Ports	80
Telegraph and Telephone	30
Electricity networks	25
Hydraulic works	80

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

Only the assets that are usually considered as infrastructure have been covered by the research. Therefore, the estimates do not measure the value of the total capital stock of sectors such as transport or energy production and distribution, but only include a specific type of assets within those sectors. As a consequence, those elements that are not fixed to the territory, do not have public character, or do not have the technical characteristics of infrastructure, have been excluded from the estimation. For instance, railway rolling stock, merchant ships, motor cars or energy production equipment (with the exception of dams) are not included in the series.

Very old infrastructure has also been kept out of the series. This category includes a number of paths, dams and canals that had been built before the eighteenth century and had in all cases reached the end of their useful life by 1844. Given the lack of information about their state of repair at that date, their valuation is not a feasible task. However, according to some contemporary indications, they seem to have been in a very precarious condition, especially in the case of paths.[11] As a consequence, they would have amounted to a very tiny share of the total stock in 1844, which would gradually have become negligible with the construction of new assets.[12]

[11] Some examples of contemporary complaints can be seen in Madrazo (1984), p. 235, or Gómez Mendoza (1989a), p. 35.
[12] Just for the sake of illustration, I have made a very optimistic valuation of those assets, assuming for them similar construction costs to eighteenth and early nineteenth century infrastructure, and a ratio between net and gross stock in 1844 of 50 per cent. Under these assumptions, those assets would amount to 13 per cent of the total stock in 1844 and only 2 per cent twenty years later. These percentages are probably an upper bound of the true figures, because the pre-eighteenth century assets were probably in a much worse condition in 1844 than that indicated by the 50 per cent ratio between net and gross stock.

Most of the new series are consistent with the available direct estimates of the value of Spanish infrastructure in the 1960's, which would be proof of their reliability.[13] In fact, in a few cases (broad and narrow gauge railways, State roads and ports) the 1960's figures have been directly used to obtain the estimates for 1935, which have been combined with the available information on previous investment flows to calculate earlier values. In other cases (underground railways, provincial and local roads, the telephone system, electricity networks and dams), the level of the series and the historical unit costs that have been used in the estimation are consistent with the information for the 1960's. The only exceptions are the telegraph network and the stock of irrigation and navigation canals. In the case of the telegraph, there is an apparent conflict between the new estimate and the value of the stock in 1965, which has been impossible to reconcile. And, in the case of canals, there is no available stock figure for the 1960's, and the shortcomings of the historical information make the reliability of my estimate rather uncertain.

In spite of these problems, the overall process of Spanish infrastructure construction seems to be adequately described by the series. However, as is usual with historical estimates, inferences drawn from small details or from short-term variations must be taken with extreme caution. There are several reasons for this *caveat*. Firstly, the usual problems of capital stock estimates must be remembered.[14] Secondly, some of the statistical data on which the estimation is based contain time gaps, which have been filled by interpolation and may to some extent have distorted the short-term behaviour of the series.[15] Thirdly, as has already been indicated for the stock of canals, in a few cases the reliability of the original quantitative information is doubtful, due to its incomplete or uncertain character. More concretely, apart from canals, sources are also rather incomplete or uncertain in the case of non-public railways, local roads before 1911 and the telephone system before 1924. Fourthly, the lack of specific sectoral deflators may have led to certain biases of unknown direction in the estimates.[16] And, finally, there is also some uncertainty about the

[13] Direct estimates of most Spanish infrastructure in the 1960's are available in Universidad Comercial de Deusto (1968).
[14] On the problems to get reliable and meaningful capital stock estimates, see Denison (1957). For infrastructure, see Gramlich (1994), p. 1178. See also Miller (1990), who warns against the severe biases that the perpetual inventory method may introduce in both the capital figures and the key parameters of production functions that are estimated on their basis.
[15] The presence of gaps and the interpolation techniques that have been used to overcome them are described in detail, for each type of infrastructure, in the Appendix of this chapter.
[16] All series have been expressed in 1990 constant pesetas to make them comparable with the *IVIE* database. Deflation is based on Prados de la Escosura's deflator for the construction sector, which has been weighted, in the case of telecommunications and electricity distribution networks, with the same author's deflator for industry (see the Appendix for the weights applied), and linked in 1954 with the official *INE* (*Instituto*

relationships between the real stock figures and the physical indicators that have been used to infer their evolution, which has made a number of *ad hoc* assumptions necessary.[17]

By contrast, and unlike other capital stock estimates, the influence of the assumed useful lifetimes of the assets on the level of the series is not high, because the estimates are largely based on physical indicators.[18] The only cases in which physical information has not been used in the estimation are broad gauge railways and State roads. However, in those two cases, the available direct estimates of the value of the stock in the 1960's have allowed the reliability of the perpetual inventory assumptions to be checked. Actually, in a great share of my series (i.e. those mainly based on physical indicators), the influence of the assumptions on the useful lifetimes of the assets is high, not for the level of net stock, but for gross investment figures, because the replacement element of gross investment has been estimated on the basis of those assumptions. For instance, if useful lifetimes had been assumed to be 50 per cent lower than those considered in Table 2.1, gross investment figures would have been on average 18 per cent higher than those presented below.

Graphs 2.1 and 2.2 combine the new estimates with the *IVIE* database to show the evolution of the Spanish infrastructure net stock and gross investment between 1845 and the present. In order to get a more complete picture, the new stock series for 1845-1935 has been carried forward until 1960, on the basis of the evolution of those assets for which

---

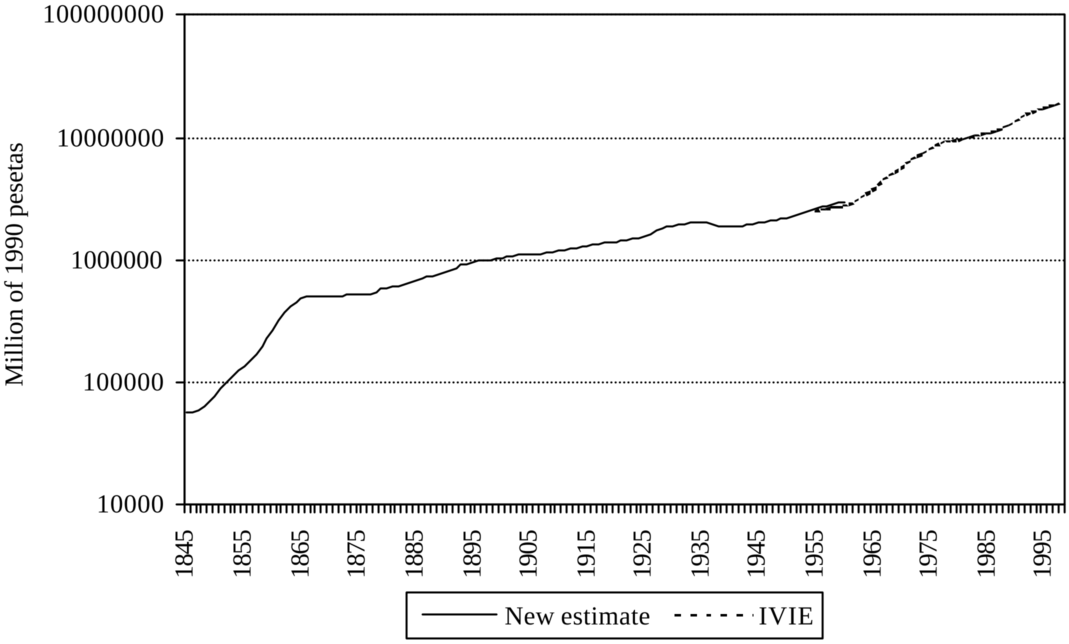
Nacional de Estadística) deflator for "other construction". Prados de la Escosura's deflators can be seen in Prados de la Escosura (1995), pp. 131-132. Actually, this author's deflator for construction is an average of prices of construction materials and wages and, therefore, it is not a price but a cost index. As a consequence, it reflects neither the evolution of productivity nor the presence of profits in construction companies. However, the use of construction cost indices is very usual in capital stock estimation exercises, even in analyses of present economies, due to the lack of adequate price information; see Pieper (1990). Besides, it is doubtful that construction productivity changed substantially during the period under study; see Feinstein (1988), pp. 262-263, or Frax Rosales et al (1996). Regarding deflation, the index number problem arises in the cases of the weights of telecommunications and electricity within total infrastructure, since Prados de la Escosura's industry deflator evolves in a slightly different fashion than construction one during the period under study, specially during the first third of the twentieth century. Using several price benchmarks in the estimation might produce lower shares for these two types of assets than those reproduced below (Table 2.2).

[17] The uncertainty of the relationship between a physical indicator and the value of the stock may be associated with many different facts. For instance, if mileage is chosen as an indirect indicator of the evolution of the value of a network, increases in the technical complexity of that network or in the quality of materials that are used in its construction may introduce a downward bias in the growth rate of the series. By contrast, upward biases may result from increases in the productivity of construction of the network, and can also arise as a consequence of the bad condition of the assets. On these problems see Caron (1972), p. 237, or Fogel (1967), p. 292. See also Hulten (1992), p. 976, who warns of the consequences of failing to adjust capital estimates for quality change. In my estimate, changes in quality and in the technical characteristics of the assets have been allowed for as far as possible, although in some cases the lack of information has prevented adjustments.

[18] On the sensitivity of capital stock figures estimated through the perpetual inventory method to the assumed useful lifetimes, see, for instance, Paccoud (1983), p. 22.

information is available.[19] The graphs offer a consistent picture of the evolution of Spanish infrastructure since the mid-nineteenth century. Both series show a very fast initial expansion and an abrupt interruption during the 1866-1874 crisis. After 1874, a slow growth process started, which only stopped during the Spanish Civil War and the first period of the Francoist dictatorship. The stagnation that characterised those years was overcome from 1964 onwards, when fast growth restarted. The next section describes in more detail the evolution of the series during the period 1845-1935.

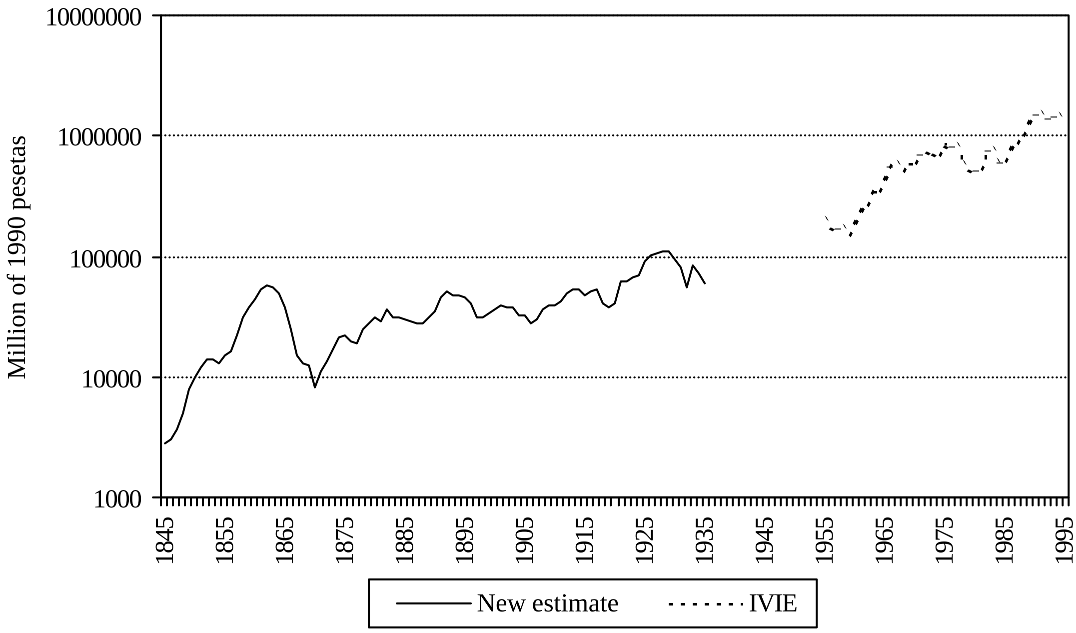
Graph 2.1
Spanish net infrastructure stock (1845-1998)



Source: Mas et al (1995/1998) and my own figures.

[19] The assets for which that information is available are broad and narrow gauge railways, State roads, ports and State hydraulic works. The main sources of information on the evolution of those assets in 1935-1960 are Suárez de Tangil y Angulo (1954), Cercos Pérez (1968), Uriol Salcedo (1968a), Comín Comín et al (1998) and the *IVIE* database. See more details in the Appendix, under each asset heading. This exercise is only a very rough approximation, given the low coverage of those data.

Graph 2.2
Spanish gross infrastructure investment (1845-1995)

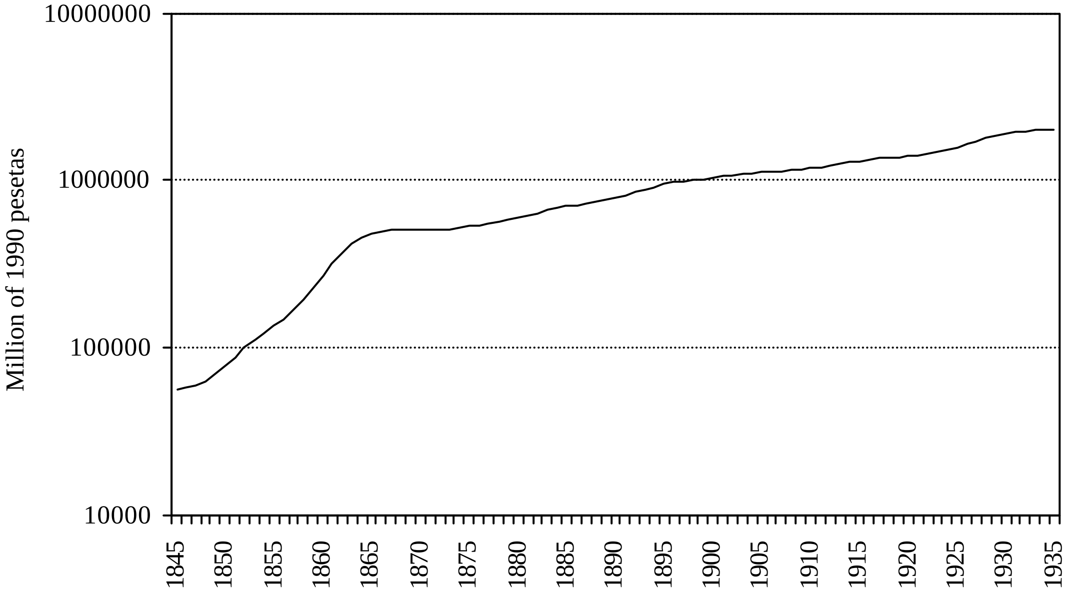


Source : Mas et al (1995/1998) and my own figures.

2.3 The process of construction of Spanish infrastructure (1845-1935)

Graph 2.3 shows the evolution of Spain's net infrastructure stock during the period up to the Civil War. The process of continuous increase that can be seen in the graph corresponds to a yearly growth rate of 3.3 per cent, which resulted in an infrastructure stock in 1935 that was 36 times larger than in 1845. Unlike the situation at the beginning of the nineteenth century, when Spanish infrastructure was made up of just some isolated structures and a deficient network of traditional paths, by 1935 the country had achieved a relatively rich and complex endowment of social overhead capital.

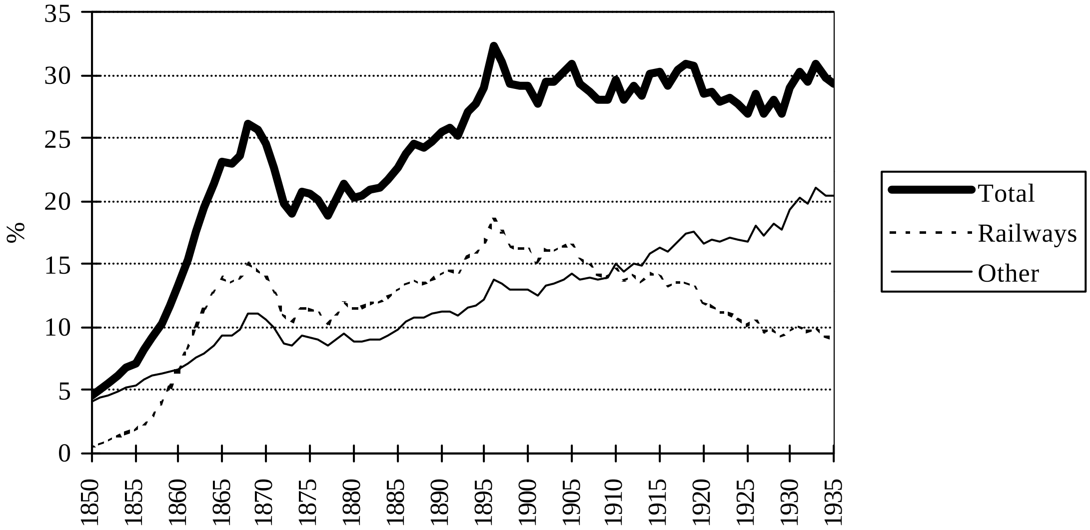
Graph 2.3
Spanish net infrastructure stock (1845-1935)



Source : see the Appendix of this chapter.

The increasing importance of infrastructure within the economy may be better observed in Graph 2.4, which presents the evolution of the relationship between Spanish infrastructure stock and GDP. According to the graph, the importance of infrastructure within the economy experienced a sharp increase up to the last few years of the nineteenth century and stagnated thereafter.

Graph 2.4
Spanish net infrastructure stock/GDP

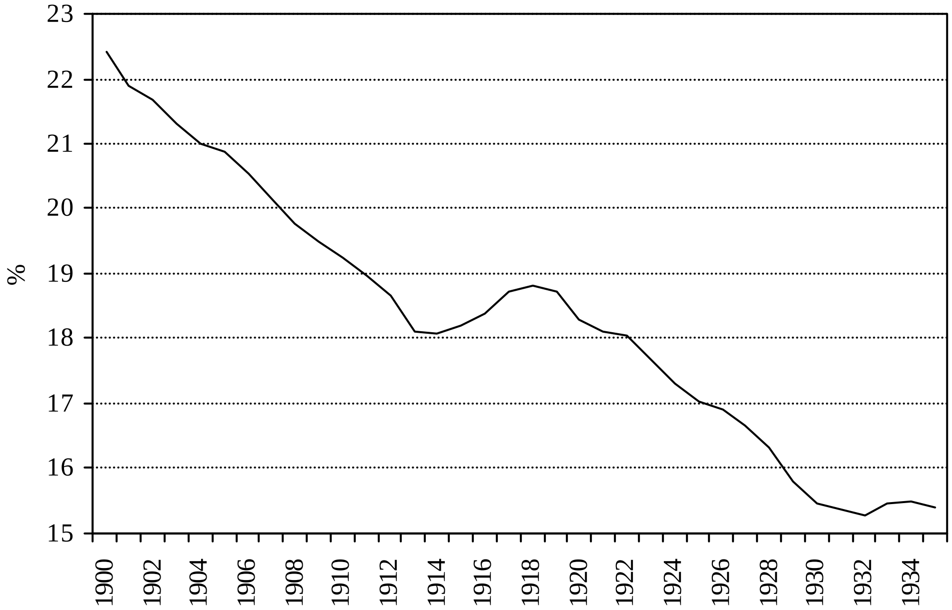


Sources : Prados de la Escosura (forthcoming) and my own figures.

On the other hand, regarding the relationship between infrastructure and total capital, the available capital stock estimates for the first third of the twentieth century indicate that, parallel to the stagnation of the ratio between infrastructure and GDP, there was a gradual reduction in the importance of infrastructure within Spanish capital, which can be observed in Graph 2.5.[20]

[20] Capital stock estimates for the nineteenth century have not yet been published. The percentages for 1900-1935 that are shown in Graph 2.5 must be taken with caution due to the differences in the estimation methods of the series of infrastructure and total stock, which may have introduced an upward bias in the ratio. Whereas my infrastructure stock estimates are mainly based on physical indicators and end-point valuations, estimates of total capital stock in Cubel Montesinos and Palafox Gamir (1997) are based on the application of the perpetual inventory method to the investment series estimated by Carreras (1990b), assuming useful lifetimes of 50 years for buildings and structures and 25 years for machinery and equipment. Whereas the second of those two figures is in line with most historical estimates, the first one is shorter than in most research for nineteenth century Europe. If a longer lifetime of, say, 75 to 100 years had been assumed, the total stock estimates would have been 10 to 15 per cent higher than Cubel and Palafox's actual figures. In addition, Cubel and Palafox's estimates include a second possible source of downward biases, as the investment figures on which they are based were elaborated using the 1958 price structure of Spanish GDP. Since inflation may be assumed to have been lower in investment goods than in the rest of GDP, Carreras' investment series might contain a downward bias, which would be larger in the first stages of the period under study. The possibility of downward biases in Cubel and Palafox's estimates is also illustrated by comparing their figure for 1958 and the *IVIE* earliest estimate of total net capital stock, which corresponds to the year 1964. Cubel and Palafox's figure is 53 per cent lower than the *IVIE* estimate, which would imply a very unlikely doubling of the Spanish total capital stock in only six years.

Graph 2.5
Spanish net infrastructure stock/total net capital stock



Sources : Cubel Montesinos and Palafox Gamir (1997) and my own figures.

According to all this evidence, two different periods can be distinguished in the development of Spanish infrastructure. Up to the late 1890's, the economy benefited from a growing endowment of infrastructure per unit of output, which would have entailed a substantial change in the conditions under which production took place. Later on, however, infrastructure endowment per unit of output stagnated, and further increases in the level of capitalisation of the Spanish economy were mainly associated with investment in machinery and equipment.[21]

The stagnation in the ratio between infrastructure and GDP and the decreasing importance of infrastructure within total capital from 1900 onwards may be related to the network dynamics involved in railway investment, which would result in a huge concentration of the investment effort in the second half of the nineteenth century. This can be seen in Graph 2.4, which shows that the different behaviour of the ratio between infrastructure and GDP before and after 1900 was associated with the evolution of the stock of railway infrastructure. Since all other infrastructure grew very gradually as a percentage of GDP during the whole period 1845-1935, the overall movements of the ratio

[21] The process of capitalisation of the Spanish economy during the first third of the twentieth century is analysed in Cubel Montesinos and Palafox Gamir (1997), p. 136.

between infrastructure and GDP and, probably, the decrease of the ratio between infrastructure and total capital stock after 1900, were mainly determined by the evolution of railway investment.

The prominence of railways in the evolution of infrastructure stock may also be observed in Table 2.2, which shows the changes in the composition of Spanish infrastructure stock between 1845 and 1935, and the growth rates of each type of stock. To allow for a more complete picture, data available for 1955 have also been included. The table indicates that railways and roads constituted by far the most important component of Spanish infrastructure during the whole period under study, amounting to between 64 and 91 per cent of the total stock. Ports and hydraulic works (mainly irrigation canals and reservoirs, although the few existing Spanish waterways are also included here) generally maintained a share of between 5 and 10 per cent each. And, finally, the networks of electricity distribution, telecommunications and urban and suburban transport, which were negligible during the second half of the nineteenth century, started gaining some importance by the First World War.

Table 2.2
Spanish net infrastructure stock (1845-1935)
A) Composition of the stock (%)

	Railways	Tramways and Underg.	Roads	Ports	Telecom.	Electricity	Hydraulic Works	Total (M of 1990 pts)
1845	0.57	0.00	63.57	24.79	0.00	0.00	11.06	55,948
1855	25.84	0.00	51.95	11.36	0.02	0.00	10.84	135,246
1865	59.92	0.00	28.71	5.66	0.06	0.00	5.65	484,772
1875	55.31	0.00	32.78	6.49	0.04	0.00	5.38	532,670
1885	56.90	0.09	34.20	4.74	0.04	0.13	3.91	695,513
1895	57.80	0.41	33.43	5.32	0.10	0.33	2.61	974,310
1905	53.55	2.11	33.37	7.27	0.08	0.96	2.66	1,116,963
1915	46.25	2.65	34.43	9.14	0.17	3.09	4.27	1,305,058
1925	37.66	5.03	34.00	8.15	0.38	7.98	6.80	1,579,934
1935	30.59	4.77	37.10	8.38	1.43	8.52	9.22	2,028,841
1955[a]	25.47	5.77[b]	36.01	9.56	na	na	17.72	2,487,451

B) Yearly growth rates of the stock (%)

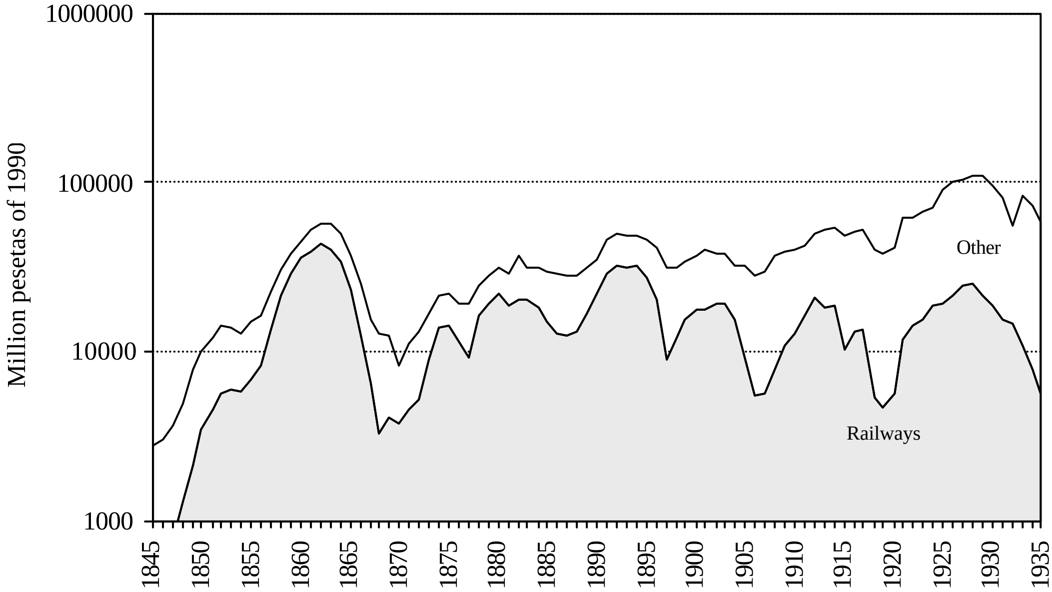
	Railways	Tramways and Underg.	Roads	Ports	Telecom.	Electricity	Hydraulic Works	Total
1845/55	45.79		7.34	1.09			9.44	9.53
1855/65	22.82		7.05	5.61	23.21		5.99	13.79
1865/75	-0.26		2.06	1.75	-3.15		0.26	0.61
1875/85	3.26		3.07	-0.74	0.59		-0.44	2.83
1885/95	3.48	21.30	2.78	4.41	12.08	11.22	-0.91	3.20
1895/1905	0.93	19.40	1.49	4.56	-1.84	11.81	1.79	1.64
1905/15	0.24	3.71	1.91	3.92	9.98	12.51	6.12	1.62
1915/25	-0.32	7.91	1.65	0.79	7.75	10.73	6.92	1.75
1925/35	0.49	2.04	3.37	2.53	16.64	2.45	5.83	2.49
1845/95	*10.14*		*4.27*	*2.53*			*2.42*	*5.43*
1895/1935	*0.26*	*6.89*	*2.11*	*2.64*	*9.89*	*10.91*	*5.76*	*1.91*
1845/1935	**4.40**		**2.98**	**3.00**			**2.63**	**3.33**

Sources: for 1845-1935, see the Appendix; for 1955, *IVIE*.
Notes: na, not available.
(a) The sum of the 1955 percentages is not 100 per cent, because airport infrastructure is also included in the total stock.
(b) Total urban infrastructure.
Stock growth is expressed in annual accumulative rates, adjusted to a log trend.

The table confirms some of the conclusions that have been drawn from Graph 2.4. After experiencing and intense process of growth during the years previous to the 1866 crisis, railways became the most important part of total infrastructure, accounting for more than half of the total stock. As a consequence, the increase in the endowment of infrastructure per unit of GDP up to the end of the nineteenth century was mainly driven by with the process of construction of the railway network. However, between the late 1890's and the Civil War, the stock of railway infrastructure virtually stagnated and its share within the total stock diminished, while other infrastructure went on growing uninterruptedly. As a result, the degree of diversification of the total stock increased. Nevertheless, the growth of other assets was not enough to raise the ratio between infrastructure and GDP, nor to keep the pace with non-infrastructure capital stock, as is shown in Graphs 2.4 and 2.5.

Similar conclusions result from an examination of the estimates of gross infrastructure investment. In addition, the series of capital formation allows a better understanding of the fluctuations and the direction of investment efforts throughout the process of construction of the stock. Graph 2.6 shows the evolution of gross infrastructure investment in the years 1845-1935, distinguishing between railways and other assets.

Graph 2.6
Spanish gross infrastructure investment (1845-1935)



Sources : see Appendix of this chapter.

As can be seen in the graph, during the first few decades of the period under study, infrastructure investment experienced a huge increase up to extremely high values, and collapsed afterwards. Those violent movements were closely associated with the evolution of railway investment, marked by an intense mania during the years 1856-1866 that ended in a severe crisis in the late 1860's and early 1870's. The violence of those movements is illustrated by the fact that the absolute level of investment of 1862 was not recovered until

1921, while its level relative to GDP or total investment was probably never reached again.[22]

After the crisis, a very long growth process started with more moderate fluctuations. Graph 2.6 shows, nevertheless, that investment cycles continued to be largely dependent on the evolution of railway capital formation for a long time. So, once the 1866 crisis had been overcome by the late 1870's, the resumption of railway construction during the next two decades resulted in a relatively high growth of total infrastructure investment. However, in the mid-1890's, railway capital formation came to a halt after the virtual completion of the main railway network and, as a result, total infrastructure investment slowed down.[23]

During the first third of the twentieth century, the first two troughs that may be observed in the evolution of the aggregate investment series, which were situated in 1904-1907 and at the end of the First World War, were also associated with abrupt interruptions in railway capital formation. That dependence of infrastructure investment fluctuations on the evolution of railway capital formation was only broken after 1920. During the 1920's, increasing State activism and the intense structural change of the Spanish economy fostered infrastructure investment, and in the early 1930's the impact of the Great Depression and the Spanish political turmoil again reduced its level.[24] However, unlike the previous period, in those fifteen years railways did not lead the evolution of total infrastructure, but they just mirrored the behaviour of investment in other assets, among

[22] As can be seen in Graphs 2.7 and 2.8 and Table 2.5 below, gross infrastructure investment reached levels of more than 25 per cent of total investment and 2.5 per cent of GDP by the early 1860's, and railway investment accounted for around three quarters of these percentages. Railway manias of that kind were a very widespread phenomenon in the Western economies at the time; on railway investment fluctuations in the nineteenth century see, for instance, Fishlow (1965), pp. 105-106, O'Brien (1977), p. 57, or Carreras (1999), pp. 41-45. Situations in which railway investment accounted for 25 per cent or more of total investment, or for 2.5 per cent or more of GDP, have been pointed out for Britain in 1847 and the US in 1854, by Mitchell (1964), Feinstein (1972), p. 40, and O'Brien (1977), p. 55; for Germany in the 1850's, the 1860's and the 1870's, by Fremdling (1983), p. 124, and Tilly (1978), p. 414; for Hungary in the late 1860's and early 1870's, by Katus (1983), p. 191; for Sweden in the 1870's, by Hedin (1967), p. 11, and Holgersson and Nicander (1968), p. 5; and (although referring to the whole infrastructure and not only to railways) for France in the 1850's, by Lévy-Leboyer (1978), p. 287, and the Netherlands in the late 1870's, by Groote (1996), p. 76.

[23] In 1895, 86 per cent of the pre-Civil War length of the main (broad gauge) railway network had already been open to public service. Obviously, apart from the virtual completion of the railway network, the international depression also had an effect on the level of infrastructure investment from the last few years of the nineteenth century. However, the need to complete the last railway projects would have prevented the depression from being noticed in Spanish infrastructure investment figures before 1895, unlike the situation in other countries such as France; see, for example, Lévy-Leboyer (1978), pp. 255-266.

[24] On the increasing activism of the Spanish State during the first third of the twentieth century see Comín Comín (1996), pp. 41-43, or Palafox Gamir (1991), pp. 109-121.

which roads, electricity distribution networks and irrigation works had the most prominent role.[25]

In spite of the intensity of its fluctuations, infrastructure investment seems to have experienced a structural process of continuous and sustained growth during the period under study. In order to detect the structural breaks that could have affected that process, the Vogelsang test has been applied to the investment series. That test is aimed at contrasting the existence of one-time breaks in linear trending data in the presence of serial correlation, regardless of whether a unit root is present or not. In the application of the test to the logarithm of Spanish gross infrastructure investment, the null hypothesis of no structural break has not been rejected for any year of the period.[26] This result is consistent with the outcomes of some recent pieces of research, which have not found any significant structural breaks in other Spanish economic variables during the period before 1936.[27] Therefore, in spite of its short-term instability, Spanish infrastructure investment experienced a sustained growth at a yearly rate of 2.3 per cent with no significant structural breaks during the country's first long wave of industrialisation.

The prominent role of railways in the evolution of infrastructure investment can also be seen if the series is analysed in relative terms. Graph 2.7 and Table 2.3 show the ratio between gross infrastructure investment and GDP. They clearly reflect the essential role of railways in the evolution of the ratio at least until the beginning of the 1920's, since the railway crises of 1866, the late 1890's and 1918 resulted in the collapse of infrastructure construction not only in absolute terms but also as a percentage of GDP.[28]

---

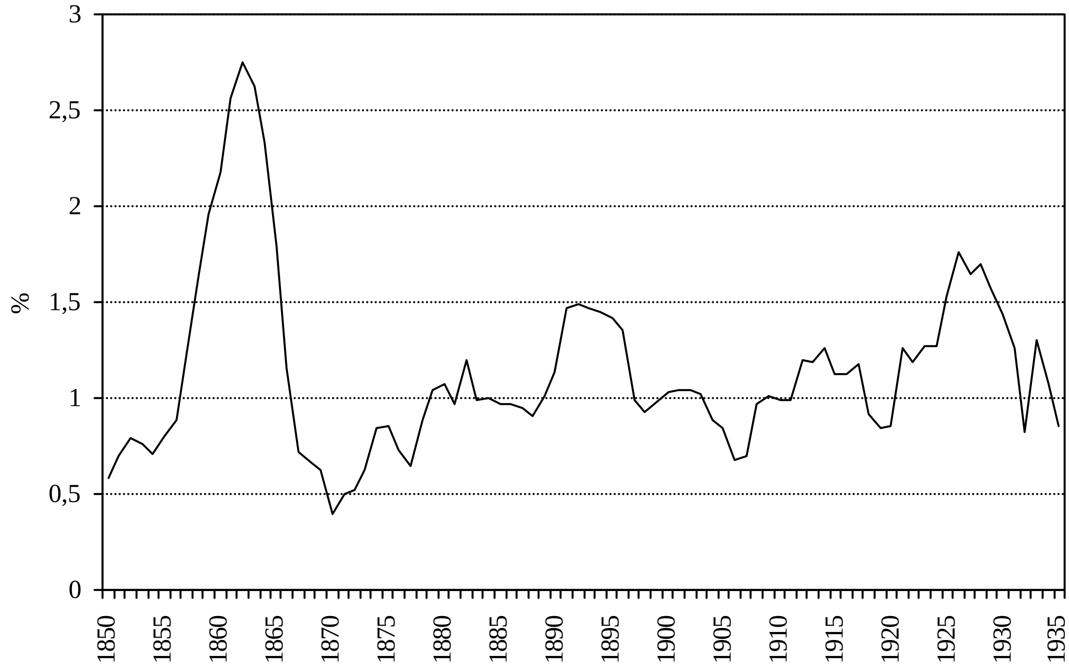
[25] A similar investment pattern to the Spanish one has been described for Dutch infrastructure in Groote (1996), pp. 54-59. This author also stresses the central role of railways in the determination of the early periods of growth (1852-1888) and further slowdown (1889-1902) of total infrastructure capital formation, and points out the prominence of other assets later on, in the gradual increase in the level of investment during the first years of the twentieth century.

[26] For the Vogelsang test, see Vogelsang (1997) and Ben-David and Papell (2000). A structural break has been tested for all years between 1854 and 1926, after excluding the 20 per cent extreme years of the series. The Wald test for the rejection of the null hypothesis of no structural break reaches its maximum F-statistic for 1864, but at a level of only 6.50, which is much lower than the critical value of the test (15.44 at the 5 per cent significance level).

[27] Cubel Montesinos and Palafox Gamir (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 Novell and Tirado Fabregat (2001) have analysed 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.

[28] The average Spanish infrastructure investment rate of 1.14 per cent of GDP in 1850-1935 is much lower than in other countries, such as the UK (2.18 per cent in 1830-1913), Germany (1.96 per cent in 1850-1913) and France (1.93 per cent in 1848-1913), and is slightly lower than the Dutch figure for 1800-1913 (1.2 per cent), although the difference would be larger if the time sample were the same, because the Dutch rate was

Graph 2.7
Spanish gross infrastructure investment/GDP



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

Table 2.3
Spanish gross infrastructure investment/GDP (%)

1850-1859	1.00
1860-1869	1.74
1870-1879	0.71
1880-1889	1.00
1890-1899	1.27
1900-1909	0.92
1910-1919	1.08
1920-1935	1.30
1850-1895	*1.15*
1895-1935	*1.13*
1850-1935	**1.14**

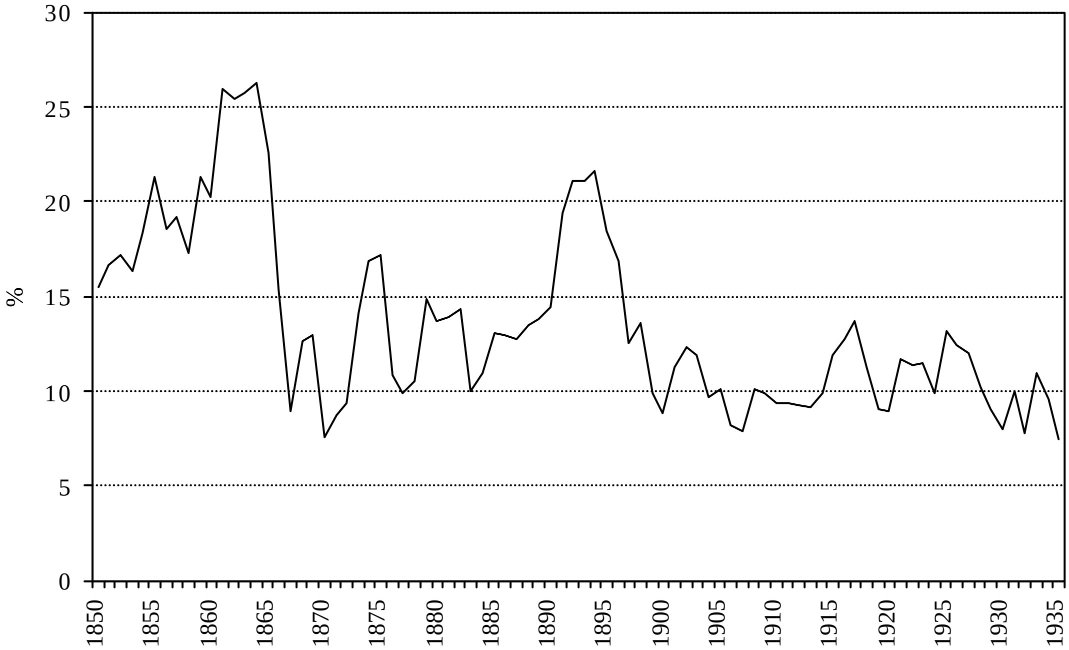
Sources: Prados de la Escosura (forthcoming) and my own estimates.

Graph 2.8 and Table 2.4 show the ratio between gross infrastructure investment and gross total capital formation, which also reflects the prominence of railways, at least during the second half of the nineteenth century. Before 1900, the periods of more intense railway construction (i.e. the early 1860's and the early 1890's) were also the periods in which the ratio reached its maximum. After that year, the ratio remained stable at relatively low

under 1 per cent during most of the period 1800-1850, and over 1.5 per cent in most of the years between 1850 and 1913. The low level of the Spanish rate is typical of a less developed economy with a large primary sector. Figures for other countries, in Groote (1996), pp. 76 and 85.

levels, which indicates the partial adaptation of infrastructure to the movements of total investment, and the reduction in its relative importance. That helps to explain the decreasing share of infrastructure assets within Spanish capital stock between 1900 and 1935 that has been described above.

Graph 2.8
Spanish gross infrastructure investment/total gross investment



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

Table 2.4
Spanish gross infrastructure investment/total gross investment (%)

1850-1859	18.17
1860-1869	19.61
1870-1879	11.99
1880-1889	12.89
1890-1899	16.90
1900-1909	10.02
1910-1919	10.56
1920-1935	10.25
1850-1895	*16.15*
1895-1935	*10.76*
1850-1935	**13.55**

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

Finally, Table 2.5 offers a complementary picture to Table 2.2, presenting the composition of infrastructure capital formation throughout the period, as well as the growth rates of investment in each type of assets, which clearly reflect the violent fluctuations of infrastructure capital formation during the period under consideration and, especially, during its first decades.

Table 2.5
Spanish gross infrastructure investment (1845-1935)
A) Composition of investment (annual average, %)

	Railw.	Tramways and Underg.	Roads	Ports	Telecom.	Electric.	Hydr. Works	Total (M of 1990 pts)
1845/55	37.19	0.00	45.93	6.23	0.02	0.00	10.63	10,006
1856/65	70.69	0.00	20.94	4.30	0.09	0.00	3.98	40,531
1866/75	48.35	0.00	38.53	9.54	0.04	0.00	3.54	15,843
1876/85	58.25	0.72	32.58	6.99	0.06	0.54	0.66	37,320
1886/95	58.79	0.88	31.34	7.34	0.26	0.74	0.64	38,994
1896/1905	43.58	6.05	30.70	13.57	0.10	3.13	2.86	35,555
1906/15	30.27	2.95	33.67	15.35	0.49	9.32	7.96	41,979
1916/25	21.16	8.25	29.10	7.71	0.92	21.50	11.36	57,449
1926/35	19.14	2.57	36.67	9.85	3.52	16.47	11.78	86,800
1845/1895	*59.98*	*0.33*	*30.80*	*5.62*	*0.13*	*0.29*	*2.84*	*26,163*
1895/1935	*26.36*	*4.61*	*33.06*	*10.92*	*1.69*	*14.03*	*9.33*	*55,224*
1845/1935	**38.57**	**3.04**	**32.29**	**8.94**	**1.12**	**9.03**	**7.01**	**39,035**

B) Yearly growth rate of investment (%)

	Railw.	Tramways and Underg.	Roads	Ports	Telecom.	Electric.	Hydr. Works	Total
1845/55	31.65		14.21	8.90			15.96	18.90
1855/65	15.17		7.69	15.44			1.53	12.15
1865/75	0.03		-4.04	-4.34			-38.49	-2.76
1875/85	4.49		6.24	5.15	-7.32		8.12	5.12
1885/95	10.72	31.60	-1.30	12.64	8.60	23.69	1.34	6.78
1895/1905	-2.84	6.96	-2.89	-2.02	10.64	2.27	26.57	-1.49
1905/15	10.26	-11.99	2.76	0.39	3.44	20.44	9.80	6.42
1915/25	7.04	17.72	3.02	-1.04	8.21	8.48	4.03	5.85
1925/35	-12.68	-7.74	-4.55	4.62	-13.05	-11.11	4.78	-5.27
1845/1895	*4.62*		*2.63*	*2.60*			*-3.90*	*3.22*
1895/1935	*-0.20*	*2.15*	*2.93*	*0.85*	*12.76*	*8.62*	*8.94*	*2.67*
1845/1935	**1.19**		**2.08**	**3.14**			**3.29**	**2.25**

Sources: see the Appendix of this chapter.
Note: Investment growth is expressed in annual accumulative rates, adjusted to a log trend.

In line with previous comments, the table reflects the enormous concentration of the investment effort on railways until the last few years of the nineteenth century, and the further diversification of investment during the first third of the twentieth century. According to the data, during the second half of the nineteenth century, 60 per cent of the resources that were invested in the improvement of Spanish infrastructure stock were devoted to railways, and most of the remaining investment was dedicated to the development of the road network. Other infrastructure received extremely small proportions of total resources. That situation gradually changed after the virtual completion of the railway network in the 1890's, when a process of intense diversification of investment started. The reduction in the importance of railways firstly benefited ports and urban and suburban transport. However, the shares of those assets in total investment were soon taken over by irrigation infrastructure. And, finally, thanks to the development of new energy and communication technologies, an increasing amount of resources was devoted to the construction of the telephone system and, especially, electricity distribution networks.[29]

* * *

In summary, if a feature may be singled out as the most characteristic of the process of construction of Spanish infrastructure between 1845 and 1935, it is the contrast between railways and all other elements. If railways are set aside, infrastructure investment grew in a sustained manner during the whole period under study and the endowment of infrastructure per unit of output also grew without interruption up to the Civil War. The growth of the railway stock, on the contrary, was very intense during the second half of the nineteenth century and stagnated thereafter. Due to the importance of railways within total infrastructure, their particular evolution determined the movements of the ratio between infrastructure stock and GDP.

The distinct evolution of railways may be explained by the characteristics of railway technology and Spain's geography. On the one hand, railways constituted a country-wide system with clear network economies. On the contrary, all other infrastructure (except for the telegraph network) had, at least until the First World War, a predominantly local or regional scope. The network economies that characterised railways meant that their private and social returns could only reach their potential maximum when the whole system was finished, which may help to explain the huge concentration of resources on railway construction during the second half of the nineteenth century.[30]

On the other hand, the limited opportunities for the development of inland waterways in Spain gave railways a crucial role in the process of reduction of long-distance transport costs and integration of the Spanish market. In other European countries, complementarity between railways and navigation was much more important, and the process of economic integration could rely on a variety of transport systems. In mid-nineteenth century Spain, on the contrary, there was no feasible alternative to the

[29] 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 railway companies by 1921; see Bartolomé Rodríguez (1995), p. 109.

[30] This idea was already advanced by Nadal Oller (1975), p. 42.

construction of the railway network as a prerequisite for market integration and the development of a modern growing economy. In that context, the State's determination to endow the economy with a railway system may be easily understood, although this does not rule out the hypothesis pointed out by some historians that the mistakes that were made throughout the construction process by Spanish governments could have put an excessive burden on the economy.[31]

The characteristics of Spain's geography also help to explain the absolute decrease in railway investment during the first decades of the twentieth century. Spain's low population density prevented the growth of the railway network beyond a certain level because, once the main long-distance lines had been constructed, opportunities to establish profitable lines with a smaller spatial scope were extremely limited.

Stagnation of railway capital formation coincided with the gradual diversification of infrastructure. However, the growth of the stock of other types of infrastructure was much smoother than in the case of railways. Among other reasons, this may be related to the fact that, before the First World War, roads were the only non-railway infrastructure that made up a large scale network.[32] However, in the second half of the nineteenth century they were mainly addressing local and regional needs. Network economies were therefore much less important than in the case of railways, and it is not possible to observe comparable phenomena of temporal concentration of investment in roads. On the other hand, road construction was much cheaper than railway construction. As a consequence, the growth of the road network went on well after the completion of the main connection lines, and the limits to the development of the network had not yet been reached by the 1930's, as can be seen in Table 2.6.

[31] See especially Tortella Casares (1973) and (1999), and also Chapter 7 of this thesis.
[32] As has been indicated before, another exception was the telegraph network, but it had very little importance within total infrastructure.

Table 2.6
Relative development of railways and roads (1870-1930)

Year	Road mileage /railway mileage
1870	4.03
1880	3.72
1890	3.64
1900	3.51
1910	3.89
1920	4.50
1930	8.08

Sources: see the Appendix of this chapter.

In all other infrastructure, such as urban transport, ports, hydraulic works and electricity distribution, investment had a clearly local scope at least until the First World War and, unlike railways, growth was rather smooth. The situation only changed in the 1920's and 1930's, when technological change generated network economies in some of those assets. By the mid-1920's, the establishment of a new network of highways well adapted to medium and long distance motor car traffic, a national telephone system, and an extensive and unified electricity distribution network arose as necessary, "lumpy" investments that needed to be undertaken as fast as possible. In those three cases, the local character of earlier investment was replaced all over Europe by the planning of national networks. In Spain, however, the turbulent years of the Great Depression and, later on, the Civil War, and the long economic stagnation that ensued, delayed improvements until the late 1950's, with the only partial exception of the national telephone network.[33]

2.4 Conclusions

This chapter has presented 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 industrialisation. Although some measurement of State capital stock had already been undertaken, this research is the first systematic attempt to estimate the value of the whole Spanish infrastructure.

[33] In the case of electricity, the development of national systems in the European countries during the Inter-war period has been described by Segreto (1993), p. 362. For Spain, the failure to develop such an integrated network before the Civil War has been analysed by Torá (1983) and Bartolomé Rodríguez (2000).

It has been necessary to use a variety of sources and techniques in the estimation. In general, the final figures are consistent with the available information on the physical evolution of Spanish infrastructure during the period, and also with its monetary value in the 1960's, when the first direct estimates were produced. The new series may therefore be accepted as reasonably reliable to the standards of historical statistics, with the possible exceptions of the telegraph network and the stock of Spanish canals.

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. This chapter has focused on the main characteristics of Spanish infrastructure stock and investment before the Civil War of 1936, i.e. during the period that constitutes the central interest of the thesis. The new quantitative evidence reflects a constant and sustained effort of improvement and enlargement of Spanish infrastructure endowment throughout the period. Although infrastructure investment was characterised by very violent fluctuations, especially during the first and the last years of the period under study, it has not been possible to confirm the presence of structural breaks in the series which could have interrupted or substantially altered its long-term growth.

Broadly speaking, it is possible to distinguish two distinct periods in the evolution of Spanish infrastructure. On the one hand, during the second half of the nineteenth century the Spanish infrastructure endowment per unit of output experienced a constant increase. That process was mainly associated with the construction of the railway network, which accounted for exceedingly high shares of total infrastructure investment. Railway construction showed, much more than any other infrastructure, a high temporal concentration, due to the network economies of the railway system and the lack of feasible alternatives for long-distance transport in Spain.

On the other hand, from the last few years of the twentieth century, railway capital formation stagnated due to the virtual completion of the main railway network. The leading role in infrastructure investment was then transferred to other assets without such important network economies and with a much smoother growth. In spite of the gradual development of those other assets, the stagnation of railway investment from the late 1890's resulted in the stability of the ratio between total infrastructure stock and GDP, and in the reduction in the share of infrastructure within total capital. That situation started changing in the last fifteen years of the period, when network economies arose in sectors such as roads, electricity distribution and telecommunications. However, the Great Depression and Civil War interrupted those changes until the second half of the twentieth century.

This description of the evolution of Spanish infrastructure conceals, however, very diverse situations in the different Spanish regions. Infrastructure investment was not evenly distributed across the Spanish territory and, parallel to its continuous growth, it is possible to observe the appearance of differences in endowment among regions. In this research, together with the estimation of the new infrastructure series, some indicators of regional infrastructure endowments have also been obtained, and they are presented and analysed in the following chapter.

APPENDIX

SOURCES AND ESTIMATION METHODS OF THE NEW INFRASTRUCTURE DATABASE

A.2.1 Transport infrastructure

This section presents new estimates of the net infrastructure stock of railways, urban transport, roads and ports. The lack of information has precluded obtaining figures for airport infrastructure, although this exclusion seems to be of minor importance in the period before 1936.[34]

[34] The *IVIE* gives yearly figures of State non-military investment in air transport since the beginning of the twentieth century. However, there are two reasons that prevent us from using those data to estimate infrastructure stock figures. Firstly, a large share of the Spanish airport investment was not financed by the State before 1936. More concretely, until 1927 most civil air transport was a private business, in which the State only took part via subsidies. The 1927 Airport Act changed that situation by setting up a system of *Juntas* that were in charge of airport investment. However, under the new system, each airport *Junta* could be financed not only by the State, but also by the Local Councils, the Provincial *Diputaciones* and private

1) Railways

In the case of railways, differences in the available information have led to different estimation procedures being adopted for broad and narrow gauge lines, which are separately described in this section. Regarding broad gauge railways, capital formation in the sector has already been studied by historians. In the 1980's, Antonio Gómez Mendoza published decennial figures of investment in "new construction" and "upkeep" of broad gauge railways, which were based on the accounting information of the "five largest" companies.[35] In recent research, Cucarella has transformed Gómez Mendoza's data into a yearly series of gross investment in broad and narrow gauge railway infrastructure, to which he has applied the perpetual inventory method to get an estimate of Spanish net railway stock.[36]

Cucarella's stock series, however, contains a number of shortcomings that make it difficult to accept without criticism. Firstly, the whole railway infrastructure has been assumed to have a useful life of 40 years. Although this figure may be appropriate for track and accessories, it is too short to be applied to stations, grading and other works. Secondly, the series has not been corrected for the value of land, which is included in Gómez Mendoza's investment figures. Thirdly, narrow gauge railways have been included in the estimation by applying to their length a unit value of 75 per cent of that of broad gauge railways. Nevertheless, information available on construction costs indicates that a lower figure would be more appropriate. Finally, in Cucarella's estimates, the whole of Gómez Mendoza's figures for "upkeep" expenses have been considered as capital formation. However, they also include certain expenses that merely relate to maintenance and surveillance. The last three problems introduce serious upward biases to the series. Although they are to some extent overcome by the assumption on the useful life of the assets, the unreliability of the final stock figures makes it advisable to carry out an alternative estimation.[37]

---

contributors. In addition, the airport of Barcelona, which was one of the most important in Spain at the time, was transferred to the Catalan regional government in 1932. Secondly, the *IVIE* data include 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 cannot be included in infrastructure. On these issues, see AENA (1996). According to the *IVIE* database, the State-owned air transport capital stock amounted in 1935 to 11,136.7 million of 1990 pesetas, i.e. around 0.5 per cent of my estimate for total infrastructure. Although this figure does not represent infrastructure stock, it may be considered indirect evidence of the little importance of airports within the Spanish infrastructure before 1936.

[35] See Gómez Mendoza (1989a), p. 69. Investment figures do not include rolling stock, although the author does not indicate which method was applied to exclude it. There is no mention either in the text of the specific companies that make up the sample.

[36] Cucarella (1999), pp. 69-76.

[37] Another problem, although less relevant for the final results, is the fact that Cucarella distributes the investment of the years 1855-1859 throughout the whole decade of 1850, obtaining as a consequence too low

In this research I have also applied the perpetual inventory method to the available investment figures, although avoiding the problems that affect Cucarella's estimation and benefiting from a large amount of additional statistical information. The main basis for the estimation is also the accounting information of a sample of companies. The accounts of *Primer Establecimiento* (First Establishment) of the Spanish railway companies reflected the amounts devoted each year to the construction or acquisition of lines. Accordingly, the positive differences between the value of those accounts in two adjacent years may be considered as a proxy for the yearly capital formation of each company.[38]

Of course, the shortcomings of the available accounting data are numerous and very difficult to overcome. Firstly, in the case of acquisitions, the amount paid by a company for an already constructed line could be very different from its construction cost.[39] Secondly, in those cases in which construction cost accounting figures are available instead of acquisition values, they usually contain an upward bias associated with the high level of corruption that dominated the construction process.[40] Thirdly, the annual increases in the value of "First Establishment" are neither "new" nor gross (i.e. "new" plus replacement) capital formation, because during the period under study the companies' replacement investment was distributed between "First Establishment" and some operation expense accounts, such as "*vía y obras*" (track and works) and "*gastos extraordinarios*" (extraordinary expenses).[41] Unfortunately, it is not possible to add the value of those two accounts to "First Establishment" figures to obtain a series of gross capital formation, because (especially in the case of "track and works") they also contain expenses that can by no means be considered replacement investment, but just maintenance and surveillance.

---

levels of yearly investment before 1860. That mistake is due to an error in the edition of Gómez Mendoza's data, which has been sorted out in a later work by the same author; see Gómez Mendoza (1991), p. 196.

[38] In some cases those accounts diminished from one year to the next. Those reductions were usually associated with sales of land or the retirement of rolling stock and, therefore, have not been considered in the estimation process. On this subject, see Gómez Mendoza (1991), p. 196.

[39] See, for instance, Cordero and Menéndez (1978), pp. 261-262, and also Tedde de Lorca (1980), who indicates that, in the case of *Andaluces*, acquisition costs of other companies' assets were only 40 per cent of the original accounting construction costs.

[40] See, among others, Tedde de Lorca (1978), pp. 235-240 and (1980), Keefer (1996), or Comín Comín et al (1998), Vol. 1, pp. 203-210. This problem is also present in construction cost data for other countries; see, for instance, for Britain, Kenwood (1965), p. 314, for the US, Fishlow (1965), pp. 351-356, and Fogel (1960), p. 54, and, for Portugal, Pinheiro (1979), p. 284.

[41] This procedure was also usual in other countries; see, for instance, Fishlow (1966), p. 591, Green (1986), p. 789, and, especially, Pollins (1969), pp. 156-158. This author has indicated that, in the case of the British railways, "*the basis for the allocation of certain important items between capital and revenue accounts was not the same in all companies, and (…) the allocation was not carried out in a consistent manner by any major companies*" (pp. 160-161), the accounting practices changing according to "*financial circumstances and the dictates of management policy* (p. 159).

In spite of those problems, the lack of good quality alternatives makes "First Establishment" data the best way to approach investment by the Spanish railway companies and, therefore, they are also the basis for the current estimation. The companies whose "First Establishment" data have been collected are: *Norte*, *MZA*, *Andaluces*, *MCPO* and *Sur*, as well as *Tudela-Bilbao* and the main Catalan broad gauge railway companies before their absorption by *Norte* and *MZA*.[42] Those data are available for the period 1858-1935, in which those companies accounted for a growing share of the broad gauge network.[43] As has been indicated, the positive differences between the value of "First Establishment" accounts in two adjacent years have been considered as capital formation figures, and have been deflated and diminished to exclude land and rolling stock.[44] The rest of the network has been assumed to have the same construction cost as the companies in the sample.[45]

In order to transform investment into stock data, it is necessary to make a number of assumptions about the distribution of investment among different assets and about each asset useful lifetimes. These have been assumed to be, in the case of track and accessories, 18 years until 1871 and 30 years from 1872 onwards[46] and, in the case of grading, works

[42] For *MZA*, *Andaluces*, *MCPO* and *Sur*, data comes from the companies' annual reports. The "First Establishment" accounts of *MCPO* and *Sur* have been assumed to remain unaltered after 1928, when they were nationalised. For other companies, data has been taken from Tedde de Lorca (1978), pp. 264-290, in the case of *Norte*; Pascual Domènech (1999b) for the Catalan companies; and Ormaechea (1989), p. 18, for *Tudela-Bilbao*. In the last two cases, infrastructure investment has been assumed to be zero during the railway crisis of 1866-1873.

[43] The share of the sample companies in the mileage of the broad gauge railway network was 57 per cent on average before 1878 and 83 per cent thereafter.

[44] As was indicated before, if nothing else is said, deflation of all series presented in this Appendix is based on Prados de la Escosura's deflator for the construction sector, in Prados de la Escosura (1995), pp. 131-132, which has been linked in 1954 with the official *INE* (*Instituto Nacional de Estadística*/National Statistic Institute) deflator for "other constructions". Land is assumed to amount to 5 per cent of the capital stock, and rolling stock is assumed to be 10 per cent of capital up to 1910, and to grow from 10 to 25 per cent between 1911 and 1935. These percentages result from the examination of the available data on the construction cost structure of Spanish railways, coming from Alzola y Minondo (1884-1885), 33, p. 228, Hernández (1983), Tedde de Lorca (1978), pp. 264-290, Pascual Domènech (1999b) and *MZA*'s annual reports. The unit construction cost that results from the "First Establishment" accounts gradually diminishes until 1898 and increases thereafter. The increase after 1898 can be explained by the process of infrastructure improvement that took place during the first third of the twentieth century (i.e. electrification, laying of double track and enlargement and modernisation of stations). However, the previous decrease is more difficult to explain and may have been associated with the fact that, during the first stages of construction, investment was concentrated on the most important and better equipped lines of the country, as well as to the high level of corruption that characterised the railway mania of 1855-1866.

[45] Total network mileage in operation comes from Cordero and Menéndez (1978), pp. 324-325. These authors' series has been transformed into a constructed mileage series by applying Fenoaltea's procedure for Italy; see Fenoaltea (1984), p. 67. This author assumes that the building of each line lasted for 5 years and distributes therefore the length that was open to operation each year throughout the former 5-year period, according to the following coefficients: 0.23, 0.3, 0.23, 0.16 and 0.08. Out-of-sample lines have been assumed to have the 1898 unit cost of the sample lines during the whole period 1845-1898, and the same yearly unit cost as the sample after 1898.

[46] See Gómez Mendoza (1982), p. 95, and (1991), p. 197, and Groote (1996), p. 98.

and stations, 100 years.[47] The shares of each asset within total construction costs have been assumed to be 25 per cent for track and accessories and 75 per cent for grading, works and stations.[48]

An additional problem to carry out the estimation is the fact that, as previously indicated, capital formation figures coming from "First Establishment" accounts are not a series of either "new" or gross investment, because replacement was partially accounted within operation expenses. In order to get a series of gross investment in broad gauge railway infrastructure, it is also necessary to make some assumptions on the share of replacement investment that was entered as "First Establishment" in the companies' accounts. Moreover, the Spanish railway companies suffered a severe process of undercapitalisation, especially from the 1890's onwards, due to their inability to meet the required replacement investment.[49] Therefore, assumptions about the companies' accounting practices have to be accompanied by additional assumptions on the companies' underinvestment during the period under study.

Given the degree of uncertainty about these two aspects, it seems convenient to look for complementary means to approach the value of the stock of broad gauge railway infrastructure during the period of analysis. Actually, the information available about Spanish broad gauge railway investment and stock after nationalisation in 1941 makes it possible to get an estimate of the value of the stock in 1935. A direct estimate of the replacement cost of the capital stock of the public company *RENFE* is available for the year 1963, which may be carried backward thanks to information on the net investment of *RENFE* in 1941-1963 and on the destruction of railway infrastructure during the Civil War of 1936-1939.[50] The resulting value of the net broad gauge railway infrastructure stock in 1935 is 406,559 million of 1990 pesetas.

---

[47] In the case of grading and works, I assume a constant replacement process to make up for the share of depreciation that is caused by deterioration, as in Feinstein (1965), p. 9.

[48] Percentages coming from Alzola y Minondo (1884-1885), 33, p. 228, Hernández (1983), Pascual Domènech (1999b) and *MZA*'s annual reports.

[49] On this subject see below, Section 7.3.

[50] The 1963 estimate, in Mira Rodríguez and Llagunes Farras (1968), p. 506. A series of *RENFE*'s total net investment and depreciation in 1942-1963 is available in Comín Comín et al (1998), Vol. 2, p. 62. These authors also offer information on the composition and level of total gross investment during those years (p. 64). The share of infrastructure in net investment has been assumed to be the same as in gross investment. For 1936-1941, gross investment has been assumed to be zero, and depreciation has been assumed to follow the same log trend as in 1942-1963. Comín Comín et al (1998), Vol. 2, p. 3, also give estimates of the destruction of infrastructure that was suffered by *Norte* and *MZA* during the Civil War, and similar rates of destruction have been assumed for the rest of the network.

If it is assumed that, during the period 1845-1935, 60 per cent of replacement investment was entered in the companies accounts as "First Establishment" and the rest as operation expenses, and that only half the resources that were required for the replacement of old assets were actually invested, the available accounting data would imply a net infrastructure stock in 1935 of 465,124 million of 1990 pesetas, i.e. only 14 per cent higher than the value resulting from *RENFE*'s information.[51] These two assumptions have therefore been retained in the estimation, and Table A.2.1 shows the series that have been obtained as a result.

Table A.2.1
Broad gauge railways (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1845	322	0	322	322	0	322	322
1846	506	1	505	826	7	499	820
1847	786	2	784	1,610	18	768	1,589
1848	1,296	4	1,292	2,902	34	1,261	2,850
1849	2,029	7	2,022	4,924	62	1,967	4,817
1850	3,208	12	3,195	8,119	105	3,102	7,919
1851	4,159	20	4,139	12,258	174	3,985	11,904
1852	5,243	30	5,212	17,470	263	4,980	16,884
1853	5,551	43	5,508	22,978	375	5,176	22,060
1854	5,738	57	5,681	28,659	493	5,245	27,306
1855	6,789	71	6,719	35,378	615	6,174	33,480
1856	8,293	87	8,205	43,583	760	7,533	41,013
1857	13,572	108	13,464	57,047	936	12,636	53,649
1858	21,219	141	21,078	78,126	1,225	19,994	73,643
1859	28,802	193	28,609	106,734	1,678	27,124	100,767
1860	35,114	264	34,851	141,585	2,292	32,822	133,589
1861	38,454	350	38,105	179,690	3,040	35,414	169,004
1862	42,780	443	42,337	222,026	3,859	38,921	207,924
1863	40,000	628	39,372	261,398	4,770	35,230	243,155
1864	33,481	770	32,711	294,109	5,615	27,866	271,020
1865	22,535	920	21,615	315,724	6,318	16,217	287,237
1866	11,858	1,099	10,759	326,483	6,782	5,076	292,313
1867	5,439	1,307	4,132	330,616	7,010	-1,571	290,742
1868	2,293	1,609	684	331,299	7,090	-4,797	285,945
1869	3,461	1,847	1,614	332,913	7,086	-3,625	282,320
1870	3,347	2,122	1,225	334,139	7,095	-3,747	278,572
1871	3,734	2,202	1,532	335,670	7,085	-3,352	275,221
1872	4,122	2,252	1,869	337,540	7,080	-2,958	272,263
1873	7,471	2,520	4,950	342,490	7,031	440	272,703
1874	12,148	2,909	9,239	351,729	7,111	5,037	277,740
1875	13,178	4,254	8,924	360,653	7,198	5,980	283,720
1876	10,397	6,193	4,204	364,857	7,240	3,157	286,877
1877	8,182	8,108	74	364,931	7,148	1,034	287,910
1878	15,428	9,701	5,727	370,658	6,933	8,495	296,406

[51] That difference might be explained by a number of reasons, such as deflation problems, or the aforementioned excess construction costs associated with corruption and the high cost of capital during the construction process.

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1879	18,812	10,568	8,243	378,901	6,758	12,054	308,460
1880	21,176	11,691	9,486	388,387	6,598	14,579	323,038
1881	16,976	11,010	5,967	394,353	6,448	10,529	333,567
1882	18,340	9,397	8,943	403,297	6,263	12,077	345,644
1883	17,290	6,671	10,619	413,916	6,173	11,117	356,762
1884	14,616	3,987	10,629	424,545	6,189	8,428	365,189
1885	11,587	2,337	9,250	433,795	6,282	5,305	370,494
1886	8,877	1,454	7,423	441,218	6,403	2,475	372,969
1887	8,547	1,665	6,882	448,100	6,520	2,027	374,996
1888	9,817	1,542	8,275	456,375	6,623	3,193	378,190
1889	12,548	1,624	10,924	467,299	6,752	5,796	383,985
1890	16,268	1,269	14,999	482,298	6,066	10,202	394,187
1891	21,640	1,301	20,339	502,638	6,311	15,330	409,517
1892	23,751	1,346	22,405	525,043	6,640	17,111	426,628
1893	22,731	1,397	21,335	546,377	7,003	15,729	442,356
1894	24,647	1,444	23,203	569,580	7,349	17,298	459,654
1895	21,069	1,496	19,573	589,153	7,725	13,344	472,999
1896	16,123	1,539	14,584	603,737	8,043	8,080	481,079
1897	6,101	1,569	4,532	608,269	8,283	-2,182	478,897
1898	8,805	1,574	7,231	615,500	8,364	441	479,337
1899	11,383	1,585	9,798	625,298	8,488	2,896	482,233
1900	12,428	1,603	10,825	636,123	8,652	3,776	486,009
1901	10,863	1,623	9,239	645,363	8,833	2,030	488,039
1902	10,901	2,096	8,805	654,168	8,989	1,913	489,952
1903	10,223	2,845	7,379	661,546	9,130	1,094	491,046
1904	5,933	3,878	2,054	663,601	9,235	-3,302	487,744
1905	2,892	3,612	-720	662,881	9,239	-6,347	481,396
1906	1,906	2,148	-242	662,639	9,203	-7,297	474,099
1907	2,337	829	1,508	664,147	9,201	-6,864	467,235
1908	3,868	2,004	1,864	666,011	9,249	-5,381	461,855
1909	6,494	2,515	3,979	669,990	9,282	-2,788	459,067
1910	7,834	1,609	6,224	676,215	9,340	-1,506	457,561
1911	9,635	931	8,704	684,918	9,449	186	457,746
1912	14,033	2,109	11,924	696,843	9,610	4,424	462,170
1913	11,730	3,253	8,477	705,320	9,801	1,929	464,099
1914	10,928	3,962	6,965	712,285	9,918	1,010	465,109
1915	3,069	4,060	-991	711,293	9,999	-6,931	458,179
1916	8,540	3,831	4,710	716,003	9,953	-1,413	456,766
1917	10,641	3,660	6,981	722,984	10,001	640	457,406
1918	2,033	4,060	-2,027	720,957	10,088	-8,055	449,351
1919	0	4,704	-4,704	716,254	10,026	-10,026	439,324
1920	0	5,811	-5,811	710,443	9,911	-9,911	429,414
1921	5,427	7,142	-1,715	708,727	9,758	-4,330	425,083
1922	8,896	7,672	1,224	709,951	9,646	-750	424,333
1923	10,281	7,428	2,853	712,804	9,571	710	425,043
1924	13,302	7,921	5,381	718,185	9,527	3,775	428,818
1925	14,432	7,048	7,384	725,569	9,515	4,917	433,735
1926	16,444	5,836	10,609	736,178	9,550	6,894	440,630
1927	20,925	3,359	17,566	753,744	9,658	11,267	451,897
1928	23,130	4,075	19,055	772,799	9,920	13,210	465,107
1929	19,851	4,765	15,086	787,885	10,194	9,657	474,764
1930	16,612	5,063	11,548	799,433	10,395	6,217	480,981
1931	12,834	4,700	8,133	807,566	10,534	2,299	483,280

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1932	11,365	4,501	6,865	814,431	10,627	738	484,019
1933	6,852	3,980	2,872	817,303	10,704	-3,852	480,167
1934	3,765	2,402	1,363	818,666	10,727	-6,962	473,205
1935	2,672	1,772	900	819,566	10,754	-8,081	465,124

In the case of narrow gauge railways, the first step of the estimation has been the elaboration of a new yearly mileage series, due to the lack of consensus among the available ones.[52] The new series of mileage in operation is based on the information provided by *MAEOP* and *AFT*, and is presented in Table A.2.2. It has been transformed into a series of constructed mileage by applying Fenoaltea's procedure for the Italian railways (see above).

The second step in the estimation has been the search for unit construction cost figures for narrow gauge railways. The "First Establishment" accounts of a sample of companies (that amounted to 89 per cent of the network) in 1922 has been used to obtain that information.[53] "First Establishment" data have been deflated according to the timing of construction of the network and have been used to get a unit construction cost figure, after subtracting 18 per cent of total cost to exclude land and rolling stock.[54] The resulting unit cost has been applied to the yearly constructed mileage data to obtain a series of "new" investment. Annual retirements (and, therefore, replacement expenses) have been estimated according to the useful life of the assets, and "new" and replacement investment figures have been added up to obtain a series of gross investment, to which the perpetual inventory method has been applied to obtain the yearly value of the net stock.[55]

[52] Yearly series of narrow gauge railway mileage are available in *AEE*, Instituto Nacional de Estadística (1965), and Gómez Mendoza (1989b), pp. 282-284. Those three series only coincide from 1915 onwards, and none of them is consistent with the information given by *MAEOP* on lines in operation.

[53] This information is available in *MAEOP*.

[54] This percentage comes from Alzola y Minondo (1884-1885), 33, p. 228.

[55] Useful lifetimes as in broad gauge railways. The share of each type of assets within total stock has been taken from Alzola y Minondo (1884-1885), who suggests 49 per cent for grading and works, 29 per cent for track and 22 per cent for stations. Replacement has been assumed to coincide with retirements, except for those lines that were closed before 1936. The value of the net stock in 1935 that results from these assumptions is 60 per cent higher than the estimate available for 1965 in Mira Rodríguez and Llagunes Farras (1968), p. 520. This is consistent with the bad condition and the increasing undercapitalisation of the narrow gauge Spanish railways after the Civil War of 1936, which are pointed out by Comín Comín et al (1998), Vol. 2, p. 316, and also with the gradual disappearance of some companies, which was very intense during the 1960's. If my estimate for 1935 is carried forward under the assumption that only 50 per cent of the required replacement investment was actually met during the period 1936-1965, the resulting net stock estimate for 1965 would be just 5 per cent lower than the direct estimate for that year that is reproduced in Mira Rodríguez and Llagunes Farras' article.

Table A.2.2
Narrow gauge railways (million of 1990 pesetas)

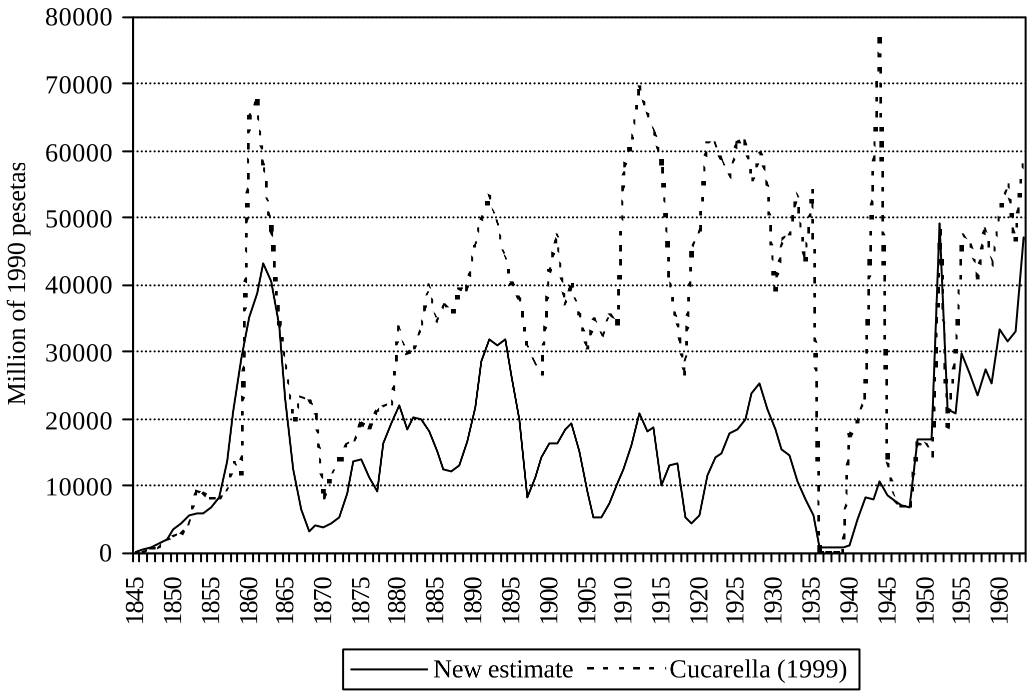
	Network length (km)	Gross Inv.	Retirements	New Inv.	Gross Stock	Depreciation	Net Inv.	Net Stock
1849		96	0	96	96	0	96	96
1850		218	0	217	314	2	216	312
1851		328	2	326	640	7	320	632
1852		440	3	437	1,077	15	425	1,058
1853	29	385	5	380	1,457	25	360	1,417
1854	37	93	7	86	1,543	34	59	1,476
1855	37	27	7	19	1,562	36	-10	1,466
1856	38	22	8	15	1,577	37	-14	1,452
1857	38	8	8	0	1,577	37	-29	1,423
1858	38	8	8	0	1,577	37	-29	1,393
1859	38	23	8	15	1,592	37	-14	1,379
1860	38	154	8	146	1,738	37	116	1,495
1861	38	283	8	275	2,012	41	242	1,737
1862	38	399	10	389	2,401	47	352	2,089
1863	43	489	12	477	2,878	56	432	2,521
1864	78	465	14	451	3,329	68	397	2,918
1865	78	404	16	388	3,717	78	326	3,244
1866	78	661	18	643	4,359	87	573	3,817
1867	78	927	49	878	5,238	103	825	4,642
1868	114	995	88	907	6,145	123	872	5,513
1869	160	558	124	435	6,579	145	414	5,927
1870	160	431	158	273	6,852	155	276	6,203
1871	160	795	143	653	7,505	161	634	6,838
1872	160	1,060	61	999	8,504	176	883	7,721
1873	160	1,420	47	1,373	9,877	310	1,110	8,831
1874	243	1,494	52	1,442	11,319	311	1,183	10,014
1875	276	898	55	843	12,162	309	589	10,603
1876	276	851	59	791	12,953	302	549	11,152
1877	289	1,033	67	966	13,919	300	734	11,886
1878	341	978	110	868	14,788	316	662	12,548
1879	362	579	151	428	15,216	330	249	12,797
1880	362	838	186	652	15,869	335	503	13,300
1881	362	1,458	214	1,243	17,112	344	1,114	14,414
1882	396	2,012	213	1,799	18,911	362	1,650	16,063
1883	397	2,761	204	2,557	21,468	390	2,370	18,434
1884	496	3,500	289	3,210	24,678	432	3,068	21,502
1885	546	3,456	401	3,055	27,733	482	2,973	24,475
1886	608	3,727	459	3,268	31,001	528	3,198	27,673
1887	745	3,517	370	3,147	34,149	577	2,940	30,613
1888	797	3,177	370	2,806	36,955	626	2,550	33,163
1889	851	4,205	477	3,728	40,682	670	3,535	36,698
1890	895	5,490	198	5,292	45,975	696	4,794	41,492
1891	1,019	7,062	223	6,839	52,814	787	6,275	47,767
1892	1,147	8,114	257	7,857	60,671	904	7,210	54,977
1893	1,350	8,416	295	8,122	68,792	1,038	7,378	62,355
1894	1,596	7,132	334	6,798	75,590	1,177	5,955	68,310
1895	1,765	5,345	367	4,978	80,568	1,294	4,051	72,361
1896	1,980	3,733	392	3,341	83,909	1,379	2,354	74,715
1897	2,029	2,193	408	1,785	85,694	1,436	757	75,472
1898	2,040	2,490	416	2,073	87,768	1,467	1,023	76,495
1899		3,011	427	2,585	90,352	1,502	1,509	78,004

	Network length (km)	Gross Inv.	Retirements	New Inv.	Gross Stock	Depreciation	Net Inv.	Net Stock
1900		3,833	439	3,394	93,747	1,546	2,287	80,291
1901		5,523	456	5,068	98,814	1,605	3,919	84,210
1902		7,522	793	6,729	105,544	1,691	5,831	90,040
1903	2,358	9,131	914	8,217	113,761	1,806	7,324	97,365
1904		9,322	972	8,349	122,110	1,947	7,375	104,740
1905	2,985	6,258	836	5,422	127,532	2,090	4,168	108,907
1906	3,083	3,362	848	2,514	130,046	2,183	1,179	110,087
1907	3,135	2,988	915	2,073	132,120	2,226	762	110,849
1908	3,196	3,552	934	2,617	134,737	2,261	1,290	112,139
1909	3,252	3,806	857	2,949	137,686	2,306	1,500	113,639
1910	3,252	4,642	969	3,672	141,358	2,357	2,285	115,924
1911	3,342	6,335	1,182	5,153	146,511	2,419	3,916	119,840
1912	3,575	6,717	1,360	5,357	151,868	2,508	4,210	124,049
1913	3,588	6,414	1,586	4,828	156,696	2,599	3,815	127,864
1914	3,673	7,708	1,871	5,837	162,533	2,682	5,026	132,890
1915	3,902	7,038	1,950	5,088	167,621	2,782	4,256	137,146
1916	4,111	4,574	2,080	2,494	170,115	2,869	1,705	138,851
1917	4,147	2,829	1,952	877	170,992	2,912	-83	138,768
1918	4,147	3,233	1,844	1,390	172,381	2,927	307	139,075
1919	4,147	4,531	2,209	2,322	174,703	2,950	1,580	140,655
1920	4,169	5,572	2,373	3,198	177,902	2,990	2,581	143,237
1921		6,183	2,834	3,349	181,251	3,045	3,138	146,375
1922	4,410	5,401	3,144	2,258	183,509	3,102	2,299	148,674
1923	4,450	4,697	3,231	1,466	184,975	3,141	1,556	150,230
1924	4,484	4,477	2,857	1,620	186,595	3,166	1,311	151,541
1925	4,519	4,038	2,340	1,697	188,292	3,194	844	152,385
1926	4,537	3,610	1,877	1,733	190,025	3,223	387	152,772
1927	4,605	3,029	1,438	1,592	191,616	3,252	-223	152,549
1928	4,682	2,256	1,528	728	192,344	3,280	-1,024	151,525
1929	4,657	1,679	2,690	0	191,333	3,292	-2,468	149,057
1930	4,657	1,912	1,912	0	191,333	3,292	-1,380	147,677
1931	4,657	2,470	2,394	76	191,409	3,292	-822	146,855
1932	4,657	3,337	3,193	143	191,552	3,293	37	146,892
1933	4,657	3,921	3,703	217	191,770	3,296	625	147,517
1934	4,623	4,045	5,152	0	190,663	3,300	-420	147,097
1935	4,646	2,960	2,742	217	190,880	3,305	-345	146,752

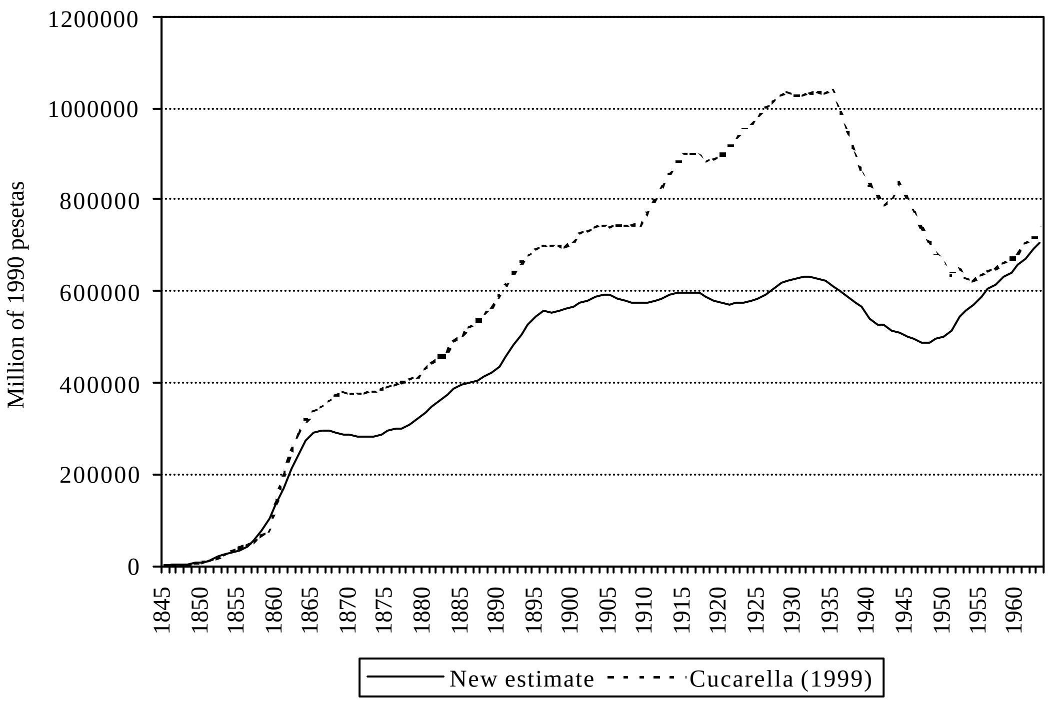
Graphs A.2.1 and A.2.2 compare the new series of gross investment and net stock of broad and narrow gauge Spanish railways with Cucarella's estimates. The large difference in levels between the series may be explained by the upward biases that affect Cucarella's figures and that have been described above.[56]

[56] Both series of stock have been carried forward up to 1963 to show their convergence at a slightly higher level than the direct estimate for 1965 in Mira Rodríguez and Llagunes Farras (1968), which is ca. 630,000 million of 1990 pesetas.

Graph A.2.1
Gross investment in railway infrastructure
(alternative estimates)



Graph A.2.2
Net stock of railway infrastructure (alternative estimates)



Additional information has been collected on other categories of Spanish railways, i.e., on the one hand, those companies that did not provide public service, which were mainly associated with mining activities, and, on the other hand, urban underground railways. Information available on non-public railways is of very bad quality. It is possible to find mileage data for most years since 1874 in *MAEOP* and *AFT*, but the two sources provide very different figures. This causes a drop in the series in 1922, the last year for which railway data were published in *MAEOP*, which has been smoothed throughout the previous and the following years.[57] The gaps have been filled with interpolations, and the resulting yearly mileage series has been transformed into a constructed mileage series by using Fenoaltea's method for Italy (see above). A unit cost of 18.5 million of 1990 pesetas per km has been applied to this series in order to get yearly figures of "new" investment.[58] This result has been added to the replacement expenses that result from the assumptions on the useful lifetimes of the assets, to get a gross investment series. This has been subjected to the perpetual inventory method.[59] The final series are shown in Table A.2.3 and in Graphs A.2.3 and A.2.4.

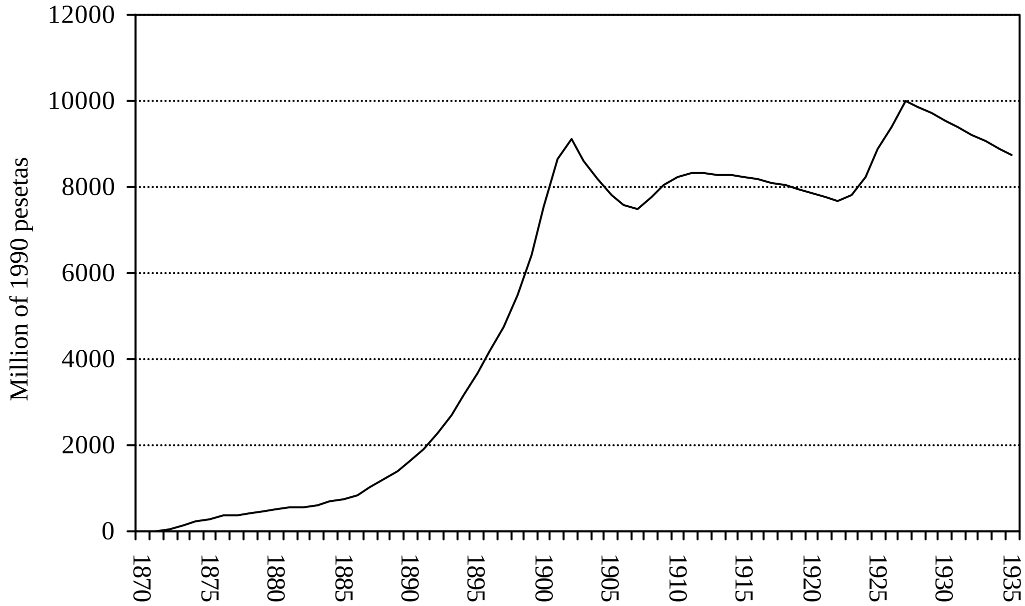
Table A.2.3
Non-public railways (million pesetas of 1990)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1870	10	0	10	10	0	10	10
1871	20	0	20	30	0	20	30
1872	49	0	49	79	0	48	78
1873	78	0	77	156	1	76	155
1874	86	0	86	242	2	84	239
1875	75	1	75	317	3	72	311
1876	66	1	65	382	5	61	372
1877	24	1	23	405	5	19	391
1878	39	1	38	443	6	33	424
1879	52	1	51	494	6	46	470
1880	64	1	62	556	7	57	527
1881	47	2	45	601	8	39	566
1882	36	2	35	636	9	28	593
1883	50	2	49	685	9	41	635
1884	72	2	70	755	10	62	697
1885	74	2	72	826	11	63	760

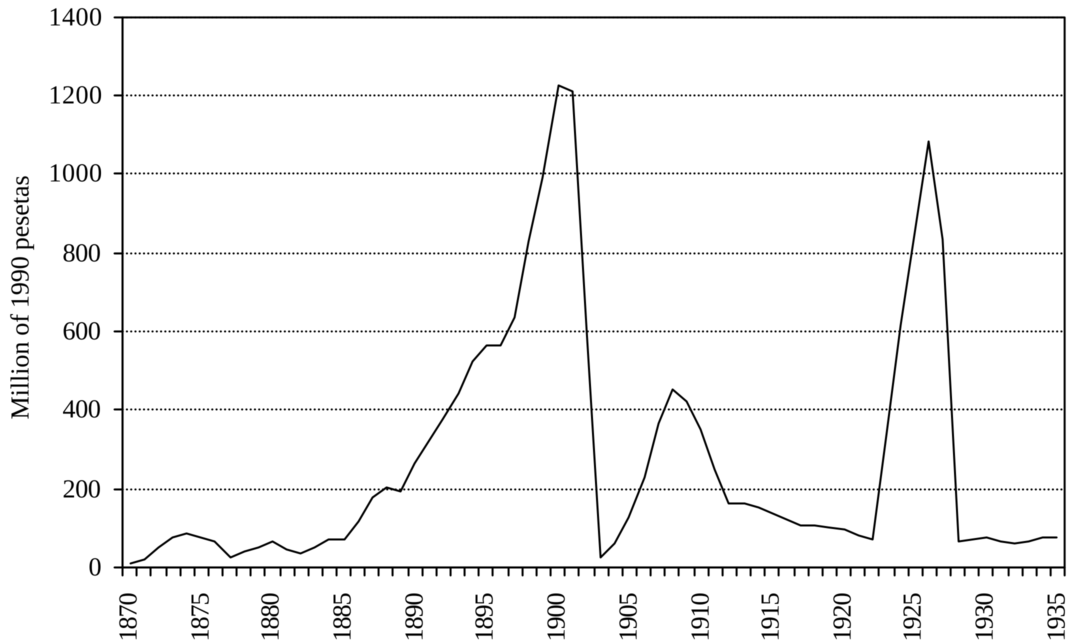
[57] This procedure has been followed because it is not clear if the drop is associated with the incomplete coverage of *AFT* or the out-to-date character of non-public railways data in *MAEOP*.
[58] This figure comes from Alzola y Minondo's suggestions about the cheapest railways, after correcting for the value of land; see Alzola y Minondo (1884-1885), 33, p. 228.
[59] The assumptions on the useful lifetimes of assets are 100 years in the case of grading (which has been assumed to account for 57 per cent of "new" investment) and 50 years in the case of track (which accounts for the remaining 43 per cent). According to Gómez Mendoza (1989a), p. 97, 50 years is the maximum useful life for track.

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1886	119	2	117	943	12	107	867
1887	176	3	174	1,117	13	163	1,030
1888	201	3	198	1,315	16	185	1,215
1889	195	4	191	1,506	19	176	1,392
1890	264	4	260	1,766	22	243	1,634
1891	319	5	314	2,080	25	294	1,929
1892	376	6	370	2,451	30	346	2,275
1893	443	7	436	2,887	35	408	2,683
1894	522	8	514	3,401	41	481	3,164
1895	565	10	555	3,956	49	516	3,680
1896	562	11	551	4,507	57	506	4,186
1897	638	13	625	5,132	64	573	4,759
1898	829	15	814	5,946	73	756	5,514
1899	992	17	975	6,921	85	907	6,422
1900	1,224	20	1,205	8,126	99	1,126	7,547
1901	1,210	23	1,187	9,313	116	1,094	8,642
1902	606	27	579	9,892	133	473	9,114
1903	28	451	-422	9,470	141	-502	8,612
1904	61	433	-372	9,098	141	-448	8,163
1905	128	415	-287	8,811	142	-361	7,802
1906	230	399	-170	8,642	143	-242	7,560
1907	367	384	-17	8,625	146	-89	7,471
1908	454	30	424	9,049	151	303	7,774
1909	420	31	388	9,437	157	263	8,036
1910	353	32	321	9,758	163	191	8,227
1911	248	33	215	9,973	167	81	8,308
1912	164	34	130	10,103	170	-6	8,302
1913	161	34	126	10,229	172	-11	8,290
1914	152	35	118	10,347	174	-22	8,268
1915	139	35	104	10,451	176	-37	8,232
1916	120	35	85	10,536	177	-57	8,175
1917	106	36	71	10,607	178	-72	8,103
1918	107	36	71	10,678	179	-73	8,030
1919	102	36	66	10,743	180	-79	7,951
1920	95	40	54	10,798	181	-87	7,865
1921	83	45	38	10,835	182	-100	7,765
1922	74	57	16	10,851	183	-109	7,656
1923	340	73	267	11,119	183	155	7,811
1924	615	75	540	11,658	187	427	8,238
1925	848	71	777	12,436	195	653	8,892
1926	1,084	584	500	12,936	206	510	9,402
1927	834	54	780	13,716	220	614	10,016
1928	67	62	4	13,720	231	-165	9,851
1929	74	68	6	13,726	231	-158	9,693
1930	77	73	4	13,730	231	-154	9,539
1931	65	65	0	13,730	231	-166	9,373
1932	61	61	0	13,730	231	-170	9,203
1933	67	67	0	13,730	231	-164	9,038
1934	76	76	0	13,730	231	-155	8,883
1935	77	77	0	13,730	231	-155	8,728

Graph A.2.3
Non-public railways: net infrastructure stock



Graph A.2.4
Non-public railways: gross infrastructure investment



Regarding the Madrid and Barcelona underground railways, a series of mileage in operation has been transformed into a series of constructed mileage by assuming a 2-year construction period.[60] The available construction cost data for the Madrid underground has been applied to that result to get "new" investment figures, which have been transformed into a gross investment series as in the previous case.[61] Stock and investment figures are shown in Table A.2.4 and in Graphs A.2.5 and A.2.6.

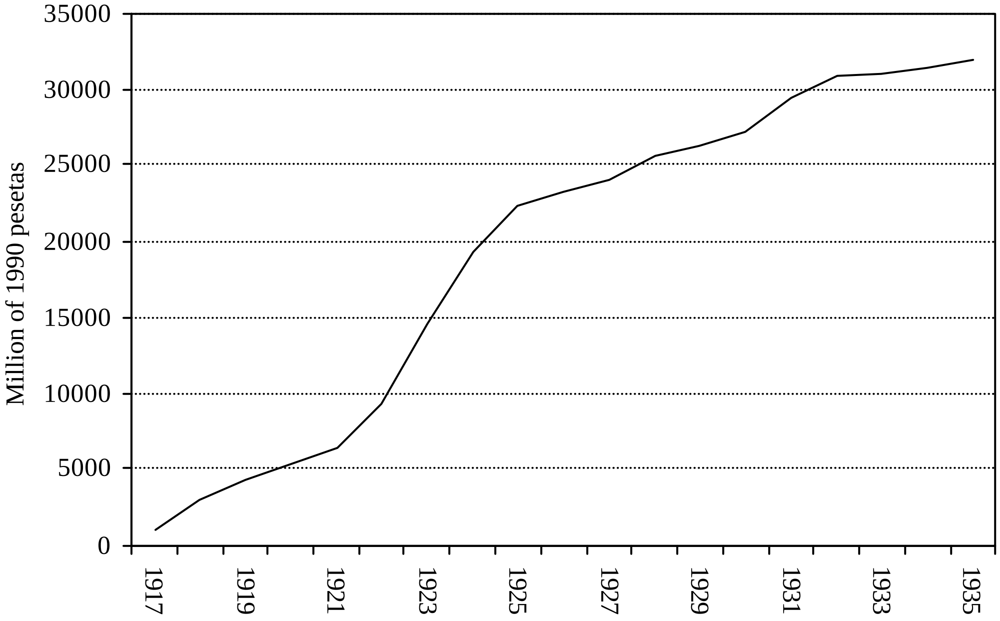
Table A.2.4
Underground railways (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1917	964	0	964	964	0	964	964
1918	1,943	14	1,928	2,893	14	1,929	2,893
1919	1,470	22	1,449	4,341	25	1,445	4,338
1920	996	27	969	5,311	43	952	5,291
1921	1,132	32	1,100	6,411	53	1,079	6,370
1922	3,042	47	2,995	9,405	64	2,978	9,348
1923	5,261	73	5,188	14,593	94	5,167	14,515
1924	4,963	97	4,866	19,459	146	4,817	19,332
1925	3,182	113	3,069	22,528	195	2,987	22,319
1926	1,130	118	1,012	23,541	225	905	23,224
1927	981	122	859	24,399	235	745	23,969
1928	1,848	131	1,717	26,116	244	1,604	25,573
1929	994	135	859	26,975	261	732	26,305
1930	1,200	140	1,060	28,035	270	931	27,236
1931	2,463	152	2,311	30,346	280	2,182	29,418
1932	1,694	159	1,535	31,881	303	1,391	30,809
1933	539	161	378	32,259	319	221	31,030
1934	650	164	487	32,746	323	328	31,358
1935	953	168	786	33,532	327	626	31,984

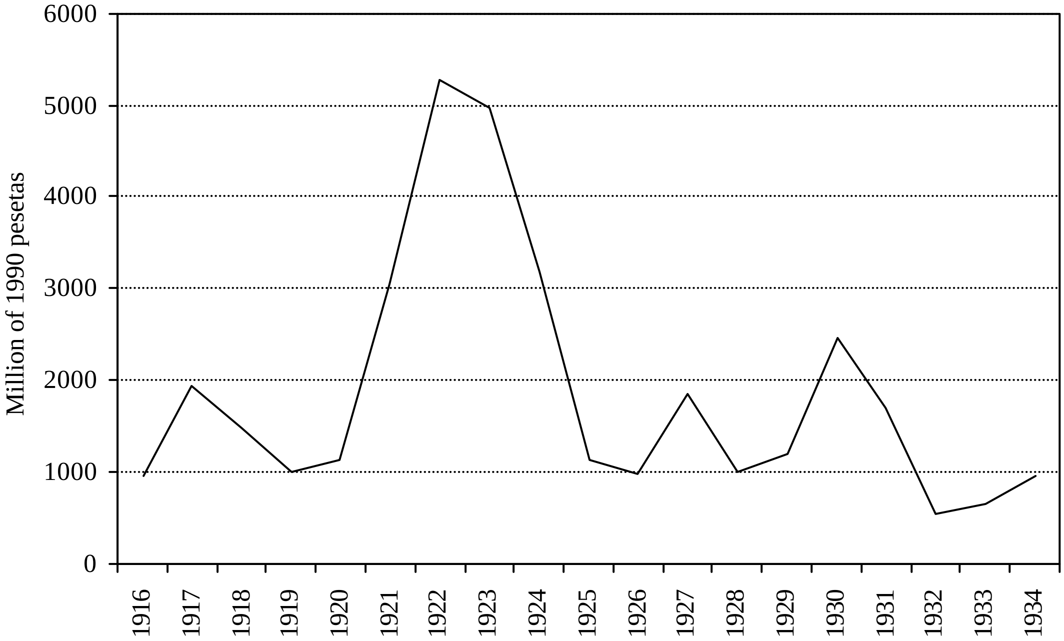
[60] Mileage in operation comes from RENFE (1958), p. 122, and Comín Comín et al (1998), Vol. 2, p. 307. Information about the length of the construction period has been taken, among others, from RENFE (1958), pp. 118-121, Wais San Martín (1987), Vol. 2, pp. 235-243, and Uriol Salcedo (1992), pp. 390-396. The new length has been distributed between the opening date and the two previous years by applying the coefficients 0.25, 0.5 and 0.25.

[61] Unit construction cost in Gómez Santos (1969), p. 40, amounts to ca. 1,154 million of 1990 pesetas per km, which is similar to the unit cost used by Gil Carretero (1968), p. 465, to directly estimate the stock of Spanish underground railways in 1965 (1,338 million of 1990 pesetas in the good quality lines). The useful life of underground railway infrastructure has been assumed to be 100 years.

Graph A.2.5
Underground railways: net infrastructure stock



Graph A.2.6
Underground railways: gross infrastructure investment



2) Tramways

An annual series of mileage of tramways in operation has been estimated for the years 1882-1936, distinguishing between types of power (horse, steam or electricity), by using the information available in *MAEOP* and *AFT*.[62] It has been transformed into a series of constructed mileage by applying Fenoaltea's method for the Italian tramways.[63]

In order to get unit cost figures, information published in *MAEOP* on "First Establishment" accounts of tramway companies has been used as a proxy for construction costs. Companies have been distributed according to the type of power, and figures of "First Establishment" have been deflated according to the year of construction of the lines. The resulting unit costs have been applied to the mileage series to obtain a yearly series of "new" investment in tramways.[64] Replacement investment has been assumed to be zero, given the high mortality rate among the Spanish tramways during the period under study.[65] The final net stock series can be seen in Table A.2.5 and in Graphs A.2.7 and A.2.8.[66]

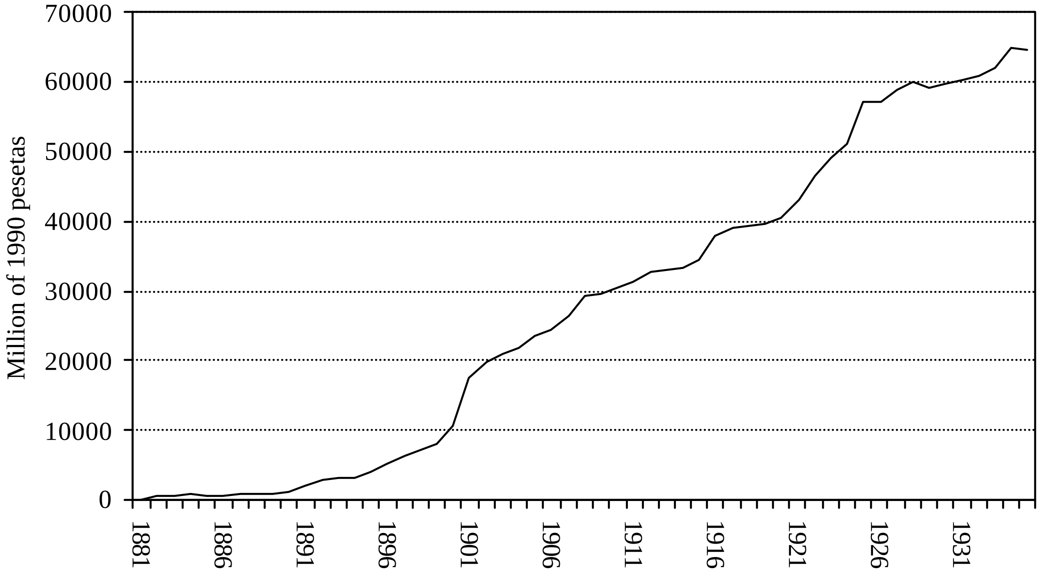
[62] The aggregate series can be seen in Table A.2.5. For the years 1882-1891, there is no information available on the type of power used in each tramway line, and it has been assumed that horse and steam-drawn tramways grew at the same pace. For further periods, gaps in the series have been filled with information provided by Ceballos Teresí (1932), Vol. 7, p. 381. Figures in Table A.2.5 are in some cases lower than other available data. This is related to some definition problems that led some lines to be classified both as narrow gauge railways and as tramways in the available statistics, which have been made up for in this series.
[63] Fenoaltea (1984), p. 68. He assumes a 6-month period of construction for tramways and applies the coefficients 0.75 and 0.25 to the year of the opening of the line and the previous one respectively. This assumption seems consistent with the available information about Spain.
[64] After subtracting 50 per cent as representative for the rolling stock, according to information in Gil Carretero (1968), p. 462, the resulting unit costs per km of infrastructure are 7.96, 8.94 and 55.66 million of 1990 pesetas for horse, steam and electric tramways. Although the figure for electric tramways is strikingly higher than the other ones, this reflects the fact that they were usually urban and much better equipped than the others, being very often endowed with double track. Some examples of the high cost of urban and electric tramways in other countries can be seen in Clark (1894), p. 51, Dawson (1897), p. 600, and Fenoaltea (1984).
[65] Useful life has been assumed to be 25 years for tramway infrastructure, which is in line with Feinstein (1988), p. 330.
[66] Gil Carretero (1968), p. 465, estimated the replacement value of the Spanish tramway infrastructure in 1965 to be ca. 5,000 million of 1990 pesetas, which is much lower than my estimate for 1935. Although he does not present physical indicators of infrastructure, he points out that tramways were disappearing from Spain by that year, which is confirmed by the facts that only 7 Spanish cities kept their tramways, and 54 per cent of their rolling stock was more than 20 years old by that date (ibidem, p. 472). That gradual disappearance, together with the shortcomings of the available information for 1965 and the inclusion in my estimation of a number of suburban lines, which might actually have been classified as light railways and were not covered by the 1965 survey, may explain the difference between the estimates for 1935 and 1965. However, more information on investment and the evolution of the network after 1935 would be necessary to improve the quality of the series and to know the importance of the possible upward and downward biases before 1936 and in 1965 respectively.

Table A.2.5
Tramways (million of 1990 pesetas)

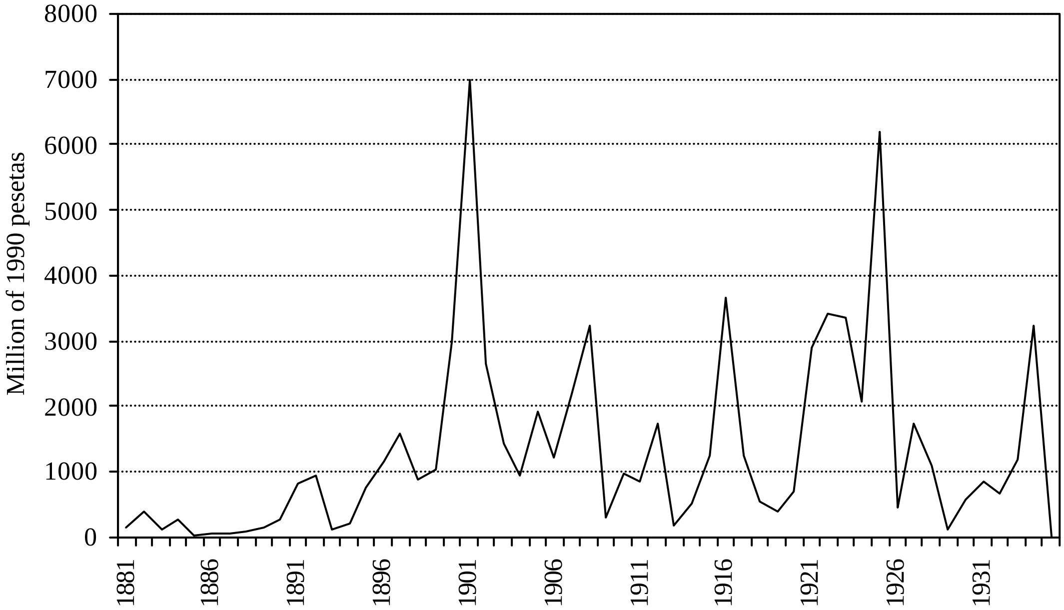
	Network length (km)	Gross Inv.	Retirements	New Inv.	Gross Stock	Depreciat.	Net Investment	Net Stock
1881		126	0	126	126	0	126	126
1882	60	389	0	389	515	5	384	510
1883	65	124	0	124	639	16	109	619
1884	107	266	0	266	905	5	261	880
1885	73	12	289	12	628	11	-280	600
1886		48	0	48	675	0	47	647
1887	84	57	0	57	733	2	55	702
1888	94	95	0	95	827	2	92	795
1889	111	137	0	137	965	4	134	928
1890	125	263	0	263	1,228	5	258	1,186
1891		822	0	822	2,050	11	812	1,998
1892	356	945	0	945	2,995	33	912	2,910
1893		110	0	110	3,105	38	72	2,982
1894	376	191	0	191	3,296	4	187	3,168
1895		756	2	756	4,049	8	746	3,914
1896	416	1,146	3	1,146	5,192	30	1,113	5,027
1897		1,590	238	1,590	6,544	46	1,313	6,340
1898	422	879	110	879	7,312	64	709	7,049
1899		1,026	110	1,026	8,229	35	885	7,934
1900	435	2,976	107	2,976	11,098	41	2,833	10,766
1901		6,979	230	6,979	17,847	119	6,637	17,403
1902	656	2,647	0	2,647	20,495	279	2,368	19,771
1903		1,427	0	1,427	21,922	106	1,322	21,093
1904		950	0	950	22,872	57	893	21,985
1905		1,901	271	1,901	24,502	38	1,603	23,588
1906		1,199	188	1,199	25,513	76	942	24,530
1907	726	2,205	255	2,205	27,463	48	1,912	26,442
1908		3,226	138	3,226	30,552	88	3,005	29,447
1909	798	290	0	290	30,841	129	161	29,608
1910		959	50	959	31,750	12	899	30,507
1911	819	841	16	841	32,575	38	787	31,294
1912		1,720	167	1,720	34,128	34	1,526	32,820
1913		183	3	183	34,308	69	111	32,932
1914		512	45	512	34,775	7	462	33,393
1915		1,244	14	1,244	36,005	20	1,210	34,603
1916	892	3,664	322	3,664	39,348	50	3,305	37,909
1917		1,233	35	1,233	40,545	147	1,052	38,961
1918		539	13	539	41,071	49	477	39,438
1919		380	12	380	41,438	22	346	39,784
1920		705	0	705	42,143	15	690	40,474
1921		2,877	68	2,877	44,952	28	2,784	43,258
1922	1,031	3,407	74	3,407	48,286	115	3,221	46,479
1923	1,049	3,356	540	3,356	51,103	136	2,701	49,180
1924	1,048	2,066	64	2,066	53,105	134	1,870	51,050
1925	1,213	6,198	74	6,198	59,229	83	6,044	57,094
1926	1,213	451	0	451	59,680	248	203	57,297
1927		1,719	25	1,719	61,375	18	1,678	58,975
1928	1,267	1,099	18	1,099	62,456	69	1,013	59,988
1929	1,242	117	839	117	61,734	44	-733	59,255
1930	1,251	560	0	560	62,294	5	555	59,810
1931		841	179	841	62,955	22	646	60,457

	Network length (km)	Gross Inv.	Retirements	Gross Inv.	Gross Stock	Depreciat.	Net Investment	Net Stock
1932	1,243	672	155	672	63,472	34	489	60,946
1933	1,246	1,186	0	1,186	64,658	27	1,159	62,105
1934	1,279	3,246	402	3,246	67,502	47	2,812	64,917
1935		0	0	0	67,502	130	-130	64,787

Graph A.2.7
Tramways: net infrastructure stock



Graph A.2.8
Tramways: gross infrastructure investment



3) State roads

The estimate of the net stock of State roads is based on two different sources of information: i) the inventory of the State road network that was carried out at the end of 1961[67] and ii) the flow of State expenses in "construction", "maintenance", "repair", "studies" and "modernisation" of roads since 1859.[68] Actually, those investment flows have been the basis for the *IVIE*'s estimation of the net stock of State roads during the period 1900-1990 using the perpetual inventory method. Here I present an alternative estimate for the period 1844-1935, which is quite similar to the *IVIE* series, but incorporates some additional information on the process of construction of the State road network.

I have aggregated the four State road investment series into a yearly series of gross capital formation. For the period before 1860, "new" investment has been estimated by applying a unit cost of 10.7 million of 1990 pesetas per km to a series of constructed mileage, and has been increased by a series of hypothetical replacement expenses.[69] The resulting gross investment series for 1845-1935 has been subjected to the perpetual inventory method in order to get net stock figures.[70]

The net stock series has been adjusted in order to account for the abandonment by the State on 7th April 1870 of 2,599 km of roads that ran parallel to railway lines. Among them, 1,770 km were taken over by Provincial *Diputaciones* and a small percentage by Local Councils. The rest remained neglected and became seriously dilapidated. Most of those roads returned to the State between 1880 and the first years of the twentieth century.

---

[67] A summary of the inventory can be seen in De Casso Ortiz de Villajos (1968).

[68] Available in Uriol Salcedo (1968a), pp. 421-424, who relies on official publications.

[69] This unit cost figure comes from Uriol Salcedo (1992), p. 67, after deducting 10 per cent as a representative share for land, which is the percentage used in Feinstein (1988). The constructed mileage series has been estimated from data on the length of the network in 1833, 1855 and 1859, in Uriol Salcedo (1992), pp. 15-16, 25 and 67. Gaps between those figures have been filled in, for 1853-1859, according to the annual State investment in roads that is available in the *IVIE* database; for 1847-1853, according to the State investment in ports, from Cercos Pérez (1968), p. 594, and for 1845-1846, through linear interpolation. Replacement in 1844-1859 has been assumed to coincide with retirements.

[70] A useful lifetime of 80 years has been assumed, which is the figure applied to the least utilised roads by Feinstein (1988), p. 319, and Groote (1996), p. 116. Investment has been distributed into grading (66 per cent) and structures (33 per cent). According to the information in De Casso Ortiz de Villajos (1968), these percentages seem to be appropriate for roads without special surface treatment, as was the case with most of the Spanish network during the period under study. In the case of grading, depreciation has been assumed to be made up of deterioration (66 per cent) and obsolescence (33 per cent), and retirement has been assumed to be a continuous process that coincided with depreciation for deterioration. To estimate the net stock in 1844, a value of 25 per cent of the construction cost has been assumed for those roads that were open before 1802 and a value of 75 per cent for those constructed in 1802-1844. Information on the network length in 1802 comes from Uriol Salcedo (1992), p. 67.

The share which that mileage accounted for has been taken out of the State road stock in 1870 and has been gradually re-included according to the process of its recovery by the State.[71] For the period in which part of those roads were under the control of the *Diputaciones*, they have been added to the total stock of provincial roads (see below).[72]

The resulting series has been brought forward to 1961, in order to check its consistency with the inventory of the network at that year. The result is a net stock value of 929,495 million of 1990 pesetas, which is around 20 per cent lower than the direct estimate for that year.[73] Graph A.2.9 compares the evolution of the two available series of State road net capital stock up to 1961, Graph A.2.10 shows the evolution of State road investment and Table A.2.6 offers the new estimate and a new series of State road network mileage, which is the result of the critical analysis of the available statistical information.[74]

Table A.2.6
State roads (million of 1990 pesetas)

	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1844					56,910			31,119
1845		1,563	711	851	57,761	711	851	31,970
1846		1,573	716	857	58,619	722	851	32,821

[71] The net value of abandoned roads has been estimated according to the ratio between net and gross stock in 1869. The procedure described in the text may have introduced a small, decreasing and transient downward bias in the stock data, because some of the abandoned stretches might have remained in use and, therefore, should still be included in the total stock, in spite of their poor condition. On this subject, see Alzola y Minondo (1979), pp. 417-418, or Pascual Domènech (1991), pp. 267-268.

[72] Apart from the recovery of the roads abandoned in 1870, transfers of roads from the *Diputaciones* to the State were constant during the whole period under study; see, for instance, Vidal Olivares (1992), pp. 85-86. However, the lack of precise information on the process has precluded considering it in the estimation of the stock. Failure to capture those transfers introduces a downward bias in the State road stock figures estimated using the perpetual inventory method, which was already pointed out by González Paz and De Cossío Cosio (1968), p. 356, and which is possibly small compared with the upward biases introduced by the bad conservation of roads or by corruption in the construction process. On the other hand, in 1934 the mileage of the provincial road network suffered a decrease of 2,629 km, which was associated with the taking over of Catalan roads by the new regional autonomous government (see references to that process in García Ortega (1982), pp. 277-278). In that year, in order to avoid a decrease in the total road stock, the State stock figures have been increased by the value of those roads.

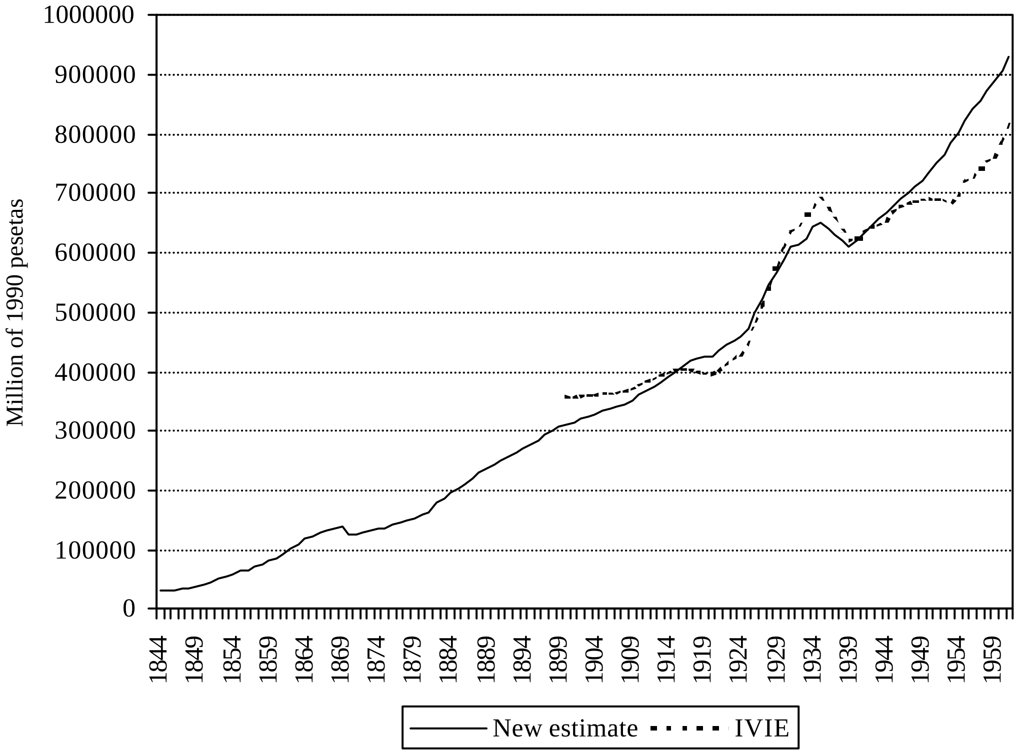
[73] See the direct estimate for 1961 in De Casso Ortiz de Villajos (1968), pp. 374-375. The difference between my estimate and the direct measurement of the stock in the early 1960's may be related to a number of problems that are difficult to overcome, such as the incomplete character of the State investment figures, the aforementioned failure to reflect the transfers of roads from the provincial *Diputaciones* to the State, or the shortcomings of the available deflators. Obviously, a possible solution would be to assume a longer useful life for the State roads. However, this procedure does not seem convenient since 80 years is among the highest usual figures for roads, and the assumption of a longer life should in fact be accompanied by the consideration of some of the conservation and repair expenses as just maintenance, and not as capital formation, as is indicated in Feinstein (1988), p. 314.

[74] Mileage data comes from *MAEOP* until 1924 and from *AEE* for 1933-1935. Figures in the *AEE* for 1925-1932 do not seem to be up to date, and, therefore, have not been included in the table.

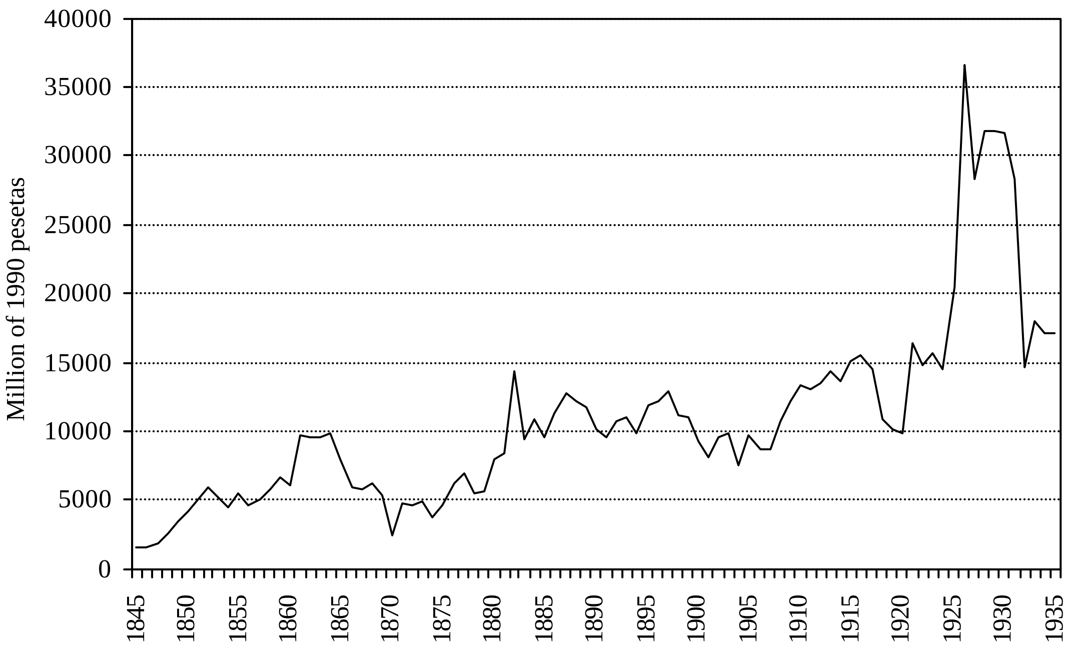
	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1847		1,856	721	1,135	59,753	733	1,123	33,944
1848		2,563	727	1,836	61,589	747	1,816	35,760
1849		3,493	737	2,756	64,345	770	2,723	38,484
1850		4,153	753	3,400	67,745	804	3,348	41,832
1851		5,044	772	4,273	72,018	847	4,197	46,029
1852		5,903	795	5,108	77,125	900	5,003	51,032
1853		5,155	824	4,331	81,457	964	4,191	55,223
1854		4,513	848	3,665	85,122	1,018	3,495	58,718
1855	8,324	5,571	868	4,703	89,825	1,064	4,507	63,225
1856		4,668	894	3,774	93,599	1,123	3,545	66,771
1857		5,097	915	4,182	97,781	1,170	3,927	70,698
1858		5,850	938	4,911	102,692	1,222	4,627	75,325
1859	9,962	6,649	966	5,683	108,376	1,284	5,366	80,691
1860	10,480	6,033	997	5,036	113,411	1,355	4,678	85,369
1861	10,516	9,694	1,025	8,669	122,080	1,418	8,276	93,645
1862	11,244	9,603	1,073	8,530	130,610	1,526	8,077	101,722
1863	12,884	9,513	1,121	8,393	139,002	1,633	7,881	109,603
1864	12,958	9,784	1,167	8,616	147,619	1,738	8,046	117,649
1865	13,313	8,055	1,215	6,840	154,459	1,845	6,210	123,860
1866	16,211	5,999	1,253	4,745	159,204	1,931	4,068	127,928
1867	16,648	5,832	1,280	4,552	163,756	1,990	3,842	131,769
1868	17,010	6,277	1,305	4,972	168,728	2,047	4,230	135,999
1869	17,622	5,351	1,333	4,018	172,746	2,109	3,241	139,241
1870	15,921	2,403	1,355	1,048	173,794	2,159	-14,477	124,764
1871	16,178	4,791	19,623	-14,832	158,962	2,172	2,618	127,382
1872	15,895	4,652	1,278	3,373	162,335	1,987	2,665	130,047
1873	16,359	4,893	1,297	3,596	165,931	2,029	2,864	132,911
1874	16,567	3,774	1,317	2,457	168,387	2,074	1,700	134,610
1875	16,763	4,608	1,331	3,277	171,665	2,105	2,503	137,113
1876	17,175	6,258	1,349	4,909	176,574	2,146	4,112	141,226
1877	17,605	6,939	1,376	5,563	182,137	2,207	4,732	145,958
1878	17,892	5,487	1,407	4,080	186,217	2,277	3,210	149,168
1879	18,370	5,670	1,430	4,240	190,457	2,328	3,342	152,510
1880	19,307	7,941	1,453	6,488	196,945	2,381	5,852	158,362
1881	19,774	8,371	1,125	7,246	204,191	2,462	5,909	164,271
1882	21,157	14,302	1,530	12,773	216,964	2,552	14,132	178,404
1883	22,029	9,406	-1,361	10,767	227,731	2,712	7,648	186,052
1884	23,066	10,884	500	10,384	238,115	2,847	9,761	195,813
1885	23,727	9,539	-391	9,930	248,045	2,976	6,563	202,376
1886	24,481	11,398	1,773	9,625	257,670	3,101	8,298	210,673
1887	25,321	12,746	1,827	10,920	268,590	3,221	9,525	220,199
1888	26,628	12,282	1,887	10,394	278,984	3,357	8,924	229,123
1889	26,686	11,727	1,945	9,782	288,766	3,487	8,240	237,363
1890	27,524	10,233	1,999	8,233	296,999	3,610	6,728	244,091
1891	28,444	9,616	1,917	7,699	304,698	3,712	5,904	249,995
1892	29,223	10,769	2,088	8,681	313,379	3,809	6,960	256,955
1893	29,821	11,031	2,136	8,895	322,275	3,917	7,114	264,070
1894	30,774	9,951	2,186	7,765	330,040	4,028	5,922	269,992
1895	31,412	11,915	2,229	9,686	339,726	4,125	7,789	277,781
1896	32,313	12,232	2,283	9,949	349,675	4,247	7,985	285,767
1897	33,345	12,878	2,338	10,541	360,216	4,371	8,507	294,274
1898	34,307	11,234	2,396	8,837	369,053	4,503	6,731	301,005
1899	34,813	10,957	2,446	8,512	377,565	4,613	6,529	307,534

	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1900	36,014	9,237	2,266	6,971	384,536	4,720	4,701	312,235
1901	36,614	8,135	2,306	5,829	390,365	4,807	3,461	315,696
1902	37,372	9,581	2,401	7,180	397,545	4,880	4,832	320,529
1903	38,048	9,871	2,442	7,429	404,974	4,969	4,901	325,430
1904	38,998	7,622	2,645	4,977	409,951	5,062	2,982	328,412
1905	39,812	9,779	2,147	7,632	417,583	5,124	4,654	333,066
1906	40,438	8,722	2,715	6,007	423,590	5,220	3,502	336,569
1907	41,396	8,747	2,748	5,998	429,588	5,295	3,452	340,021
1908	42,024	10,676	2,782	7,894	437,482	5,370	5,306	345,326
1909	42,742	12,127	2,826	9,302	446,783	5,469	6,659	351,985
1910	43,554	13,290	2,877	10,413	457,197	5,585	7,706	359,691
1911	44,501	13,005	2,935	10,070	467,266	5,715	7,290	366,981
1912	45,259	13,573	2,991	10,582	477,849	5,841	7,733	374,713
1913	46,316	14,325	3,050	11,275	489,124	5,973	8,352	383,065
1914	47,262	13,712	3,113	10,599	499,723	6,114	7,598	390,663
1915	48,448	15,139	3,171	11,967	511,690	6,247	8,892	399,555
1916	50,020	15,583	3,238	12,345	524,035	6,396	9,187	408,742
1917	50,754	14,437	3,307	11,130	535,166	6,550	7,887	416,629
1918	51,914	10,865	3,368	7,497	542,663	6,690	4,176	420,804
1919	52,455	10,146	3,410	6,736	549,399	6,783	3,363	424,168
1920	53,012	9,917	3,447	6,469	555,868	6,867	3,049	427,217
1921	53,651	16,343	3,483	12,859	568,728	6,948	9,394	436,611
1922	54,250	14,844	3,555	11,289	580,016	7,109	7,734	444,346
1923	55,007	15,714	3,618	12,097	592,113	7,250	8,464	452,810
1924	57,171	14,427	3,685	10,742	602,855	7,401	7,025	459,835
1925		20,453	5,545	14,908	617,764	7,536	12,917	472,752
1926		36,542	5,672	30,870	648,633	7,722	28,820	501,572
1927		28,267	6,024	22,243	670,876	8,108	20,159	521,731
1928		31,733	6,445	25,288	696,163	8,386	23,347	545,078
1929		31,713	6,966	24,747	720,910	8,702	23,011	568,088
1930		31,598	7,392	24,206	745,117	9,011	22,587	590,675
1931		28,331	7,891	20,441	765,557	9,314	19,017	609,692
1932		14,712	8,347	6,365	771,922	9,569	5,142	614,835
1933	68,452	17,948	8,151	9,797	781,719	9,649	8,299	623,134
1934	69,835	17,153	8,019	9,134	790,853	9,771	21,352	644,486
1935	70,522	17,133	-9,079	26,212	817,065	9,886	7,248	651,734

Graph A.2.9
State roads: net capital stock (alternative estimates)



Graph A.2.10
State roads: gross infrastructure investment



4) Provincial and local roads

In the case of the roads owned by provincial and local institutions, the lack of investment figures (with the exception of local roads during the years 1911-1924) makes it necessary to resort to physical indicators of the evolution of the stock. Unfortunately, information on provincial and local road mileage is scarce, and the figures that are suggested here are only a proxy for the actual ones.

Regarding provincial roads, mileage information is available on a non-continuous basis in *MAEOP* and *AEE* since 1855.[75] A yearly mileage series has been obtained by interpolation, to which a unit cost figure of 6.7 million of 1990 pesetas, coming from contemporaneous construction cost estimates, has been applied.[76] The resulting "new" investment series has been supplemented with a hypothetical replacement series in order to get gross investment estimates, to which the perpetual inventory method has been applied.[77] The net and gross stock series have been increased by the value of the roads that were abandoned by the State and taken over by the provincial *Diputaciones* in 1870 for the period during which the roads remained under their control (see above).

Local road mileage data is of very bad quality, especially for the earlier periods, and has been corrected to avoid inconsistencies.[78] Gaps have been filled by interpolation. Mileage figures have been multiplied by a unit cost figure coming from the information about State investment in local roads from 1911 (2.1 million of 1990 pesetas per km).[79] An estimate of replacement investment has been added to the resulting "new" investment

[75] Figures from the *AEE* between 1925 and 1930, which are reproduced in Ceballos Teresí (1932) and Gómez Mendoza (1989b), are not up to date and have not been considered here. For 1844-1862, the provincial networks have been assumed to grow at the same pace as the State network. As has been indicated above, provincial mileage data reflect a process of road transfers to the State (especially since 1880) and to the Catalan autonomous government (in 1932).

[76] Estimates have been taken from the bids for road construction at the expense of the Provincial *Diputaciones* in 1896-1899, in the *Revista de Obras Públicas*. This publication suggested very similar values in 1855, which is an indication of the stability of provincial road construction costs during the period under study; see *Revista de Obras Públicas*, 3, 3, 1855, pp. 25-30. Uriol Salcedo (1968b), p. 429, assumes slightly higher unit values for the provincial and local road networks in 1965, when their surfaces had already started to be improved.

[77] The assumptions on useful lifetimes, depreciation and replacement are the same as in the State roads (see above).

[78] The main problem of early data on local roads is associated with the heterogeneous criteria with which they were collected in the different Spanish provinces; on this problem see, for instance, *MAEOP*, 1893-1894, p. 5.

[79] Data on State investment in local roads in Gómez Mendoza (1991), p. 192. The total amount invested in 1911-1924 has been divided by the number of km that were built during the period, and a 10 per cent has been subtracted to account for the value of land. The *Revista de Obras Públicas*, 46, 1264, 1899, p. 479, offers a very similar figure to the unit cost suggested here.

series in order to get gross investment figures, which have been the basis for the net stock series.[80]

Provincial and local road mileage together with stock data are shown in Tables A.2.7 and A.2.8, and the net stock and gross investment infrastructure series are represented in Graphs A.2.11 and A.2.12.

Table A.2.7
Provincial roads (million of 1990 pesetas)

	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1844					4,796			2,817
1845		141	64	77	4,873	64	77	2,894
1846		142	65	77	4,950	65	77	2,971
1847		167	65	102	5,052	66	101	3,071
1848		230	66	164	5,217	68	163	3,234
1849		313	67	247	5,463	70	244	3,477
1850		371	68	303	5,766	73	299	3,776
1851		450	70	380	6,146	77	373	4,149
1852		525	72	453	6,599	81	444	4,593
1853		454	74	380	6,979	87	367	4,960
1854		393	77	317	7,296	92	302	5,262
1855	1,209	487	78	409	7,705	96	391	5,653
1856		552	81	472	8,176	101	452	6,105
1857		583	83	499	8,676	107	476	6,581
1858		615	86	529	9,205	113	502	7,082
1859		648	89	560	9,764	119	529	7,611
1860		684	92	592	10,356	126	558	8,169
1861		722	95	627	10,983	134	588	8,758
1862	1,613	762	99	664	11,647	142	621	9,378
1863		1,291	102	1,189	12,836	150	1,141	10,519
1864		1,415	109	1,306	14,142	165	1,250	11,770
1865		1,552	116	1,436	15,578	181	1,371	13,141
1866	2,353	1,702	124	1,578	17,156	199	1,503	14,644
1867		890	133	757	17,912	219	671	15,314
1868		927	137	789	18,701	228	698	16,013
1869	2,671	965	142	823	19,525	238	727	16,739
1870		146	-13,240	13,386	32,911	249	11,169	27,908
1871		348	221	128	33,038	416	-68	27,841
1872	2,722	1,714	221	1,492	34,531	417	1,296	29,137
1873		1,988	-2,439	4,428	38,958	436	3,781	32,918
1874		1,311	254	1,057	40,015	491	820	33,738
1875		1,120	260	860	40,875	505	615	34,353
1876		1,095	265	830	41,704	515	579	34,932
1877		1,902	269	1,633	43,337	526	1,376	36,308
1878		1,840	279	1,562	44,899	546	1,294	37,603
1879		1,858	287	1,571	46,470	566	1,293	38,895
1880		296	1,177	-881	45,589	585	-1,021	37,874
1881	4,415	426	291	135	45,725	574	-148	37,726

[80] As in the case of provincial roads, the growth of the local road network in 1844-1866 has been assumed to coincide with the evolution of State roads. Assumptions about useful life and replacement investment are the same as in provincial and State roads.

	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1882	4,694	292	4,621	-4,330	41,395	576	-3,829	33,897
1883	4,893	268	2,133	-1,865	39,530	522	-1,768	32,129
1884	5,034	193	3,169	-2,976	36,554	499	-2,703	29,426
1885	5,500	2,202	176	2,026	38,580	461	1,741	31,167
1886	5,900	2,519	188	2,332	40,911	487	2,033	33,200
1887	6,016	779	201	578	41,490	516	263	33,463
1888	6,016	282	204	78	41,568	523	-241	33,222
1889	6,016	204	204	0	41,568	524	-320	32,902
1890	6,016	204	368	-164	41,404	524	-449	32,453
1891		1,319	203	1,115	42,519	522	797	33,250
1892	6,508	1,491	210	1,281	43,800	536	955	34,205
1893		614	217	397	44,197	552	62	34,267
1894	6,627	488	219	269	44,467	557	-69	34,198
1895		482	220	261	44,728	560	-79	34,119
1896	6,750	814	222	592	45,320	564	250	34,369
1897		408	225	183	45,503	571	-163	34,207
1898	6,805	410	226	184	45,687	573	-163	34,044
1899		227	454	-227	45,460	576	-516	33,527
1900	6,737	226	452	-226	45,234	573	-512	33,015
1901		225	388	-163	45,071	570	-463	32,552
1902	6,688	224	386	-162	44,909	568	-460	32,092
1903		625	223	402	45,311	566	59	32,151
1904		225	950	-725	44,586	571	-856	31,295
1905		2,386	221	2,165	46,751	562	1,824	33,119
1906		2,388	222	2,166	48,917	564	1,824	34,943
1907	6,821	2,390	223	2,167	51,084	566	1,824	36,767
1908		2,814	224	2,590	53,674	568	2,246	39,013
1909	8,539	3,150	254	2,896	56,569	636	2,512	41,525
1910		600	288	313	56,882	712	-111	41,414
1911	8,633	604	289	315	57,196	715	-112	41,303
1912		488	291	197	57,393	719	-232	41,071
1913		490	292	197	57,590	722	-232	40,839
1914		491	293	198	57,788	724	-233	40,606
1915		493	294	199	57,987	727	-234	40,372
1916	8,781	495	296	199	58,187	729	-234	40,138
1917		950	297	653	58,840	732	218	40,356
1918	9,133	1,991	300	1,690	60,530	740	1,251	41,607
1919		839	310	529	61,059	761	77	41,684
1920		846	313	533	61,593	768	78	41,763
1921		854	316	538	62,131	774	79	41,842
1922		861	319	543	62,674	781	80	41,922
1923		869	322	548	63,221	788	81	42,004
1924	9,619	877	325	552	63,773	795	82	42,086
1925		2,618	370	2,248	66,021	802	1,817	43,902
1926		2,709	383	2,327	68,348	830	1,880	45,782
1927		2,818	410	2,408	70,756	859	1,959	47,741
1928		2,950	458	2,492	73,248	889	2,061	49,802
1929		3,097	517	2,580	75,828	920	2,177	51,979
1930		3,233	563	2,670	78,498	952	2,281	54,260
1931	12,243	3,384	621	2,764	81,262	986	2,399	56,659
1932	12,262	806	677	129	81,391	1,020	-214	56,445
1933	13,176	6,730	636	6,093	87,485	1,022	5,708	62,153
1934	10,547	635	18,162	-17,527	69,958	1,098	-12,864	49,289

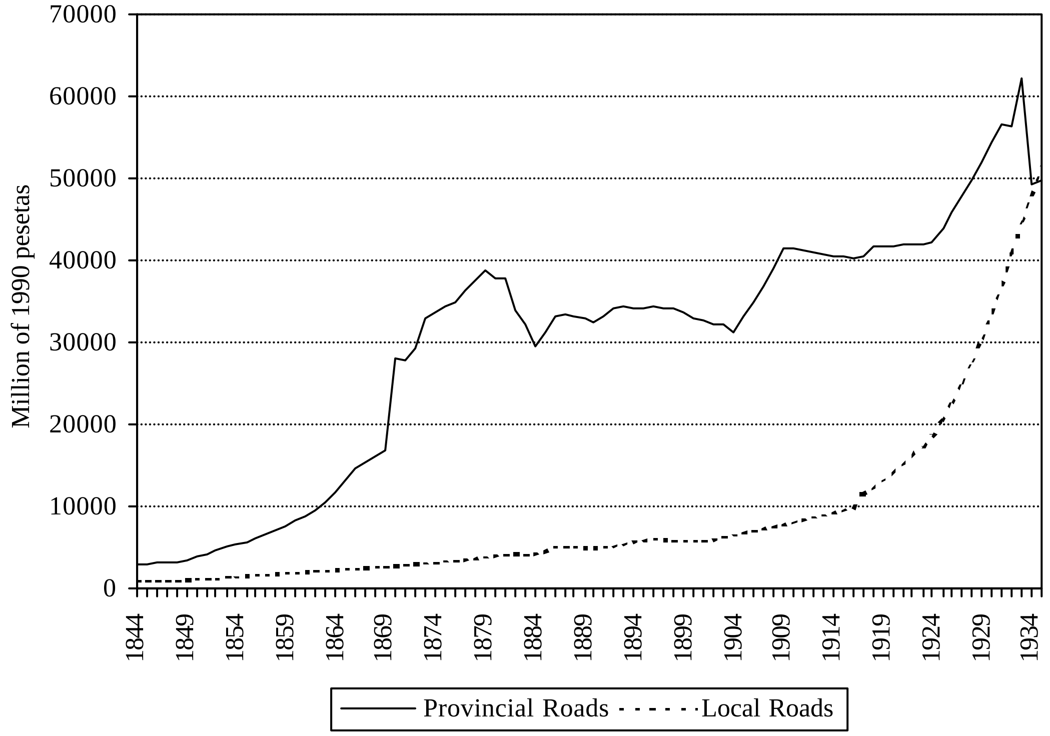
	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1935	10,642	1,222	589	633	70,591	879	343	49,632

Table A.2.8
Local roads (million of 1990 pesetas)

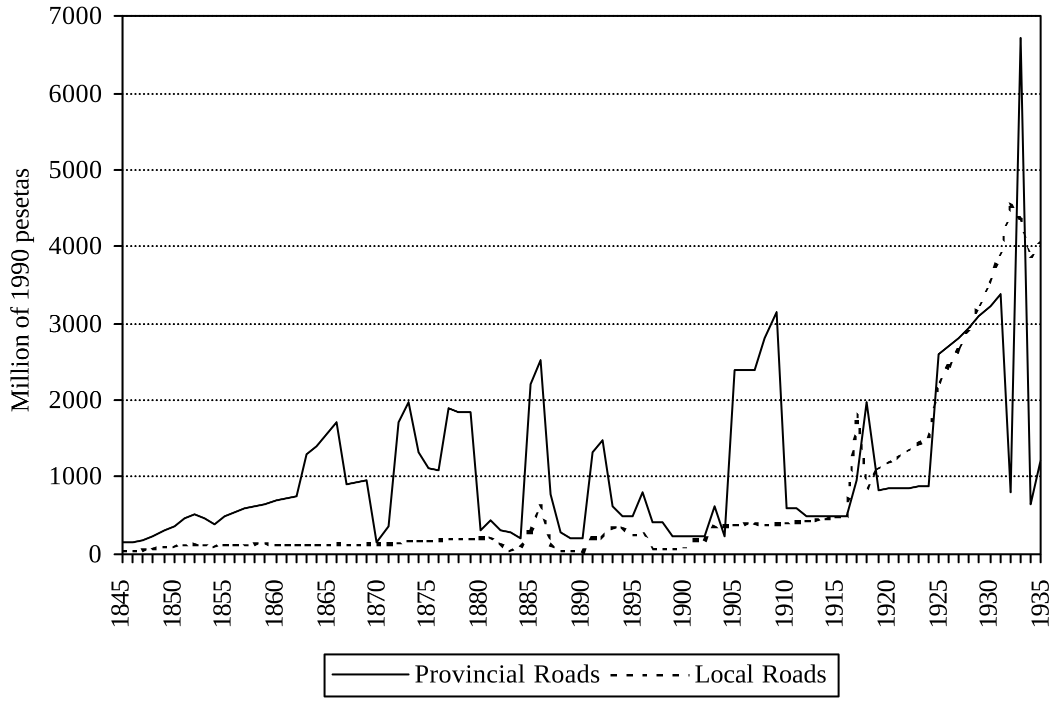
	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1844					1,253			685
1845		34	16	19	1,272	16	19	704
1846		35	16	19	1,290	16	19	723
1847		41	16	25	1,315	16	24	747
1848		56	16	40	1,355	16	40	787
1849		76	16	60	1,415	17	59	846
1850		90	17	74	1,489	18	73	918
1851		109	17	92	1,581	19	91	1,009
1852		128	17	110	1,692	20	108	1,117
1853		110	18	92	1,784	21	89	1,206
1854		96	19	77	1,861	22	73	1,280
1855		118	19	99	1,960	23	95	1,375
1856		98	20	78	2,039	25	73	1,448
1857		107	20	87	2,125	25	81	1,530
1858		123	21	102	2,228	27	96	1,626
1859		140	21	119	2,346	28	112	1,738
1860		99	22	77	2,423	29	70	1,807
1861		102	22	80	2,503	30	72	1,879
1862		105	23	82	2,586	31	74	1,953
1863		108	23	85	2,671	32	76	2,029
1864		111	24	88	2,759	33	78	2,107
1865		115	24	91	2,850	34	80	2,187
1866	1,427	124	25	99	2,949	36	88	2,275
1867		115	25	90	3,039	37	78	2,354
1868		118	26	93	3,132	38	80	2,434
1869		122	26	96	3,227	39	83	2,517
1870		125	27	99	3,326	40	85	2,601
1871		129	27	102	3,428	42	87	2,689
1872	1,709	132	28	105	3,532	43	90	2,778
1873		159	28	131	3,663	44	115	2,893
1874		165	29	136	3,799	46	119	3,012
1875		171	30	141	3,939	47	123	3,135
1876		177	31	146	4,085	49	127	3,262
1877		183	31	151	4,237	51	132	3,394
1878		189	32	157	4,394	53	136	3,530
1879		196	33	163	4,556	55	141	3,671
1880		203	34	169	4,725	57	146	3,817
1881	2,371	210	35	175	4,900	59	151	3,968
1882	2,424	145	36	109	5,009	61	84	4,051
1883	2,422	37	37	0	5,009	63	-26	4,025
1884	2,464	104	21	83	5,092	63	41	4,066
1885	2,595	292	21	270	5,362	64	228	4,294
1886	2,885	624	23	601	5,963	67	557	4,851
1887	2,934	127	26	100	6,063	75	52	4,903
1888	2,934	27	27	0	6,063	76	-49	4,854
1889	2,934	27	27	0	6,063	76	-49	4,805

	Network length (km)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Investment	Net Stock
1890	2,934	27	27	0	6,063	76	-49	4,756
1891		202	27	175	6,238	76	126	4,882
1892	3,106	208	28	180	6,419	78	130	5,012
1893		331	29	302	6,721	80	251	5,263
1894	3,406	348	30	317	7,038	84	264	5,526
1895		238	32	206	7,244	88	150	5,676
1896	3,607	245	33	212	7,455	91	154	5,830
1897		48	34	14	7,469	93	-45	5,785
1898	3,528	48	35	14	7,483	93	-45	5,741
1899		49	35	14	7,497	94	-45	5,696
1900	3,634	49	35	14	7,511	94	-45	5,650
1901		177	35	142	7,653	94	83	5,733
1902	3,773	180	36	145	7,798	96	85	5,818
1903		343	36	307	8,105	97	246	6,064
1904		357	38	319	8,424	101	256	6,319
1905		371	40	331	8,755	105	266	6,585
1906		386	42	344	9,099	109	277	6,862
1907	6,821	402	44	358	9,457	114	288	7,150
1908		368	46	322	9,780	118	250	7,400
1909	8,539	381	47	333	10,113	122	258	7,658
1910		394	49	345	10,458	126	268	7,926
1911	8,633	408	51	356	10,814	131	277	8,202
1912		422	53	369	11,183	135	287	8,489
1913		436	55	381	11,564	140	297	8,785
1914		451	57	394	11,958	145	307	9,092
1915		467	59	408	12,366	149	318	9,410
1916	6,187	483	62	421	12,787	155	329	9,739
1917		1,817	64	1,753	14,540	160	1,657	11,395
1918	7,417	863	74	790	15,329	182	682	12,077
1919		1,101	78	1,023	16,352	192	909	12,986
1920		1,175	84	1,091	17,443	204	970	13,957
1921		1,254	90	1,164	18,607	218	1,036	14,993
1922		1,338	96	1,241	19,848	233	1,105	16,098
1923		1,428	103	1,324	21,173	248	1,179	17,277
1924	10,928	1,523	111	1,413	22,585	265	1,259	18,536
1925		2,246	129	2,117	24,703	282	1,964	20,500
1926		2,456	141	2,316	27,018	309	2,148	22,648
1927		2,690	157	2,533	29,551	338	2,352	25,000
1928		2,950	179	2,770	32,322	369	2,580	27,580
1929		3,236	206	3,030	35,352	404	2,832	30,412
1930		3,544	230	3,314	38,666	442	3,103	33,514
1931	20,463	3,884	259	3,625	42,290	483	3,401	36,915
1932	22,522	4,544	289	4,255	46,545	529	4,016	40,931
1933	24,490	4,370	303	4,067	50,613	582	3,788	44,719
1934	26,214	3,880	317	3,563	54,176	633	3,247	47,966
1935	28,012	4,065	349	3,716	57,891	677	3,388	51,354

Graph A.2.11
Provincial and local roads: net infrastructure stock



Graph A.2.12
Provincial and local roads: gross infrastructure investment



5) Ports

The estimates of the net stock of port infrastructure are based, as in the case of the State roads, on a series of yearly investment in the Spanish ports since 1845 and on a direct estimate of the stock value in 1965.[81] Again in this case, the information available on investment flows has also been the basis for the *IVIE*'s estimation of the evolution of the State's net capital stock of ports throughout the period 1900-1990. Here an alternative estimate of total (not only State's) port infrastructure is presented that covers the period 1844-1935 and incorporates additional information on the process of construction of Spanish ports.

Data on investment in ports is available for the years 1845-1908 (new construction) and 1940-1965 (construction and replacement).[82] New construction expenses in ports and lighthouses between 1845 and 1908 have been considered as "new" investment and have been deflated and accumulated through time in order to get a gross stock figure for 1908.[83] The reliability of the 1908 gross stock estimate has been confirmed by comparing it with

[81] That information comes from Cercos Pérez (1968).
[82] Investment figures have been taken from Cercos Pérez (1968), who reproduces, for the period 1845-1908, the information available in *MAEOP* on port construction expenses. Alternative series are available in Artola (1978a), p. 16, for 1845-1872, and in Alemany Llovera (1991), p. 233, for 1851-1904, which are also based on *MAEOP*. All three series show similar fluctuations, although Artola and Alemany's data are higher than Cercos' figures because they include certain share of conservation expenses. There is some uncertainty on the homogeneity of the *MAEOP* figures of port investment, because sometimes the source is not completely clear on their coverage and it is difficult to say if they include all capital formation that was undertaken or only the State's contribution. The exclusion of some investment flows, however, cannot have been very important, because the level of investment figures is consistent with the physical development of the stock (see below). Nevertheless, there may be some transient biases of unknown direction and magnitude in the final stock estimates; on this subject see Gómez Mendoza (1991), pp. 199-200, and Alemany Llovera (1991), pp. 103 and 233.
[83] "New" investment figures have been added to the gross value of the stock in 1844, for which two alternative estimates have been produced. The first one, of ca. 23,700 million of 1990 pesetas, assumes that port infrastructure grew at the same pace as roads up to that year. The second one values the total length of walls of the Spanish ports in the 1860's at a unit cost of 900,000 pesetas of 1990 per m and subtracts the accumulated "new" investment of 1845-1860's from the result, obtaining a figure of 33,800 million of 1990 pesetas for the stock in 1844. According to information in Cunningham (1914), pp. 6-53, on port construction costs, 900,000 pesetas of 1990 per m would be a relatively low amount, but it makes sense in this case because data on the total length of port walls in the mid-nineteenth century, coming from the *MAEOP*, included the smallest ports and some canalisation works, both of them much cheaper than the main ports. Out of the two alternative estimates for 1844, the lowest one has been preferred, because the oldest infrastructure seems to have been cheaper and of poorer quality than the new one. On the poor quality of the old Spanish port infrastructure, see, among others, Guimerá Ravina (1996), p. 129, Alvargonzález Rodríguez (1996), pp. 167-168 or Romero Muñoz and Sáenz Sanz (1996), p. 197. In the case of lighthouses, new investment data are only available from 1855. The value of the stock in 1855 has been estimated by applying a unit cost of 40.2 million of 1990 pesetas to the number of lighthouses that were in operation that year, which is available in *MAEOP*. That figure results from dividing the amount invested in lighthouses up to 1908 by the number of lighthouses built during the years 1855-1908. Investment in lighthouses in 1845-1855 has been assumed to follow the same pace as port investment.

the physical description of a sample of the Spanish ports at that date, which is available in *MAEOP*.[84]

There are no investment figures available for the period 1908-1935. In order to obtain estimates for investment flows and the value of the stock in those years, the unit cost figures resulting from the 1908 census have been applied to the next available port census, which was carried out in 1925.[85] The difference between the gross value of the stock in 1908 and 1925 has been considered as the accumulated "new" investment that was undertaken between those two years. In order to distribute this "new" investment through time, it has been assumed to follow the same evolution as the total expenses of the autonomous port management institutions (*Juntas*).[86]

For the years 1926-1935, the direct estimate of the Spanish port stock that was carried out in 1965 has been compared with the estimate for 1925. The difference between the port gross stock in 1925 and 1965 has been assumed to be the accumulated "new" investment between those dates. The yearly evolution of "new" investment has been estimated according to the amounts devoted to port investment in the State budget.[87]

"New" investment in ports has been increased by a hypothetical series of replacement expenses in order to obtain a yearly estimate of gross investment, which has been used in the estimation of the net stock of Spanish port infrastructure.[88] The resulting

[84] The sample covered by that description accounted for 68 per cent of the total length of walls of Spanish ports in 1908. The reliability of the gross stock estimate for 1908 coming from the investment series has been contrasted by dividing it by the total physical development of Spanish ports that is shown in that description. The ports excluded from the sample have been assumed to be 50 per cent cheaper than those included, because the description focused on the most important ones. The resulting unit costs are 188.3 million pesetas of 1990 per ha of dock and 3.1 million pesetas of 1990 per m of available quayage, which are consistent with the available technical information; see Cunningham (1914).

[85] Junta Central de Puertos (n.d.), pp. 204-213. That census was much more exhaustive than the 1908 one. The ports of the sample accounted for around 94 per cent of the total length of walls of Spanish ports in 1908. There are two possible alternative estimates of the value of the gross stock in 1925, depending on which unit cost is applied, i.e. relative to dock surface or to available quayage. Out of the two alternative estimates, the higher one has been chosen, given the quality improvements that appear to have taken place in Spanish ports during the first third of the twentieth century. An estimate of the gross stock in lighthouses has been added to that figure, which results from the accumulation of Cercos Pérez's estimates of "new" investment in lighthouses in 1908-1925. This researcher applied a coefficient of 0.724 to the expenses in lighthouse construction that were included in the State budget during those years; see Cercos Pérez (1968), p. 585.

[86] The evolution of the expenses of the *Juntas* has been taken from Junta Central de Puertos (n.d.), pp. 214-222.

[87] Suárez de Tangil y Angulo (1954), pp. 50-51, offers data for 1925-1953, and Cercos Pérez (1968), p. 605, for 1908-1965. Out of these two alternative series, the first one has been preferred for the years 1926-1951, because it is more complete and includes some extraordinary amounts that are absent from Cercos Pérez's data. On the contrary, from 1952 onwards, Cercos Pérez's figures are more appropriate, because they include the amounts invested by institutions other than the State, which are not considered by Suárez de Tangil.

[88] Retirement has been assumed to be a continuous process that coincided with depreciation associated with deterioration, which has been assumed to be 80 per cent of total depreciation. The useful life of port

series are shown in Table A.2.9 and Graphs A.2.13 and A.2.14. In addition, Graph A.2.13 compares the new estimate of port net infrastructure stock with the *IVIE* alternatives up to 1965.[89]

Table A.2.9
Ports (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1844				25,273			13,900
1845	389	316	73	25,347	421	-32	13,868
1846	368	316	52	25,399	422	-54	13,814
1847	382	316	66	25,465	423	-41	13,773
1848	413	316	97	25,562	424	-12	13,761
1849	465	316	149	25,711	426	39	13,801
1850	549	316	233	25,945	429	121	13,921
1851	599	316	283	26,228	432	167	14,088
1852	713	316	398	26,626	437	276	14,364
1853	887	316	571	27,197	444	443	14,808
1854	758	316	442	27,639	453	305	15,112
1855	713	316	397	28,036	461	252	15,365
1856	1,134	316	818	28,854	467	666	16,031
1857	732	316	416	29,270	481	251	16,283
1858	839	316	523	29,793	488	351	16,634
1859	1,235	316	919	30,712	497	738	17,372
1860	1,220	316	904	31,616	512	708	18,080
1861	1,502	316	1,186	32,802	527	975	19,055
1862	1,762	316	1,446	34,248	547	1,215	20,270
1863	2,999	316	2,683	36,931	571	2,428	22,698
1864	2,999	316	2,683	39,614	616	2,383	25,081
1865	2,999	316	2,683	42,296	660	2,339	27,420
1866	2,999	316	2,683	44,979	705	2,294	29,714
1867	1,285	316	970	45,949	750	536	30,250
1868	1,336	316	1,020	46,969	766	571	30,820
1869	1,008	316	692	47,661	783	225	31,045
1870	830	316	514	48,175	794	36	31,081
1871	1,281	316	965	49,140	803	478	31,559
1872	1,519	316	1,203	50,343	819	700	32,258
1873	678	316	362	50,705	839	-161	32,097
1874	2,258	316	1,942	52,647	845	1,413	33,510
1875	1,924	316	1,608	54,255	877	1,046	34,556
1876	459	316	143	54,398	904	-445	34,111
1877	464	316	148	54,546	907	-442	33,669
1878	473	316	157	54,703	909	-437	33,232
1879	508	316	192	54,895	912	-404	32,828
1880	650	316	334	55,229	915	-265	32,564

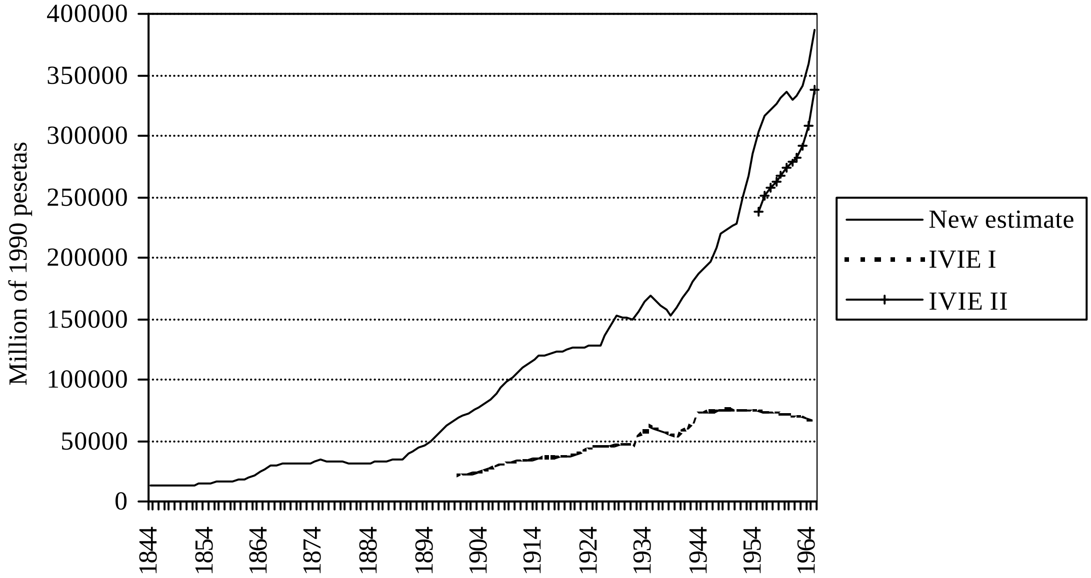
infrastructure has been assumed to be 80 years. The ratio between net and gross stock in 1844 has been assumed to be the same as in State roads.

[89] As has been pointed out before, the *IVIE* series for 1900-1990 only refers to infrastructure financed by the State and does not include investment undertaken by other institutions. The *IVIE* database includes a second series of port infrastructure that starts in 1955 and refers to the whole port system, which is also shown in Graph A.2.13.

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1881	582	316	267	55,496	920	-338	32,226
1882	540	316	224	55,720	925	-385	31,841
1883	620	316	304	56,024	929	-309	31,533
1884	1,197	316	881	56,906	934	263	31,796
1885	2,149	316	1,833	58,739	948	1,201	32,997
1886	1,357	316	1,041	59,780	979	378	33,375
1887	1,526	316	1,210	60,990	996	529	33,904
1888	1,468	316	1,152	62,142	1,016	452	34,356
1889	1,515	316	1,199	63,341	1,036	479	34,835
1890	1,674	316	1,358	64,699	1,056	618	35,453
1891	4,818	316	4,502	69,201	1,078	3,740	39,193
1892	4,073	316	3,757	72,958	1,153	2,919	42,113
1893	3,623	316	3,307	76,265	1,216	2,407	44,519
1894	3,867	316	3,551	79,816	1,271	2,596	47,115
1895	4,714	316	4,398	84,214	1,330	3,384	50,499
1896	4,740	316	4,424	88,638	1,404	3,336	53,835
1897	6,241	316	5,925	94,562	1,477	4,763	58,598
1898	5,977	316	5,661	100,224	1,576	4,401	62,999
1899	5,065	316	4,749	104,973	1,670	3,395	66,394
1900	4,762	316	4,446	109,419	1,750	3,012	69,406
1901	3,813	316	3,497	112,916	1,824	1,990	71,396
1902	4,114	316	3,798	116,714	1,882	2,232	73,628
1903	3,899	316	3,583	120,298	1,945	1,954	75,582
1904	4,592	316	4,276	124,574	2,005	2,587	78,169
1905	5,056	316	4,740	129,314	2,076	2,980	81,149
1906	5,846	316	5,530	134,844	2,155	3,691	84,840
1907	6,177	316	5,861	140,705	2,247	3,929	88,769
1908	7,997	316	7,681	148,385	2,345	5,652	94,421
1909	6,938	316	6,622	155,007	2,473	4,464	98,885
1910	6,285	316	5,969	160,976	2,583	3,702	102,587
1911	6,445	316	6,129	167,105	2,683	3,762	106,348
1912	6,685	316	6,369	173,474	2,785	3,900	110,248
1913	5,829	316	5,513	178,988	2,891	2,938	113,187
1914	6,500	316	6,184	185,171	2,983	3,517	116,703
1915	5,718	316	5,402	190,574	3,086	2,632	119,335
1916	4,086	316	3,770	194,344	3,176	910	120,245
1917	4,719	316	4,403	198,747	3,239	1,480	121,725
1918	4,150	316	3,834	202,581	3,312	837	122,563
1919	4,426	316	4,110	206,691	3,376	1,050	123,612
1920	4,431	316	4,115	210,807	3,445	986	124,599
1921	5,278	316	4,962	215,769	3,513	1,765	126,363
1922	4,135	316	3,819	219,587	3,596	538	126,902
1923	4,277	331	3,947	223,534	3,660	618	127,519
1924	4,461	341	4,120	227,655	3,726	736	128,255
1925	4,347	354	3,992	231,647	3,794	552	128,808
1926	4,136	374	3,762	235,409	3,861	275	129,083
1927	11,631	404	11,227	246,636	3,923	7,707	136,790
1928	11,844	413	11,432	258,068	4,111	7,734	144,524
1929	12,646	465	12,181	270,249	4,301	8,345	152,869
1930	3,597	549	3,048	273,297	4,504	-907	151,962
1931	3,398	599	2,798	276,095	4,555	-1,157	150,804
1932	3,168	713	2,455	278,550	4,602	-1,434	149,371
1933	10,726	887	9,839	288,388	4,642	6,083	155,454

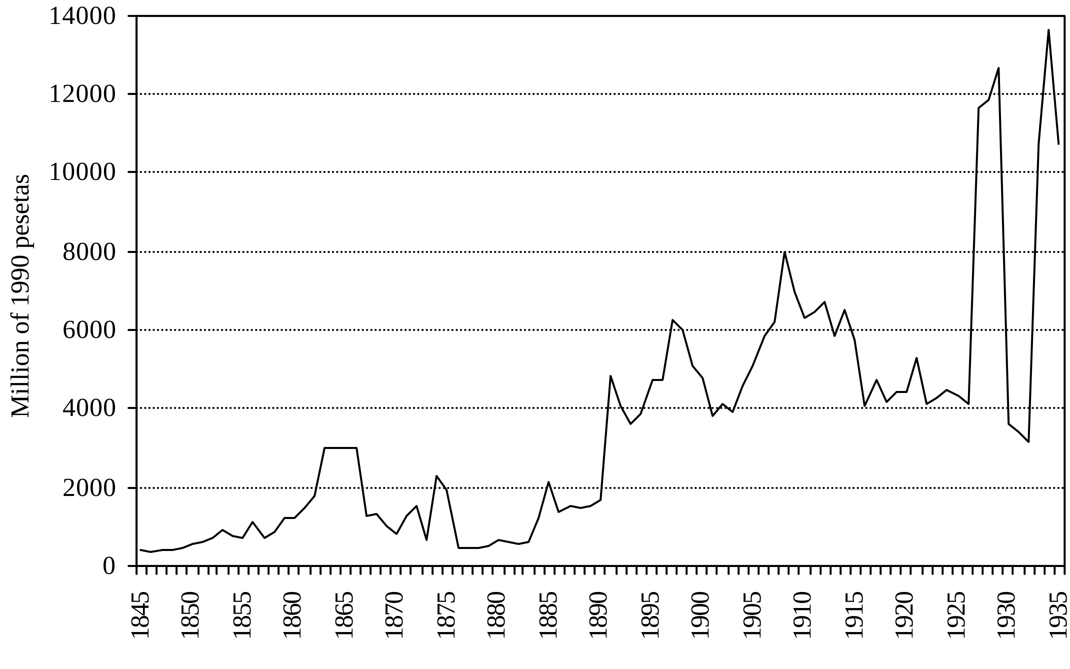
	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1934	13,643	758	12,885	301,273	4,806	8,836	164,290
1935	10,702	713	9,989	311,263	5,021	5,681	169,971

Graph A.2.13
Ports: net infrastructure stock (alternative estimates)



NOTE: IVIE I refers to State; IVIE II to total port infrastructure.

Graph A.2.14
Ports: gross infrastructure investment



A.2.2 Communication networks

1) Telegraph

Within the telegraph system, only the network has been considered as infrastructure. Machinery was relatively small and not fixed to the territory and the buildings in which it was located were often devoted to other uses.[90] The starting point for the estimation of telegraph infrastructure stock has been an assessment of the materials that made up the Spanish telegraph network in 1896, on the basis of technical information.[91] The resulting gross stock figure has been increased by 20 per cent to account for the contribution of labour, and has been carried backward and forward according to the evolution of the length of lines and wires.[92] The resulting yearly series of gross stock has then been first-differenced to get a "new" investment series, which has in turn been the basis for the net stock estimates.[93]

The physical evolution of the network is shown in Table A.2.10, and the series of net stock and gross investment can be seen in Table A.2.10 and in Graphs A.2.15 and A.2.16. The final 1935 net stock figure of 735 million of 1990 pesetas is much lower than the network value in 1965 which, according to the direct estimate available for that year, was around 14,290 million of 1990 pesetas.[94] In fact, my estimate is much more consistent

[90] See Capel Sáez and Tatjer (1994), p. 45.

[91] The unit costs that have been applied are the following (in 1990 pesetas):

- posts: 948 to 4,274 pesetas per unit (depending on quality and size).
- wire: 81,667 to 130,552 pesetas per 1,000 kg (depending on quality).
- cable: 1,381 to 1,648 pesetas per m.
- insulators: 183 to 324 pesetas per unit (depending on size).

These figures come from Sauer (1869), except in the case of cable, for which telephone information coming from López Hernández (1968) has been used. De Urquijo y De la Fuente (1968), p. 694, offers quite similar unit costs for the Spanish network in 1965; Sauer's figures have been preferred here because they allow a higher level of detail in the assessment and are technologically closer to the Spanish network for most of the period under study. In addition, the Spanish telegraph network of the nineteenth century was constructed to a great extent with imported materials; see Capel Sáez and Tatjer (1994), p. 49, and Calvo Calvo (2001). The description of the stock in 1896 comes from the *Estadística Telegráfica de España*. Prices have been expressed in 1990 pesetas by using Prados de la Escosura's deflators for industry; see Prados de la Escosura (1995), pp. 130-131.

[92] The share of labour in the total cost comes from Sauer (1869). The value of wires has been carried backward and forward according to the length of wire, and the value of posts, cables and insulators, according to the length of lines. Since 1884 the Spanish telegraph network was divided into State and local assets; see Calvo Calvo (forthcoming). However, data on local networks is only available from 1909 onwards; for former periods a similar evolution to the State network has been assumed. The information on the physical development of the network comes from the *Estadística Telegráfica de España* and *AEE*. Inconsistencies among different years in the mileage series have been corrected. The last *Estadística Telegráfica* refers to 1934; the stock figure for 1935 has been calculated as a projection of the previous 10-year trend.

[93] The assumed useful life for the telegraph network has been 30 years, as in Feinstein (1988), p. 354.

[94] See De Urquijo y De la Fuente (1968), p. 697

with the data of "First Establishment" expenses of the State telegraph system during the nineteenth century.[95] Therefore, the new estimates seem to contain a downward bias that increases with time, probably associated with the inability of the series to capture the quality improvements in the system during the first third of the twentieth century. Unfortunately, the lack of information on the physical characteristics of the stock between 1935 and 1965 makes the correction of this bias very difficult. As a consequence, the reliability of the telegraph stock series is lower than for other types of infrastructure.

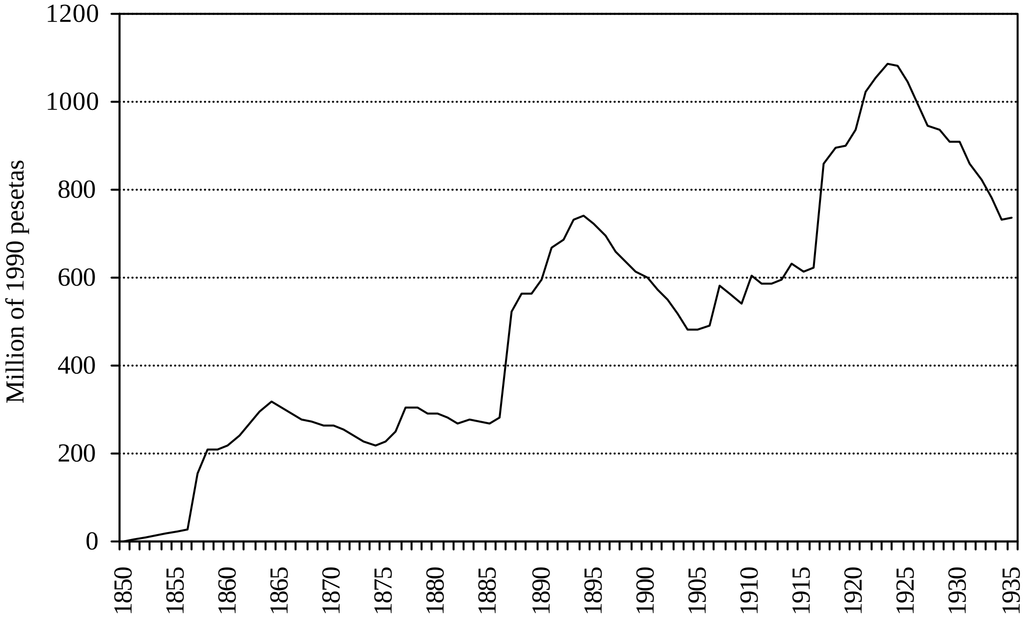
Table A.2.10
Telegraph infrastructure (million of 1990 pesetas)

	Network length (km)	Network length (including local lines)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Invest.	Net Stock
1851			5	0	5	5	0	5	5
1852			5	0	5	9	0	5	9
1853			5	0	5	14	0	4	14
1854			5	0	5	19	0	4	18
1855	713		5	0	5	24	1	4	22
1856	883		6	0	6	29	1	5	27
1857	4,775		129	0	129	158	1	128	155
1858	6,560		59	0	59	218	5	54	209
1859	6,775		7	0	7	225	7	0	209
1860	7,215		15	0	15	241	8	8	217
1861	8,280		33	0	33	273	8	25	242
1862	8,828		35	0	35	308	9	26	268
1863	10,001		40	0	40	348	10	30	298
1864	10,918		30	0	30	379	12	19	316
1865	11,253		0	0	0	379	13	-13	304
1866	10,153		0	0	0	379	13	-13	291
1867	10,804		0	0	0	379	13	-13	278
1868	11,137		7	0	7	386	13	-5	273
1869	11,220		4	0	4	390	13	-9	264
1870	11,601		14	0	14	404	13	1	265
1871	11,754		2	0	2	406	13	-12	254
1872	11,754		2	0	2	408	14	-11	243
1873	11,754		0	0	0	408	14	-14	229
1874	11,754		0	0	0	408	14	-14	216
1875	12,260		27	0	27	436	14	14	229
1876	13,094		34	0	34	469	15	19	248
1877	14,854		71	0	71	540	16	55	304
1878	15,406		18	0	18	558	18	0	303
1879	15,489		4	0	4	562	19	-15	288
1880	16,124		19	0	19	581	19	0	289
1881	16,264		11	5	7	588	19	-8	281
1882	15,744		8	5	3	591	20	-12	269
1883	17,174		26	5	21	612	20	6	276
1884	17,489		17	5	13	625	20	-3	273
1885	17,840		15	5	10	635	21	-6	267

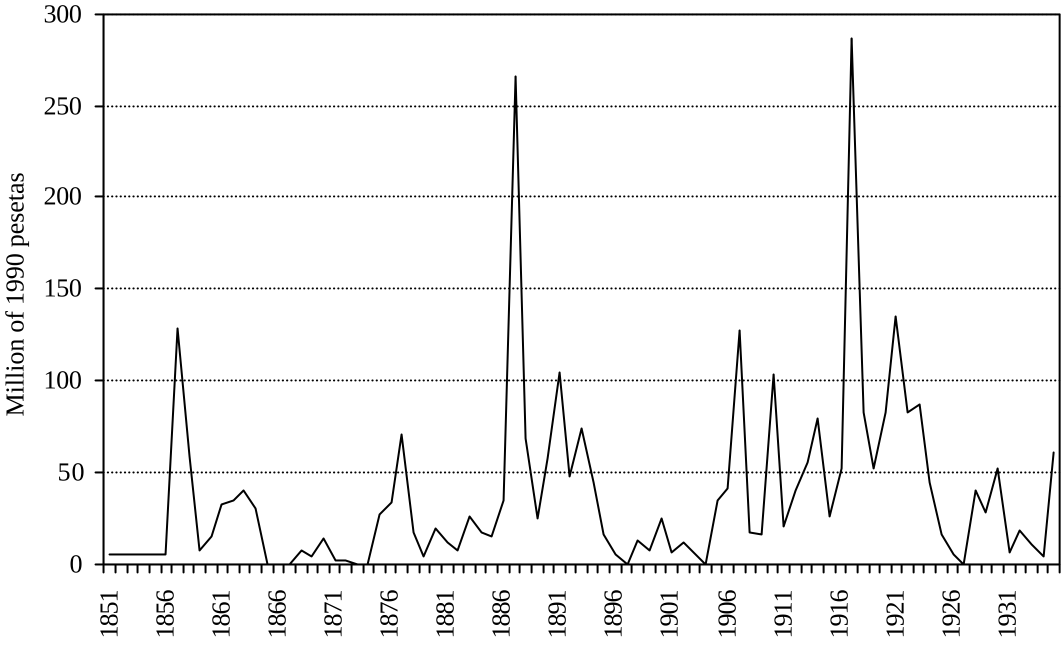
[95] See, for instance, Calvo Calvo (2001).

	Network length (km)	Network length (including local lines)	Gross Investment	Retirem.	New Investment	Gross Stock	Depreciat.	Net Invest.	Net Stock
1886	18,419		34	6	29	664	21	13	280
1887	23,292		265	129	136	800	22	243	523
1888	23,196		68	59	9	809	27	42	565
1889	23,809		25	7	18	827	27	-2	563
1890	24,756		57	15	42	869	28	30	593
1891	27,071		105	33	72	942	29	76	669
1892	26,729		47	35	12	954	31	16	685
1893	28,134		74	40	34	988	32	43	728
1894	28,386		44	30	14	1,002	33	11	739
1895	28,797		16	0	16	1,019	33	-17	722
1896	28,828		5	0	5	1,024	34	-29	693
1897	28,392		0	0	0	1,024	34	-34	659
1898	28,704		13	7	5	1,029	34	-22	638
1899	28,557		7	4	3	1,032	34	-27	611
1900	29,030		25	14	10	1,043	34	-10	601
1901			7	2	5	1,047	35	-28	573
1902			12	2	9	1,056	35	-23	549
1903	29,252		5	0	5	1,061	35	-30	519
1904	28,809		0	0	0	1,061	35	-35	484
1905	29,612		35	27	8	1,069	35	0	484
1906	29,947		41	34	7	1,077	36	5	489
1907	32,097		128	71	57	1,134	36	92	581
1908	30,056		18	18	0	1,134	38	-20	561
1909	31,085		17	4	13	1,147	38	-21	540
1910	34,701	37,007	103	19	84	1,231	38	65	605
1911	34,463	36,673	20	11	9	1,240	41	-21	585
1912	35,,587	37,831	40	8	32	1,272	41	-2	583
1913	36,454	38,688	55	26	29	1,301	42	13	596
1914			79	17	62	1,363	43	36	632
1915	38,152	41,272	26	15	12	1,374	45	-19	613
1916	38,603	42,546	52	34	18	1,392	46	6	619
1917	39,195	43,535	286	265	21	1,413	46	240	859
1918	39,476	44,424	82	68	14	1,427	47	35	894
1919	40,118	46,213	52	25	27	1,454	48	4	898
1920	40,723	45,970	83	57	26	1,479	48	35	933
1921	41,872	47,674	134	105	29	1,509	49	85	1,018
1922	42,369	48,376	82	47	35	1,544	50	32	1,051
1923	42,950	49,429	87	74	13	1,556	51	35	1,086
1924	42,950	49,429	44	44	0	1,556	52	-8	1,078
1925	36,765	43,688	16	16	0	1,556	52	-35	1,043
1926	41,728	46,848	5	5	0	1,556	52	-47	996
1927	41,583	46,461	0	0	0	1,556	52	-52	944
1928	41,528	46,415	40	13	28	1,584	52	-11	933
1929	40,623	45,241	29	7	21	1,605	53	-24	908
1930	40,996	45,514	52	25	28	1,633	54	-1	907
1931	41,005	45,580	7	7	0	1,633	54	-48	859
1932	41,084	46,152	18	12	7	1,640	54	-36	823
1933	41,113	45,864	11	5	6	1,646	55	-43	780
1934	41,145	45,675	5	0	5	1,651	55	-50	729
1935			61	35	26	1,676	55	6	735

Graph A.2.15
Telegraph: net infrastructure stock



Graph A.2.16
Telegraph: gross infrastructure investment



2) Telephone

Unlike the telegraph system, in the case of the telephone infrastructure has been assumed to include not only the network but also the main buildings and equipment, which constituted fixed elements that were an integral part of the network. In order to elaborate gross stock data, different procedures have been followed for the two periods before and after the establishment of the quasi-monopolistic *Compañía Telefónica Nacional de España* (*CTNE*) in 1924. For the second of those periods, the annual reports of the *CTNE* offer detailed information about the evolution of the company's physical assets. They have been multiplied by the available unit cost figures and, as a result of that calculation, a series of *CTNE* gross infrastructure stock has been obtained, which presents a very similar evolution to the total value of the company's assets in its annual accounts.[96] That series has been broadened to account for the few independent telephone companies that were still in operation after 1924, the most important one being the *Red Provincial de Guipúzcoa*. Those companies' stock has been valued according to the evolution of the number of their subscribers (for urban circuits) and centres (for long-distance circuits and equipment).[97]

For the period before 1924, the *Estadística Telegráfica de España* provides information about the number of urban networks and their subscribers. This has made possible an assessment of urban circuits and equipment, by applying ratios of the later period. The resulting figures of gross stock have been increased by 2.5 per cent, in order to allow for the "private" lines, which were often open to public service.[98] Unfortunately, there is no comparable information available about the Spanish long-distance telephone network between 1891 (when long-distance connections started) and 1924. Therefore, its evolution has been assumed to be similar to that of the urban networks.[99]

[96] Unit cost figures from López Hernández (1968). Some adjustments have been necessary to carry out the valuation. Firstly, there is no information on buildings before 1929, and they have been assumed to account for the same share of stock as in 1929-1935. Secondly, urban circuits are not described in detail every year, and they have been assumed to follow the same evolution as the number of subscribers of the company. An average of Prados de la Escosura's deflators for industry (weighted 70 per cent) and construction (weighted 30 per cent) has been applied to the unit costs.

[97] Data for the *Red Provincial de Guipúzcoa* is available in Echaide (1929) and in the company's annual reports, and less complete information for other companies is available in the *Estadística Telegráfica de España*. In order to transform physical indicators into stock data, coefficients coming from *CTNE* information have been applied.

[98] The percentage of "private" lines also comes from the *Estadística Telegráfica de España*.

[99] This implies a very slow development until 1904 and a gradual acceleration thereafter, which is consistent with the qualitative information about the development of the long-distance network; see Bahamonde Magro and Otero Carvajal (1993), p. 220, and Calvo Calvo (1998).

The resulting gross stock figures have been increased by 10.6 per cent in order to include buildings.[100] Finally, the stock of the *Red Provincial de Guipúzcoa* before 1924 has been separately assessed using specific information on the company's assets.[101] The resulting series of gross stock of telephone infrastructure for 1884-1935 has been first-differenced in order to get a "new" investment series, which has been used as the basis for the yearly net stock estimate.[102]

The final net stock in 1935 is around 10 per cent of its value in 1965, which is consistent with the extraordinary growth and technological change of the telephone network during the 1950's and 1960's.[103] The series can be seen in Table A.2.11 and in Graphs A.2.17 and A.2.18.

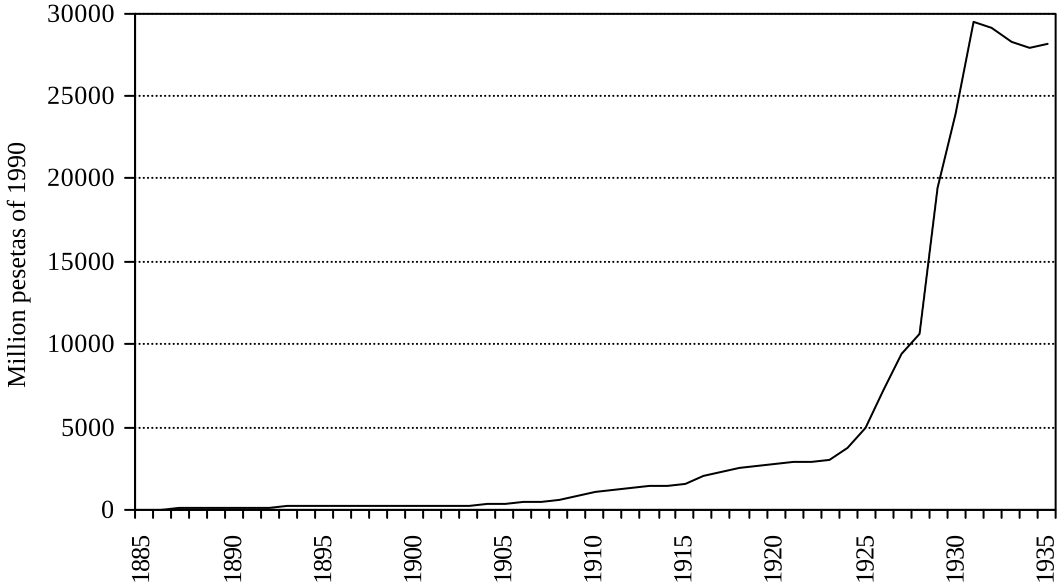
Table A.2.11
Telephone infrastructure (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1884				0			0
1885	4	0	4	4	0	4	4
1886	2	0	2	6	0	2	6
1887	22	0	22	28	0	22	28
1888	22	0	22	50	1	21	49
1889	15	0	15	65	2	13	62
1890	6	0	6	71	2	4	66
1891	6	0	6	76	2	4	70
1892	55	0	55	132	2	53	123
1893	39	0	39	171	4	35	158
1894	40	0	40	210	5	34	192
1895	69	0	69	280	6	63	255
1896	10	0	10	290	9	2	256
1897	4	0	4	294	9	-5	251
1898	6	0	6	300	9	-3	248
1899	15	0	15	315	9	6	254
1900	12	0	12	327	10	3	256
1901	8	0	8	336	10	-2	255
1902	10	0	10	345	10	0	254
1903	10	0	10	356	11	0	254
1904	54	0	54	410	11	43	297
1905	114	0	114	523	13	101	398
1906	60	0	60	583	16	44	441
1907	85	0	85	668	18	67	509

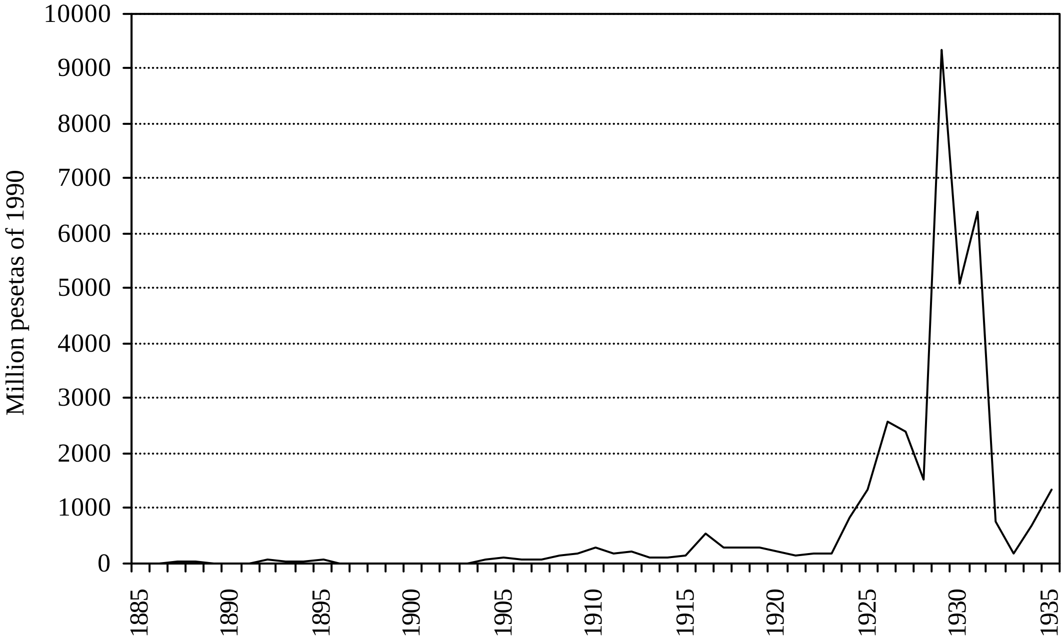
[100] This percentage comes from *CTNE* data.
[101] Echaide (1929).
[102] The useful lifetimes have been assumed to be 100 years for buildings and 30 years for other infrastructure, as in Feinstein (1988), p. 354.
[103] The valuation of *CTNE* stock in 1965, in López Hernández (1968), p. 726. The progress of the system in the 1950's and 1960's can be seen, for instance, in the number of telephone stations, which was 329,130 in 1935 and 2,736,828 in 1965.

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1908	124	0	124	793	21	104	612
1909	196	0	196	989	24	172	784
1910	282	0	282	1,271	31	252	1,036
1911	178	0	178	1,449	39	139	1,175
1912	238	0	238	1,687	45	193	1,368
1913	115	0	115	1,802	52	63	1,431
1914	109	0	109	1,911	56	53	1,484
1915	145	3	142	2,052	59	86	1,570
1916	545	2	543	2,595	63	482	2,051
1917	277	20	257	2,852	80	197	2,248
1918	302	20	282	3,134	88	214	2,462
1919	296	13	283	3,418	97	200	2,662
1920	232	5	227	3,645	105	127	2,789
1921	150	5	145	3,790	112	38	2,827
1922	194	49	145	3,935	117	77	2,904
1923	202	35	167	4,101	121	80	2,984
1924	827	35	792	4,893	127	701	3,685
1925	1,351	62	1,290	6,183	152	1,200	4,885
1926	2,582	9	2,573	8,756	192	2,390	7,275
1927	2,407	4	2,403	11,159	271	2,136	9,410
1928	1,529	5	1,523	12,682	346	1,183	10,594
1929	9,316	13	9,303	21,985	393	8,924	19,517
1930	5,065	11	5,054	27,039	682	4,383	23,900
1931	6,389	7	6,381	33,420	840	5,549	29,449
1932	780	9	771	34,192	1,041	-261	29,187
1933	190	9	181	34,372	1,065	-875	28,313
1934	668	48	620	34,993	1,070	-401	27,911
1935	1,365	102	1,263	36,256	1,086	278	28,189

Graph A.2.17
Telephone net infrastructure stock



Graph A.2.18
Telephone gross infrastructure investment



A.2.3 Energy distribution networks

Energy distribution infrastructure was made up of two main sectors: gas and electricity. It has not been possible to estimate the value of Spanish gas distribution networks, due to the scarcity of information. However, the sector had very little importance and its exclusion from the series of stock does not seem to be a serious shortcoming.[104]

On the contrary, information about electricity distribution networks is much more abundant. In the mid-1940's, Becerril published the accounting value (gross of depreciation) of each type of asset in the sector. His figures seem to be quite exhaustive, although he probably missed the companies that produced electricity for their own use. However, that absence is not a problem for this research, since these producers did not contribute to the distribution network.[105]

Those accounting figures have been corrected for price changes during the investment period.[106] The result of this calculation is an estimate of gross capital stock in the sector in 1943 expressed in 1990 pesetas, in which, according to Becerril's information, 50 per cent was distribution infrastructure. The value of this share of the gross stock has then been carried backward according to the evolution of electricity production, in order to get a yearly gross stock series.[107] This has then been first-differenced to obtain a "new" investment series, which has been used to estimate net stock figures, as in previous cases.[108] The final series are shown in Table A.2.12 and in Graphs A.2.19 and A.2.20.

[104] There are some indications about the size of the sector that give an idea of its lack of importance. On the one hand, Spanish gas production in 1901 was 105 million m^3, i.e. only 2.6 per cent of the British figure; see Sudrià Triay (1983), pp. 108-109. If the value of British gas distribution infrastructure (40 per cent of the total capital stock in the gas sector) is applied this percentage, the resulting figure is 7,020 million of 1990 pesetas, which would account for around 0.7 per cent of Spanish net infrastructure stock in that year. In this calculation, the British stock figure comes from Feinstein (1988), pp. 302-304, and infrastructure is considered as those elements different from factories. On the other hand, during the nineteenth century the investment in the Spanish gas sector by foreign companies (which were absolutely dominant at the time) amounted to around 20,000 million of 1990 pesetas; see Costa Campí (1981), p. 55; and the 40 per cent of this figure (which would represent infrastructure) is similar to the other indicator.

[105] Becerril y Antón-Miralles (1946).

[106] A weighted average of Prados de la Escosura's deflators for industry (40 per cent) and construction (60 per cent) has been applied to these figures, according to the timing of capital formation in the electricity sector from 1900 onwards, which has been approached through production figures as is indicated below. A series of Spanish electricity production is available in Bartolomé Rodríguez (1999).

[107] Production figures have also been used by Fenoaltea for Italy with similar purposes; see Fenoaltea (1982), p. 626. Production data coming from Bartolomé Rodríguez (1999) have been smoothed by calculating 3-year moving averages, in order to avoid jumps associated with the elaboration of electrical censuses, which are warned of by the author.

[108] The assumed useful life for the electricity distribution network is 25 years, as in Feinstein (1988), p. 305, and Groote (1996), p. 162.

Their level is consistent with figures of paid-up capital in the sector during the period under study.[109]

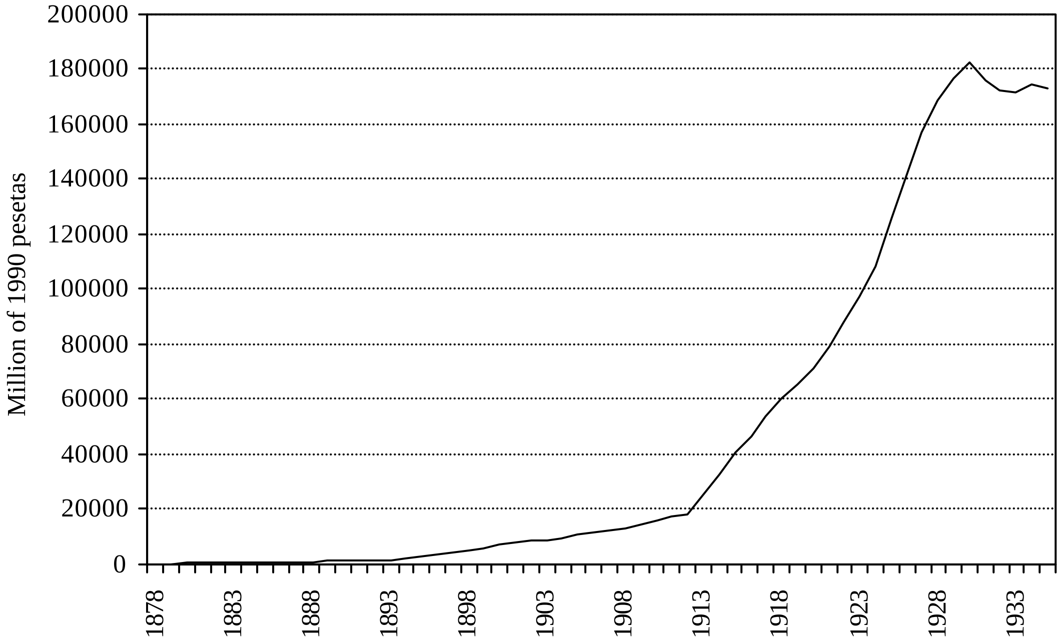
Table A.2.12
Electricity distribution networks (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1879	229	0	229	229	0	229	229
1880	249	0	249	478	9	240	469
1881	270	0	270	748	19	251	720
1882	64	0	64	812	30	34	754
1883	70	0	70	882	32	37	791
1884	76	0	76	958	35	41	832
1885	82	0	82	1,040	38	44	876
1886	89	0	89	1,130	42	48	924
1887	97	0	97	1,227	45	52	976
1888	105	0	105	1,332	49	56	1,032
1889	115	0	115	1,447	53	62	1,094
1890	113	0	113	1,561	58	55	1,149
1891	171	0	171	1,732	62	109	1,258
1892	198	0	198	1,930	69	129	1,387
1893	405	0	405	2,335	77	328	1,715
1894	654	0	654	2,989	93	561	2,276
1895	938	0	938	3,927	120	818	3,094
1896	1,038	0	1,038	4,965	157	881	3,975
1897	978	0	978	5,943	199	779	4,754
1898	866	0	866	6,809	238	628	5,382
1899	934	0	934	7,743	272	662	6,044
1900	1,467	0	1,467	9,211	310	1,158	7,202
1901	1,409	0	1,409	10,620	368	1,040	8,242
1902	1,027	0	1,027	11,646	425	602	8,844
1903	561	0	561	12,207	466	95	8,940
1904	1,204	229	975	13,182	488	716	9,655
1905	1,648	249	1,399	14,582	527	1,121	10,776
1906	1,578	270	1,308	15,890	583	995	11,771
1907	1,189	64	1,125	17,015	636	554	12,325
1908	1,032	70	962	17,977	681	352	12,677
1909	2,419	76	2,343	20,320	719	1,699	14,376
1910	2,272	82	2,190	22,510	813	1,459	15,835
1911	2,699	89	2,609	25,119	900	1,798	17,634
1912	1,773	97	1,676	26,795	1,005	768	18,402
1913	7,995	105	7,890	34,685	1,072	6,923	25,326
1914	8,401	115	8,286	42,971	1,387	7,014	32,339
1915	9,750	113	9,636	52,607	1,719	8,031	40,370
1916	8,373	171	8,201	60,809	2,104	6,268	46,638
1917	9,823	198	9,625	70,433	2,432	7,390	54,029
1918	8,758	405	8,353	78,786	2,817	5,941	59,969
1919	8,399	654	7,745	86,532	3,151	5,248	65,217

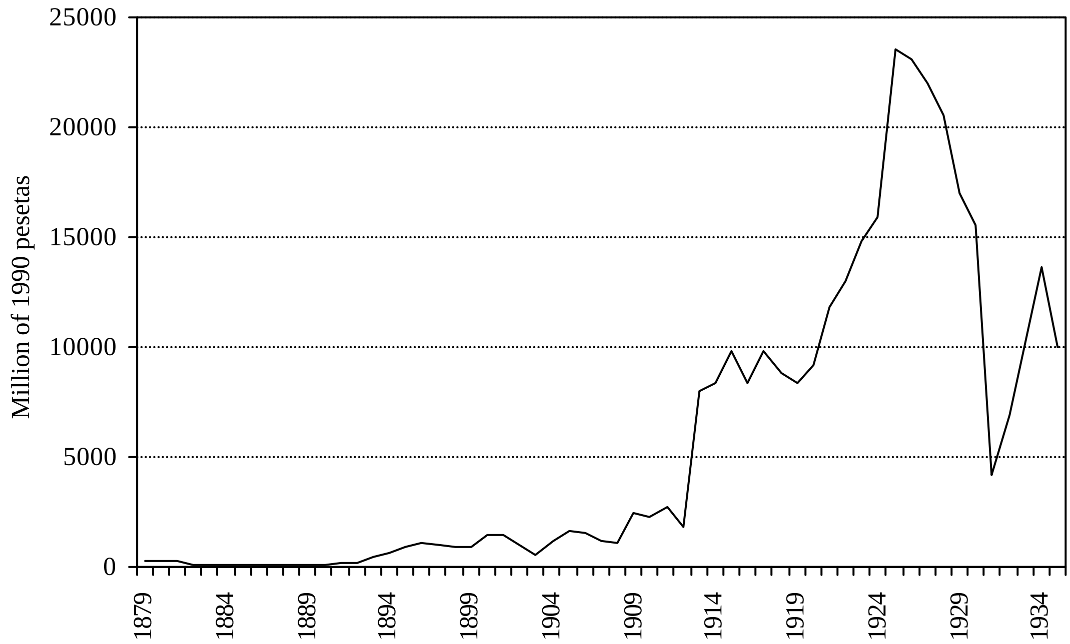
[109] See, for instance, Sintes Olives and Vidal Burdils (1933), pp. 122-123, or Hernández Andreu (1981), pp. 142-148. The reliability of the series is confirmed by the fact that the net stock of electricity distribution infrastructure was estimated in 1965 to be around ten times as large as my estimate for 1935, and electricity production had experienced a similar growth between those two years; see Gabinete de Investigación de la Universidad Comercial de Deusto (1968).

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1920	9,187	938	8,249	94,781	3,461	5,726	70,943
1921	11,820	1,038	10,781	105,562	3,791	8,028	78,972
1922	12,952	978	11,974	117,536	4,222	8,729	87,701
1923	14,789	866	13,923	131,460	4,701	10,088	97,789
1924	15,922	934	14,988	146,447	5,258	10,664	108,452
1925	23,514	1,467	22,047	168,494	5,858	17,657	126,109
1926	23,047	1,409	21,638	190,132	6,740	16,307	142,416
1927	21,952	1,027	20,925	211,057	7,605	14,347	156,763
1928	20,485	561	19,924	230,981	8,442	12,043	168,805
1929	16,927	1,204	15,723	246,704	9,239	7,687	176,493
1930	15,535	1,648	13,887	260,592	9,868	5,667	182,160
1931	4,160	1,578	2,582	263,173	10,424	-6,264	175,896
1932	6,896	1,189	5,707	268,880	10,527	-3,631	172,265
1933	10,289	1,032	9,257	278,137	10,755	-466	171,799
1934	13,650	2,419	11,231	289,368	11,125	2,525	174,324
1935	10,007	2,272	7,735	297,103	11,575	-1,568	172,756

Graph A.2.19
Electricity distribution: net infrastructure stock



Graph A.2.20
Electricity distribution: gross infrastructure investment



A.2.4 Hydraulic Works

1) Reservoirs

The estimates for the net stock or reservoirs are based on a census carried out in 1965, which provides detailed information about physical characteristics, year of inauguration and construction cost of the Spanish reservoirs with a dam higher than 15 m, except for a few cases in which construction cost was unknown.[110] In order to give a value to those reservoirs with no construction cost information, data from the remaining works has been used to get unit construction costs by type and size of dam.[111]

The (true or estimated) construction cost of each reservoir has then been distributed among the 10 years before the date of its inauguration, in order to get figures of "new"

[110] Garrido Bartolomé (1968), pp. 723-737.
[111] The cost of land has been subtracted. The average unit values of the dams for which there is information about construction costs are the following (in 1990 pesetas): earth dams, 3,830 pesetas per m^3; masonry dams, 7,307 to 13,252 pesetas per m^3 (depending on the reservoir capacity); ashlar or concrete dams: 11,374 to 32,996 pesetas per m^3 (depending on the reservoir capacity). Those values have been applied to the reservoirs on which information on the volume of the dam was available. In a few cases there was no information on the volume of the dam either, and the reservoir capacity has been multiplied by the average construction cost per hm^3.

investment.[112] The resulting series has then been broadened to include reservoirs with a dam lower than 15 m, which were absent from the 1965 census. The available information indicates that those small reservoirs might have accounted for 15 per cent of the total stock at least until 1910, and would have a decreasing importance as the construction of large reservoirs accelerated after that date.[113] In the 1965 census, they were estimated to account for 6.45 per cent of the total stock of reservoirs.[114] Therefore, in this research, the "new" investment series has been increased by 15 per cent until 1910 and, from that year, by a share that decreased gradually to the level of 6.45 per cent in 1935.

A hypothetical series of replacement investment has been added to the "new" investment figures.[115] The resulting gross investment series has then been used as the basis for the estimation of the yearly net stock, which is presented in Table A.2.13 and in Graphs A.2.21 and A.2.22.

Table A.2.13
Reservoirs (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1844				209			127
1845	12	2	10	219	3	9	137
1846	26	2	24	243	3	23	160
1847	26	2	24	267	3	23	183
1848	28	2	26	293	3	25	207
1849	94	2	92	385	4	91	298
1850	94	2	92	477	5	89	387
1851	36	2	34	511	6	30	418
1852	70	2	68	579	6	64	482
1853	70	2	68	648	7	63	545
1854	139	2	137	784	8	130	675
1855	139	2	137	921	10	129	804
1856	139	2	137	1,057	12	127	931
1857	139	2	137	1,194	13	125	1,056
1858	139	2	137	1,331	15	124	1,180
1859	2	2	0	1,331	17	-15	1,165
1860	2	2	0	1,331	17	-15	1,151
1861	2	2	0	1,331	17	-15	1,136
1862	2	2	0	1,331	17	-15	1,121
1863	2	2	0	1,331	17	-15	1,107
1864	2	2	0	1,331	17	-15	1,092
1865	2	2	0	1,331	17	-15	1,078

[112] 10 years seem to be the average length of dam building during the period under study; see, for instance, Giebens (1926), p. 419, as well as numerous examples of dam construction in Bolea Foradada (1986).
[113] Information from *MAEOP* and Bello (1914).
[114] Garrido Bartolomé (1968), p. 715.
[115] The assumed useful life for reservoirs is 80 years, similar to Feinstein (1988), pp. 331-332, and Groote (1996), p. 135.

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1866	2	2	0	1,331	17	-15	1,063
1867	2	2	0	1,331	17	-15	1,048
1868	2	2	0	1,331	17	-15	1,034
1869	4	2	2	1,333	17	-12	1,021
1870	4	2	2	1,335	17	-12	1,009
1871	4	2	2	1,337	17	-12	997
1872	4	2	2	1,339	17	-12	984
1873	55	2	53	1,393	17	38	1,023
1874	88	2	86	1,478	17	70	1,093
1875	153	2	151	1,629	18	135	1,227
1876	153	2	151	1,780	20	133	1,360
1877	153	2	151	1,931	22	131	1,491
1878	209	2	207	2,138	24	185	1,676
1879	235	2	233	2,371	27	208	1,884
1880	300	2	298	2,669	30	271	2,154
1881	300	2	298	2,967	33	267	2,421
1882	300	2	298	3,265	37	263	2,684
1883	203	2	201	3,466	41	162	2,846
1884	143	2	141	3,607	43	100	2,946
1885	22	2	20	3,628	45	-23	2,923
1886	25	2	23	3,650	45	-21	2,902
1887	51	2	49	3,700	46	6	2,908
1888	54	2	52	3,752	46	8	2,916
1889	54	2	52	3,804	47	7	2,923
1890	65	2	63	3,866	48	17	2,940
1891	78	2	76	3,942	48	30	2,970
1892	105	2	103	4,045	49	56	3,025
1893	117	2	115	4,160	51	67	3,092
1894	128	2	126	4,287	52	76	3,168
1895	121	2	119	4,405	54	67	3,235
1896	132	2	130	4,535	55	77	3,312
1897	78	2	76	4,612	57	22	3,334
1898	54	2	52	4,663	58	-4	3,330
1899	70	2	68	4,731	58	12	3,342
1900	113	2	111	4,842	59	54	3,395
1901	137	2	135	4,977	61	76	3,471
1902	150	2	148	5,125	62	88	3,559
1903	192	2	190	5,314	64	128	3,687
1904	357	2	355	5,669	66	291	3,977
1905	380	2	378	6,047	71	309	4,286
1906	591	2	589	6,636	76	515	4,802
1907	989	2	987	7,623	83	906	5,708
1908	1,064	2	1,062	8,685	95	969	6,676
1909	1,376	2	1,374	10,059	109	1,267	7,944
1910	1,338	2	1,336	11,395	126	1,212	9,156
1911	1,574	2	1,572	12,966	142	1,432	10,587
1912	1,985	2	1,983	14,949	162	1,822	12,410
1913	2,323	2	2,321	17,270	187	2,136	14,546
1914	2,136	2	2,134	19,404	216	1,920	16,466
1915	2,268	2	2,266	21,670	243	2,026	18,491
1916	2,243	2	2,241	23,911	271	1,972	20,464
1917	1,788	2	1,786	25,698	299	1,490	21,953
1918	2,164	2	2,162	27,860	321	1,843	23,796

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1919	2,092	2	2,090	29,950	348	1,744	25,540
1920	2,380	2	2,378	32,328	374	2,006	27,546
1921	2,360	14	2,346	34,674	404	1,956	29,502
1922	2,732	14	2,718	37,392	433	2,298	31,800
1923	2,590	14	2,576	39,968	467	2,123	33,923
1924	3,047	14	3,033	43,001	500	2,547	36,470
1925	3,548	12	3,536	46,537	538	3,010	39,480
1926	4,031	26	4,005	50,542	582	3,450	42,930
1927	4,359	26	4,333	54,875	632	3,727	46,657
1928	4,914	28	4,886	59,761	686	4,228	50,885
1929	5,126	94	5,032	64,792	747	4,379	55,264
1930	5,583	94	5,489	70,281	810	4,773	60,037
1931	5,281	36	5,245	75,526	879	4,403	64,439
1932	4,544	70	4,474	80,000	944	3,600	68,039
1933	3,905	70	3,835	83,835	1,000	2,905	70,945
1934	3,544	139	3,405	87,240	1,048	2,496	73,441
1935	2,647	139	2,508	89,748	1,091	1,556	74,997

2) Canals

The information available about irrigation canals and the few existing waterways is much less detailed than for reservoirs. Data about either the costs or the age of each canal is very scarce, and the smallest works are just mentioned in the sources, without any specification of their physical characteristics.[116] Therefore, it has only been possible to estimate a very rough proxy of the stock of this type of infrastructure, which excludes the smallest irrigation canals at least until 1912.

For the period prior to 1912, a similar method to that followed with reservoirs has been applied. However, as has been indicated, construction cost figures are only available for a small sample of canals. They have been deflated according to the year of inauguration of each canal in the sample, and used to calculate a unit cost figure, which has been applied to the assessment of the remaining canals, for which no construction cost information exists.[117] The (true or estimated) construction costs of each canal have then been accumulated through time, and a gross stock series for 1844-1911 has been obtained as a

[116] The main sources of information about irrigation canals and waterways that have been used in this research are *MAEOP*, Bello (1914), Alzola y Minondo (1979), Ceballos Teresí (1932) and Fernández Ordóñez (1986). Information in these sources ends around 1911, and is not exhaustive.

[117] The unit cost figure has been obtained by dividing, for each canal in the sample, construction cost by the product of length times capacity, and by calculating a weighted average of the results. A 10 per cent of the value has been subtracted as a representative share for land. This percentage comes from a very small sample of canals for which this information is available.

result, which has been the basis for the figures of "new" and (after adding replacement expenses) gross investment in canal infrastructure.

From 1912 onwards, State investment in irrigation infrastructure has been used as representative for gross investment.[118] This is consistent with the change in the State's irrigation policy, which became much more active after the 1911 Act.[119] As a result, a continuous gross investment series for 1845-1935 has been obtained.

The net stock series that results from those gross investment figures has a very similar evolution to the reservoir net stock, and is reproduced in Table A.2.14 and Graph A.2.21.[120] Gross investment is depicted in Graph A.2.22 and, finally, Graph A.2.23 compares the evolution of the new estimate of the Spanish net stock of hydraulic works (reservoirs and canals) with the *IVIE* figures of hydraulic infrastructure net stock. As the *IVIE* series only refers to State investment, its level is lower than my estimate.

Table A.2.14
Canals (million of 1990 pesetas)

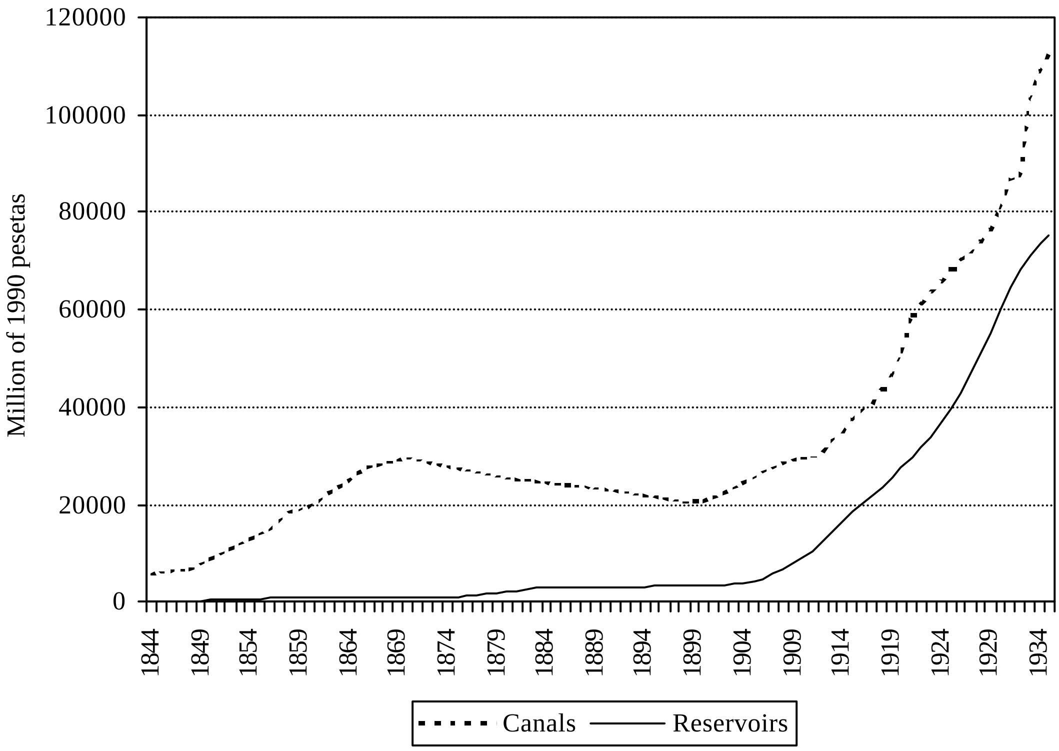
	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1844				10,178			5,825
1845	356	0	356	10,534	127	228	6,053
1846	356	0	356	10,890	132	224	6,277
1847	356	0	356	11,245	136	220	6,497
1848	356	0	356	11,601	141	215	6,712
1849	1,211	0	1,211	12,812	145	1,066	7,778
1850	1,211	0	1,211	14,022	160	1,051	8,829
1851	1,211	0	1,211	15,233	175	1,036	9,864
1852	1,211	0	1,211	16,444	190	1,020	10,885
1853	1,211	0	1,211	17,655	206	1,005	11,890
1854	1,211	0	1,211	18,865	221	990	12,880
1855	1,211	0	1,211	20,076	236	975	13,855
1856	1,223	0	1,223	21,299	251	972	14,827
1857	2,063	0	2,063	23,362	266	1,797	16,624
1858	2,063	0	2,063	25,425	292	1,771	18,395
1859	866	0	866	26,291	318	548	18,944
1860	866	0	866	27,157	329	537	19,481
1861	1,728	770	958	28,115	339	1,388	20,869
1862	1,728	770	958	29,072	351	1,376	22,246
1863	1,728	770	958	30,030	363	1,364	23,610
1864	1,728	770	958	30,987	375	1,352	24,962
1865	1,728	770	958	31,945	387	1,340	26,302
1866	1,716	770	946	32,890	399	1,316	27,619
1867	875	770	105	32,996	411	464	28,083
1868	875	770	105	33,101	412	463	28,546

[118] That information is available in *IVIE*, which distinguishes between "irrigation infrastructure" and "basic infrastructure" (i.e. reservoirs).
[119] See Villanueva Larraya (1991), pp. 151-161.
[120] Again in this case a useful life of 80 years has been assumed.

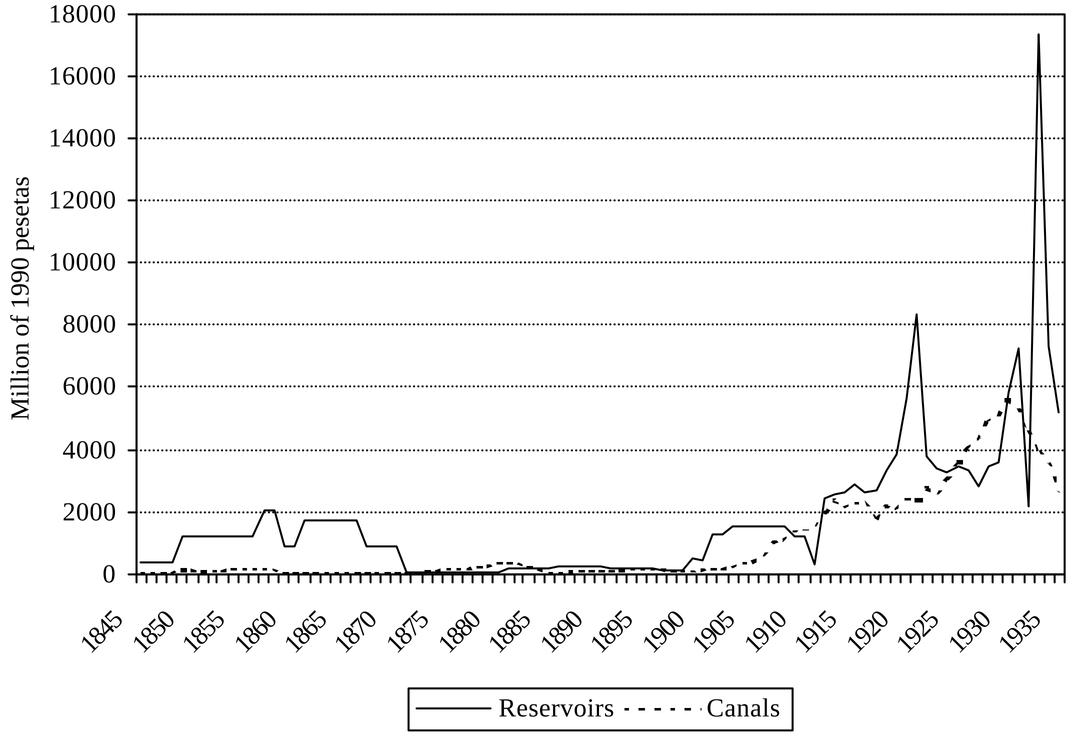
	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1869	875	770	105	33,206	414	462	29,007
1870	875	770	105	33,311	415	460	29,467
1871	14	0	14	33,324	416	-403	29,065
1872	14	0	14	33,338	417	-403	28,662
1873	14	0	14	33,352	417	-403	28,259
1874	14	0	14	33,365	417	-403	27,855
1875	14	0	14	33,379	417	-403	27,452
1876	14	0	14	33,392	417	-404	27,048
1877	14	0	14	33,406	417	-404	26,645
1878	14	0	14	33,419	418	-404	26,241
1879	14	0	14	33,433	418	-404	25,837
1880	14	0	14	33,446	418	-404	25,432
1881	193	0	192	33,639	418	-225	25,207
1882	193	0	192	33,831	420	-228	24,979
1883	193	0	192	34,024	423	-230	24,749
1884	193	0	192	34,216	425	-233	24,516
1885	193	0	192	34,409	428	-235	24,281
1886	198	0	198	34,606	430	-232	24,049
1887	198	0	198	34,804	433	-235	23,814
1888	198	0	198	35,002	435	-237	23,577
1889	198	0	198	35,200	438	-240	23,337
1890	229	0	229	35,429	440	-211	23,127
1891	138	0	138	35,567	443	-305	22,822
1892	138	0	138	35,704	445	-307	22,515
1893	138	0	138	35,842	446	-309	22,206
1894	138	0	138	35,980	448	-310	21,896
1895	138	0	138	36,117	450	-312	21,584
1896	132	0	132	36,250	451	-319	21,265
1897	132	0	132	36,382	453	-321	20,945
1898	132	0	132	36,514	455	-322	20,622
1899	495	363	132	36,647	456	39	20,661
1900	464	363	101	36,748	458	5	20,666
1901	1,255	363	892	37,640	459	796	21,462
1902	1,255	363	892	38,533	471	785	22,246
1903	1,550	363	1,187	39,720	482	1,068	23,314
1904	1,550	363	1,187	40,906	496	1,053	24,367
1905	1,550	363	1,187	42,093	511	1,038	25,406
1906	1,550	363	1,187	43,280	526	1,023	26,429
1907	1,550	363	1,187	44,467	541	1,009	27,438
1908	1,550	363	1,187	45,654	556	994	28,431
1909	1,174	0	1,173	46,828	571	603	29,034
1910	1,174	0	1,173	48,001	585	588	29,622
1911	295	0	295	48,295	600	-305	29,317
1912	2,409	0	2,409	50,705	604	1,806	31,123
1913	2,574	0	2,574	53,279	634	1,940	33,063
1914	2,646	0	2,646	55,925	666	1,980	35,043
1915	2,838	0	2,837	58,762	699	2,139	37,182
1916	2,627	0	2,627	61,389	735	1,892	39,074
1917	2,667	0	2,667	64,056	767	1,900	40,974
1918	3,321	0	3,321	67,377	801	2,520	43,494
1919	3,835	0	3,835	71,212	842	2,993	46,487
1920	5,642	0	5,642	76,854	890	4,752	51,239
1921	8,338	1,040	7,298	84,152	961	7,377	58,616

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1922	3,746	356	3,390	87,542	1,052	2,694	61,310
1923	3,388	356	3,032	90,574	1,094	2,294	63,603
1924	3,250	356	2,894	93,468	1,132	2,117	65,721
1925	3,477	356	3,121	96,589	1,168	2,308	68,029
1926	3,339	356	2,983	99,572	1,207	2,131	70,160
1927	2,829	356	2,473	102,045	1,245	1,584	71,744
1928	3,446	356	3,090	105,135	1,276	2,170	73,915
1929	3,558	1,211	2,347	107,482	1,314	2,244	76,158
1930	5,861	1,211	4,650	112,132	1,344	4,517	80,676
1931	7,273	1,211	6,063	118,194	1,402	5,872	86,548
1932	2,172	1,211	961	119,156	1,477	695	87,242
1933	17,344	1,211	16,134	135,289	1,489	15,855	103,097
1934	7,291	1,211	6,080	141,369	1,691	5,600	108,697
1935	5,166	1,211	3,955	145,324	1,767	3,399	112,096

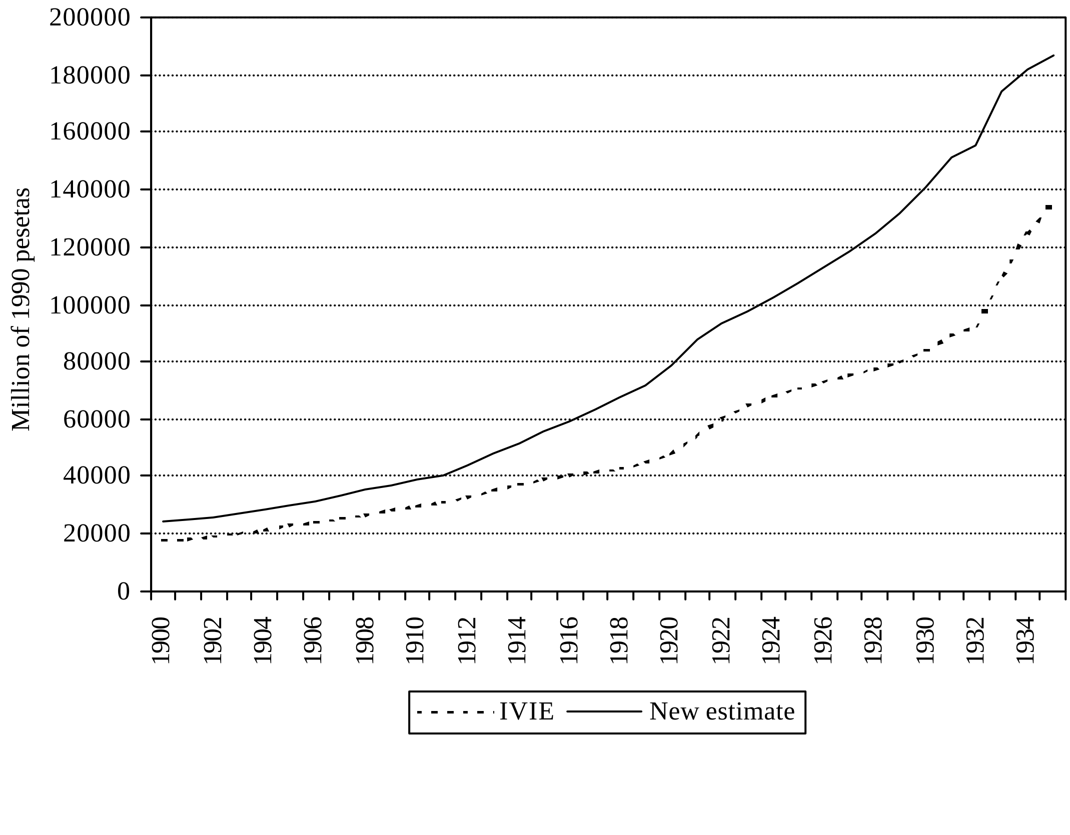
Graph A.2.21
Hydraulic works: net infrastructure stock



Graph A.2.22
Hydraulic works: gross infrastructure investment



Graph A.2.23
Hydraulic works: net infrastructure stock (alternative estimates)



A.2.5 Summary

The estimates for the whole infrastructure are summarised in Table A.2.15.

Table A.2.15
Spanish infrastructure (million of 1990 pesetas)

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1844				98,620			54,474
1845	2,817	1,109	1,707	100,328	1,342	1,474	55,948
1846	3,005	1,116	1,889	102,217	1,367	1,638	57,586
1847	3,613	1,122	2,491	104,708	1,395	2,218	59,804
1848	4,941	1,131	3,810	108,519	1,434	3,508	63,312
1849	7,779	1,146	6,633	115,152	1,493	6,285	69,597
1850	9,894	1,168	8,726	123,877	1,596	8,298	77,895
1851	11,941	1,198	10,743	134,620	1,737	10,204	88,099
1852	14,238	1,236	13,002	147,622	1,913	12,325	100,424
1853	13,829	1,283	12,546	160,168	2,129	11,700	112,124
1854	12,945	1,325	11,620	171,788	2,342	10,603	122,727
1855	15,060	1,362	13,698	185,486	2,541	12,519	135,246
1856	16,134	1,407	14,727	200,213	2,775	13,360	148,605
1857	22,429	1,452	20,978	221,191	3,037	19,393	167,998
1858	30,914	1,511	29,402	250,593	3,424	27,490	195,488
1859	38,372	1,594	36,778	287,371	3,984	34,388	229,876
1860	44,187	1,700	42,487	329,858	4,704	39,483	269,359
1861	52,520	2,589	49,931	379,789	5,554	46,966	316,325
1862	57,176	2,736	54,440	434,229	6,529	50,646	366,971
1863	56,170	2,974	53,196	487,425	7,602	48,568	415,539
1864	50,015	3,172	46,843	534,268	8,638	41,377	456,916
1865	37,390	3,380	34,010	568,278	9,534	27,856	484,772
1866	25,060	3,607	21,453	589,730	10,168	14,891	499,663
1867	15,365	3,881	11,484	601,214	10,548	4,817	504,480
1868	12,831	4,253	8,578	609,792	10,734	2,097	506,577
1869	12,348	4,560	7,788	617,581	10,843	1,505	508,082
1870	8,186	-8,490	16,676	634,257	10,937	-6,200	501,882
1871	11,117	22,533	-11,416	622,841	11,126	-9	501,874
1872	13,267	4,159	9,108	631,949	10,970	2,297	504,171
1873	16,756	1,771	14,984	646,933	11,137	7,847	512,018
1874	21,338	4,880	16,457	663,390	11,329	10,009	522,027
1875	22,167	6,248	15,919	679,309	11,494	10,673	532,700
1876	19,502	8,215	11,287	690,596	11,613	7,889	540,589
1877	18,966	10,172	8,794	699,390	11,599	7,367	547,956
1878	24,674	11,848	12,826	712,217	11,499	13,175	561,131
1879	28,157	12,789	15,368	727,584	11,417	16,739	577,870
1880	31,751	14,860	16,890	744,475	11,353	19,957	597,827
1881	28,970	13,000	15,970	760,445	11,305	17,665	615,492
1882	36,622	16,121	20,501	780,946	11,261	24,200	639,691
1883	31,047	8,007	23,040	803,986	11,329	19,159	658,850
1884	31,260	8,291	22,970	826,956	11,501	19,086	677,936
1885	29,626	3,159	26,757	853,423	11,768	17,577	695,513
1886	29,017	4,223	24,795	878,218	12,115	16,902	712,415
1887	28,110	4,538	23,571	901,789	12,466	15,644	728,059
1888	27,796	4,411	23,385	925,174	12,798	14,997	743,056
1889	30,965	4,606	26,359	951,533	13,134	17,831	760,888

	Gross Investment	Retirements	New Investment	Gross Stock	Depreciation	Net Investment	Net Stock
1890	34,894	4,199	30,695	982,228	12,629	22,241	783,128
1891	46,297	4,027	42,269	1,024,497	13,107	33,190	816,318
1892	50,270	4,287	45,983	1,070,481	13,780	36,491	852,809
1893	48,073	4,438	43,634	1,114,115	14,489	33,583	886,393
1894	48,150	4,570	43,580	1,157,696	15,144	33,006	919,399
1895	46,365	4,675	41,692	1,199,386	15,841	30,521	949,920
1896	40,912	4,800	36,114	1,235,497	16,519	24,389	974,310
1897	31,290	5,143	26,385	1,261,644	17,093	13,966	988,276
1898	31,742	5,097	26,755	1,288,289	17,506	14,129	1,002,405
1899	34,232	5,757	28,585	1,316,764	17,893	16,251	1,018,655
1900	36,816	5,615	31,307	1,347,965	18,345	18,387	1,037,043
1901	39,741	5,742	34,228	1,381,963	18,900	20,632	1,057,675
1902	38,228	6,421	31,807	1,413,770	19,520	18,723	1,076,398
1903	37,865	7,591	30,697	1,444,045	19,819	17,657	1,094,056
1904	32,226	9,826	22,804	1,466,444	20,218	11,552	1,105,608
1905	30,510	8,499	22,669	1,488,455	20,534	9,368	1,114,976
1906	25,871	7,546	18,884	1,506,780	20,891	4,471	1,119,447
1907	27,566	6,213	21,962	1,528,132	21,157	5,854	1,125,300
1908	39,555	6,926	32,767	1,560,761	21,541	17,881	1,143,181
1909	41,935	6,928	35,007	1,595,768	22,035	19,900	1,163,082
1910	39,527	6,295	33,282	1,629,000	22,470	17,009	1,180,090
1911	42,286	5,857	36,444	1,665,429	23,041	19,230	1,199,320
1912	50,247	7,429	42,986	1,708,248	23,658	26,429	1,225,749
1913	52,630	8,723	43,910	1,752,155	24,354	28,273	1,254,022
1914	53,826	9,827	44,044	1,796,154	25,116	28,667	1,282,689
1915	48,333	10,034	38,313	1,834,453	25,951	22,369	1,305,058
1916	51,386	10,388	41,319	1,875,451	26,724	24,353	1,329,411
1917	52,538	10,152	42,421	1,917,837	27,544	24,960	1,354,371
1918	40,352	10,521	29,845	1,947,668	28,251	12,088	1,366,459
1919	37,669	11,791	25,891	1,973,546	28,806	8,851	1,375,310
1920	41,260	13,413	27,846	2,001,393	29,305	11,955	1,387,265
1921	62,233	16,529	45,772	2,047,097	29,838	32,330	1,419,595
1922	61,703	16,724	45,053	2,092,076	30,704	30,928	1,450,524
1923	67,280	17,062	50,760	2,142,294	31,507	35,251	1,485,774
1924	69,801	16,859	53,007	2,195,236	32,415	37,324	1,523,098
1925	90,269	17,958	72,385	2,267,548	33,362	56,836	1,579,934
1926	101,567	16,789	85,293	2,352,326	34,945	66,253	1,646,187
1927	104,439	13,403	91,061	2,443,362	36,417	67,999	1,714,186
1928	108,291	14,272	94,037	2,537,380	38,300	69,973	1,784,160
1929	108,362	19,181	91,031	2,626,561	40,096	66,605	1,850,765
1930	94,431	18,912	75,519	2,702,080	41,860	52,571	1,903,336
1931	80,780	19,701	61,258	2,763,159	43,297	37,311	1,940,646
1932	54,770	20,587	34,338	2,797,342	44,253	10,361	1,951,007
1933	84,079	20,217	63,862	2,861,204	44,836	39,243	1,990,250
1934	72,251	39,267	34,493	2,894,188	45,926	26,344	2,016,594
1935	59,031	1,090	57,940	2,952,128	46,784	12,247	2,028,841

CHAPTER THREE

THE GEOGRAPHICAL DISTRIBUTION OF SPANISH INFRASTRUCTURE

3.1 Introduction

Modern Spain has been characterised by a wide heterogeneity between the different regional economies of the country. At the end of the twentieth century, for instance, income per capita in the poorest Autonomous Community (Extremadura) was 45 per cent lower than in the most developed one (Balearic Islands).[227] Although the origin of those striking differences has been traced back to the second half of the seventeenth century,[228] the development of the modern Spanish regional structure was not completed until the nineteenth and early twentieth centuries, i.e. the period covered by this research, in which the process of regional divergence substantially accelerated.[229]

As a result of that divergence process, two different areas may be distinguished in the country. Since the beginning of the twentieth century, regional figures of income per capita, regional percentages of industrial active population, or the available estimates of the "physical index of quality of life" (which summarise information on literacy, infant mortality and life expectancy) reflect a division of the country between a rich "North" (made up by most Northern and Mediterranean regions and Madrid), which has enjoyed an intense development process during the nineteenth and twentieth centuries, and a poor "South" (Andalusia, Extremadura, Castile-La Mancha, Murcia and the Canary Islands), which has remained relatively stagnant or has experienced a gradual economic decline in

---

[227] Zapata Blanco (2001), p. 590.
[228] Llopis Agelán (2001), p. 523.
[229] Carreras (1990a), pp. 14-15.

relative terms. Some regions are of course difficult to incorporate in that division, as is the case with the largest and most heterogeneous ones (such as Castile-Leon, Andalusia or Aragon), or with Galicia and Asturias, which during the second half of the nineteenth century had relatively high indices of quality of life and low levels of income per capita. However, in spite of that complexity, the existence of a fundamental geographical dualism in the Spanish economy in Late Modern times is broadly confirmed by the available information.[230]

The reasons for that regional divergence are complex. To start with, the literature on Early Modern Spain has stressed the importance of the differences in population density that resulted from the Christian conquest of each region in the Middle Ages.[231] The most sparsely-populated areas of the interior initiated in the mid-seventeenth century a process of purely extensive agrarian growth without productivity increases, based on the colonisation of empty lands. By contrast, at the same time, some densely populated peripheral regions, especially on the Mediterranean coast, started a process of expansion of intensive agrarian products, with a much greater impact on productivity.[232]

From the early-nineteenth century, a number of additional factors, such as technological change, the State's economic policy, the integration of the national market or changes in the external relations of the Spanish economy altered some of the previous regional advantages that were mainly associated with population density.[233] Among those factors, the distribution of infrastructure endowment has often been mentioned as having an influence on the Spanish regional divergence during the nineteenth and early twentieth centuries.

On the one hand, both contemporaries and historians have stressed the uneven distribution of infrastructure among the Spanish regions. In some cases, the shortage of transport networks has been considered as a limit for local development. For instance, in Asturias, the scarcity of infrastructure has been blamed for the take-over of the local iron

[230] The main regional economic variables for nineteenth and twentieth century Spain may be seen in Zapata Blanco (2001) and also below (Table 3.4).
[231] According to Llopis Agelán (2001), pp. 514-515, the main reasons for the differences in regional population density in the eighteenth century were the timing of the Christian conquest and the control that the upper classes exerted on the colonisation process in each region after the conquest.
[232] See Llopis Agelán (2001), pp. 516-522, who indicates that other factors such as institutions, the geographic situation of each region, and the previous existence of market traditions were also relevant in the process of regional economic divergence that started around 1650.
[233] Ibidem, p. 523.

industry by the Basque one during the second half of the nineteenth century.[234] In other areas, such as Galicia or the Pyrenees, the lack of connections with the national transport network was felt at the time as a major obstacle to industrialisation.[235] Other authors have insisted on the privilege that some "Northern" regions, such as the Basque Country, Madrid, Cantabria or some provinces of Castile-Leon, received from the public sector regarding infrastructure investment. Actually, Cantabria and the three Castilian provinces of Valladolid, Palencia and Burgos appear to have been a privileged area since Early Modern times, when the Canal of Castile and the road that connected it with the sea were constructed to allow the commercialisation of Castilian production.[236]

On the other hand, the geographical structure of the national transport and communication networks has been said to have been inefficient and mainly inspired by political criteria. The radial character of the Spanish road, railway and telegraph systems, which adapted to the previous structure of postal services, and also imitated the design of the French networks, might have been inadequate for Spanish needs and made connections between production and consumption centres expensive.[237] In addition, the political decision-making process was blamed at the time for being a vehicle used by individual members of parliament to win votes, giving rise to the construction of "parliamentary" roads and railways which were not justified on economic grounds.[238]

In this context, this chapter constitutes a first approach to the evolution of the geographical distribution of Spanish infrastructure between the middle of the nineteenth century and the Civil War. The distribution of each type of infrastructure among the Spanish regions is compared in the text with the features of each regional economy, in

[234] Ojeda (2001), p. 52.
[235] On Galicia, see some contemporaries' opinions in Veiga Alonso (1999). On the Pyrenees, see Vidal Raich (1994), who, for instance, quoted a pamphlet published by the local elites of Northern Aragon in 1859, in which they complained that "*Neglected in the interior due to consideration of badly applied economy, condemned to complete isolation (…) the High Aragon sees everywhere activity and life, while it is condemned to the torture of quietness*" (p. 181).
[236] For the Basque Country, see González Portilla et al (1995), p. 77, or Núñez Romero-Balmas (1998), pp. 14-15; for Madrid, see García Delgado and Carrera Troyano (2001), pp. 230-233; for Cantabria, Domínguez Martín and Pérez González (2001) and, for Castile-Leon, Moreno Lázaro (2001), p. 188-189 and 206.
[237] On the radial design of the Spanish networks, see García Delgado and Carrera Troyano (2001), pp. 230-233. Fierce criticisms to the radial structure of the railway network can be found in Nadal Oller (1975), pp. 48-50, Casañas Vallés (1977), p. 52, Hernández (1999), p. 419, or Broder (2000), pp. 77-78. Nevertheless, other historians consider that the radial framework adapted quite well to the previously existing transport flows, and was the cheapest way to connect the whole country; see, for instance, Equipo Urbano (1972), Artola (1978a), p. 24, Cordero and Menéndez (1978), p. 173, Tortella Casares (1994a), p. 114, Gómez Mendoza (1997), p. 492, and Comín Comín et al (1998), Vol. 1, p. 11.
[238] On "parliamentary" roads, see Alzola y Minondo (1979), pp. 437-438; Calvo Calvo (2001) has recently detected similar situations in the case of the telegraph system.

order to get a more accurate impression of the main aims and efficiency of the investment process. The outcomes of this analysis allow a better understanding of the reasons for the uneven infrastructure endowment throughout the Spanish regions during the nineteenth and twentieth century.

This chapter is organised as follows. Firstly, Section 3.2 describes, for each type of infrastructure for which data are available, the evolution of its geographical distribution during the period under study. Secondly, in Section 3.3 an econometric exercise is carried out that tries to identify the main determinants of the spatial distribution pattern of the most important Spanish infrastructure, i.e. the networks of railways and roads. Section 3.4 summarises the major conclusions of the chapter.

3.2 The geographical distribution of Spanish infrastructure stock

It has not been possible in this research to estimate figures of infrastructure stock in monetary terms for the Spanish provinces or regions, because information on investment flows is much scarcer at those levels than for the whole economy. Instead, in order to measure regional differences in infrastructure availability, physical indicators of the endowment of land transport and communication networks in each province have been collected for each decade of the period. Within the transportation sector, figures of provincial mileage have been gathered for broad and narrow gauge railways from 1860,[239] for the road network (including State, provincial and local roads) from 1870,[240] and for urban transport from 1890.[241] In the case of communication infrastructure, I have collected information on the length of the telegraph network in each one of the so-called *Secciones*

[239] Figures have been elaborated on the basis of the information available in *MAEOP* and *AFT*. Cucarella (1999) offers provincial figures of railway infrastructure stock for the years 1845-1997 which are also based on physical indicators and, therefore, are rather similar to those presented below. The main differences in the resulting pattern of geographical distribution come from the fact that, unlike this research, broad and narrow gauge railways are weighted differently in Cucarella's estimates, which reduces the level of the railway endowment indicators in those regions with a high share of narrow gauge railways.

[240] Information comes from *MAEOP* up to 1920. For the period 1925-1935 no provincial data are available, and figures of road mileage in 1930 have been obtained as the average between the data for 1924 and 1940, in *MAEOP* and Ministerio de Obras Públicas (1940), Vol. 1, pp. 200-201, respectively. For the first decades of the period under study, figures on provincial and local roads are not completely reliable, due to the lack of homogeneity in the statistical criteria that were followed in different provinces; on this subject see above, Section A.2.1. On the other hand, my estimates do not include a few roads that were owned and managed by private "societies", which were especially relevant in the Basque Country. According to Alzola y Minondo (1898), p. 91, for instance, there were 53 km of this kind of roads in Vizcaya at the end of 1897.

[241] Data from *MAEOP*, *AFT* and RENFE (1958).

(which roughly coincided with the Spanish provinces), and on the number of urban telephone networks in each province.[242]

The geographical distribution of other types of infrastructure is not analysed here. This is due to the fact that, in the case of ports, electricity infrastructure and hydraulic works, physical indicators do not provide meaningful information on each region's relative advantage in infrastructure endowment, because the location and size of those assets was highly dependent on geographical features. For instance, in the case of ports, the provincial figures available for length of walls were strongly influenced by the physical characteristics of each province's coastline, because in certain regions natural barriers made protection works less necessary.[243] In the case of dams and electricity, the provincial figures available for reservoir capacity or power capacity for the first third of the twentieth century are not a sign of a good infrastructure endowment but mainly reflect the relief and water resources of each province.[244] In both cases, whereas the assets were usually established in harsh and relatively poor locations, their economic benefits (via irrigation or energy supply) were enjoyed by more or less distant regions.[245] The analysis in this chapter focuses therefore on railways, roads, urban transport and the telegraph network, which accounted for a share of between 64 and 92 per cent of the total infrastructure stock during the period.

The comparison among the infrastructure endowment of different regions is not an easy task, as it requires an appropriate index of the actual service capacity of each type of infrastructure in each regional context.[246] For the so-called "point-type" infrastructure (i.e., those relatively small-scale assets such as urban transport, which are located inside population centres), the available physical stock should be related to the population served. On the contrary, in the case of large-scale transport and communication infrastructure, which can be characterised as "space-serving" assets, network density (i.e. the ratio

---

[242] Data on telegraph network length comes from the *Estadística Telegráfica de España*. The submarine network has not been included in the analysis because its length cannot be compared with the length of the aerial network. This absence introduces a downward bias in the estimates for the Balearic and the Canary Islands. On the other hand, information on the number of telephone urban networks in each province comes also from the *Estadística Telegráfica de España* and (from 1924 onwards) from the *CTNE*'s annual reports.

[243] Those figures are available in *MAEOP* and Junta Central de Puertos (n.d.).

[244] Information on the location of each Spanish dam is available in Garrido Bartolomé (1968), and provincial data of electricity power capacity has been kindly provided to the author by Isabel Bartolomé Rodríguez.

[245] For instance, in the case of electricity, Huesca in Aragon and Lérida in inland Catalonia were among the provinces with highest power capacity in the wake of the Civil War, but the energy produced there was mainly consumed elsewhere, concretely in the industrial districts of coastal Catalonia and the Basque Country.

[246] On the problems of measurement of the service capacity of infrastructure, see Biehl (1991), pp. 19-21.

between the length of the network and the surface of the service area) constitutes the most adequate measure of service capacity.[247] Increases in the density of a network are probably the most direct way to reduce transport and communication costs, through reductions in the average distance from each production or consumption point to the network, as well as decreases in the average detour of paths through the network.

Obviously, density data only allows a preliminary approach to the service capacity of large-scale networks. For instance, in the case of railways, service capacity also depends on a large series of technical features, such as the number of access points to the system (stations, halts, stops, etc.), the extension of double track, gauge, curves, grades or electrification. All those elements reduce transport costs by affecting the cost of joining the network, travel speed and the average train load. However, in spite of their preliminary nature, density figures offer a global picture of the quality of infrastructure endowment in different regions and, in addition, they are probably the only data on which exhaustive information can be obtained for most large networks.[248]

With these considerations in mind, different indicators of service capacity have been elaborated for those types of infrastructure for which meaningful provincial data are available. In the case of urban transport, service capacity has been measured by the ratio between length of lines and urban population, whereas the capacity of the railway, road and telegraph networks has been measured by the ratio between network length and regional surface.

Starting with the railway and road networks, which constituted the most important investment during the period of analysis, Maps 3.1 to 3.6 show their density in each of the Spanish provinces in the years 1870, 1900 and 1930. All these maps present a rather similar picture. Firstly, both in the cases of railways and roads, infrastructure distribution

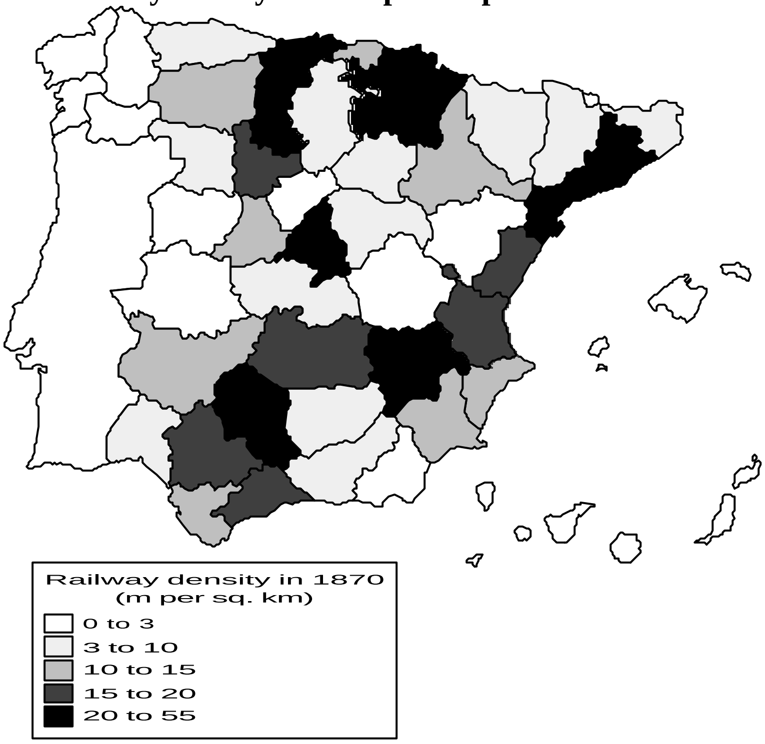
[247] Ibidem, p. 20. Network density is also called “coefficient of penetration” of a network; its inverse (the area served by each km of the network) is called “coefficient of *couverture*”; see Laffut (1983), p. 206. The use of network density is very widespread in comparative analyses; see, for instance, Limão and Venables (2000) or Canning et al (1994).

[248] Accessibility/market potential indicators constitute an alternative approach to the quality of the infrastructure endowment of an area. Those measures have already been used in the case of the Spanish railways at the provincial level in the context of research that focuses i) on the determinants of industrial location in nineteenth century Spain, such as Tirado et al (2002), or ii) on the Spanish urban hierarchy, such as Serrano Rodríguez (1999). However, in spite of their relevance in that kind of analyses, accessibility measures have some drawbacks as indicators of infrastructure endowment, because they are highly dependent on the geographical position of each area and tend to perpetuate the differences between core and periphery; on those problems see Vickerman (1994), pp. 5-6, and, for the Spanish case, Serrano Rodríguez (1999), p. 888.

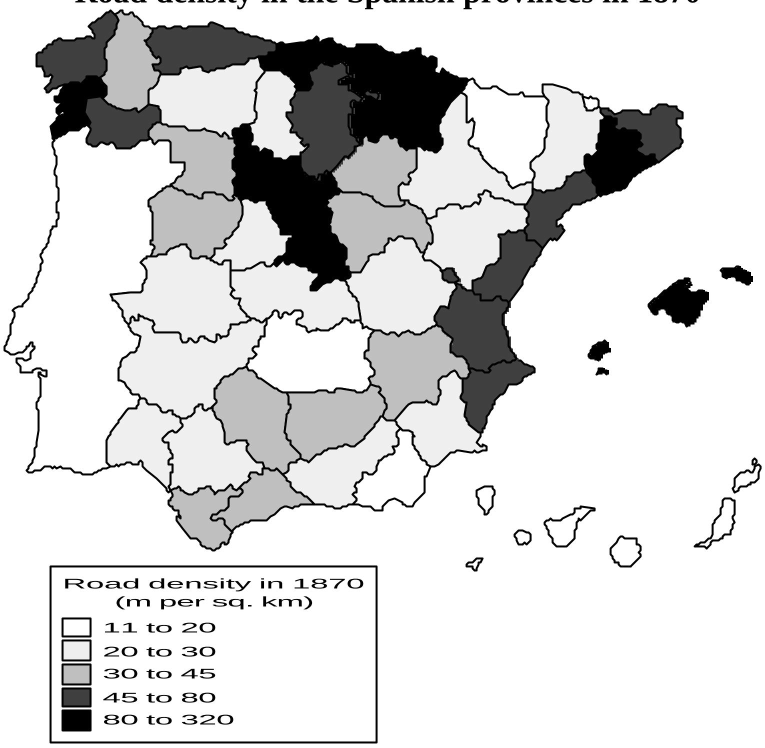
among the Spanish provinces was very uneven, reflecting much higher regional disparities than in other European countries at the time.[249] And, secondly, in all cases it is possible to observe the high density of the transport networks both in the coastal provinces of Catalonia and Valencia and in a cluster of provinces situated in the central-Northern area of Spain: the Basque Country, Navarre, La Rioja, Cantabria, Asturias, Madrid and the central provinces of Castile-Leon. At the other end of the range, the inland and sparsely-populated regions of Extremadura, Aragon and most provinces of both Castiles, as well as the South-East corner of Spain and the Canary Islands, were quite poorly endowed during the whole period under study. Finally, as happens with most regional economic variables, Western Andalusia and Galicia are difficult to integrate in that framework, since they were well endowed with one type of infrastructure (railways in Andalusia and roads in Galicia) but poorly endowed with the other.

[249] For instance, in France, a country that is comparable to Spain in size, the coefficient of variation of the railway density of the *départements* was 40% in 1907, whereas among the Spanish provinces it was 71% at that time. Data on France in Price (1983), pp. 222-223; the *département* of Seine (i.e. the city of Paris) has been excluded from the calculation to keep the coefficients comparable.

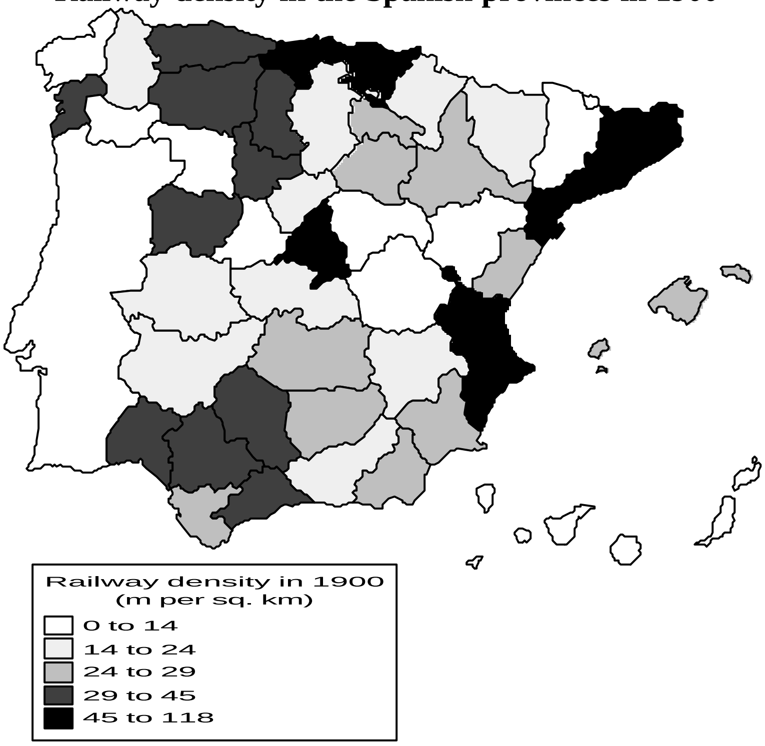
Map 3.1
Railway density in the Spanish provinces in 1870



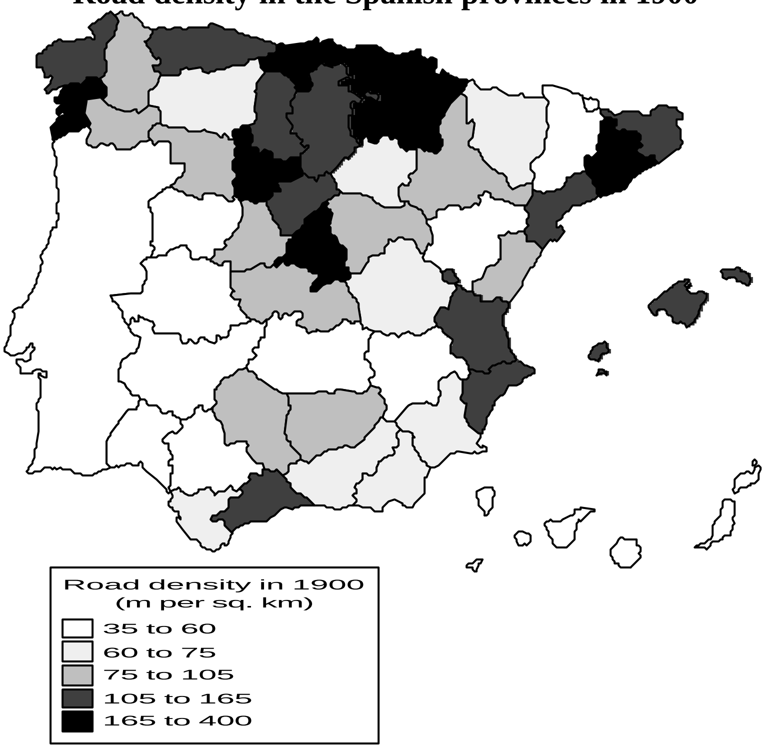
Map 3.2
Road density in the Spanish provinces in 1870



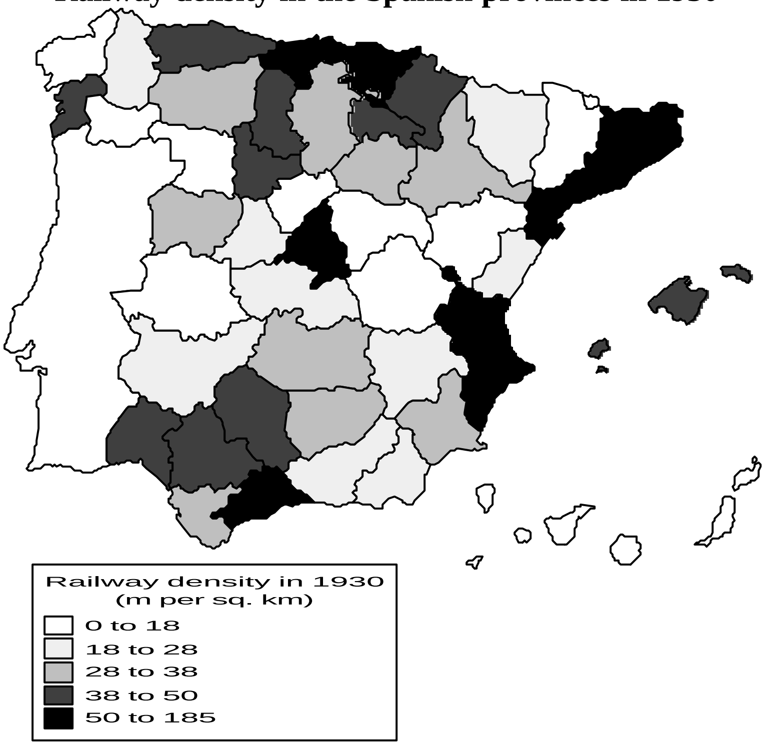
Map 3.3
Railway density in the Spanish provinces in 1900



Map 3.4
Road density in the Spanish provinces in 1900



Map 3.5
Railway density in the Spanish provinces in 1930



Map 3.6
Road density in the Spanish provinces in 1930

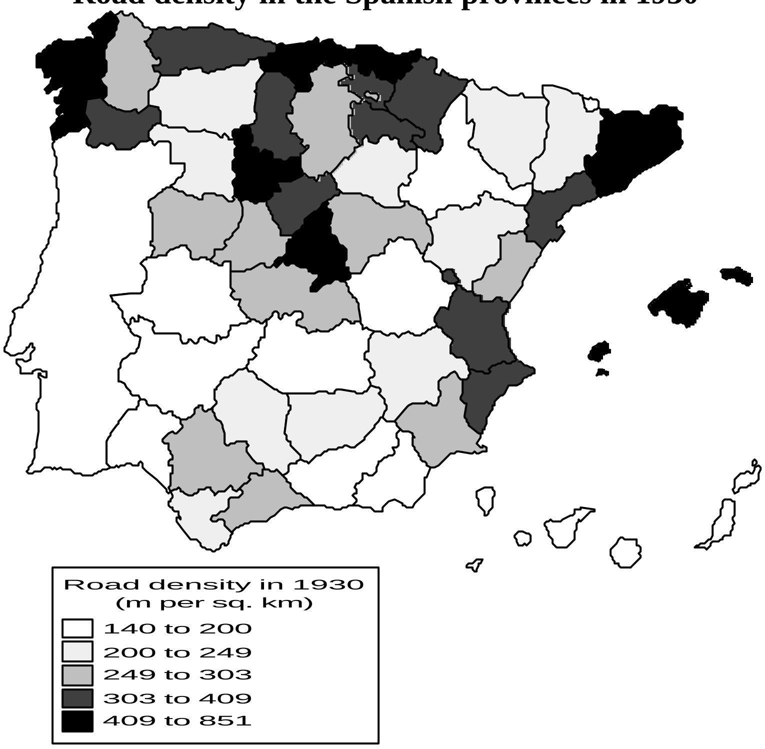


Table 3.1 summarises the information in the maps and offers a preliminary hierarchy of the Spanish regions according to their infrastructure endowment in 1870, 1900 and 1930. The table presents the density of the regional road and railway networks both in absolute terms and normalised by the overall Spanish figure. An index of the regional endowment of transport infrastructure is calculated as the weighted average of the normalised railway and road network density figures, using as weights the relative importance of railways and roads within Spanish total capital stock in each data. Regions are arranged in the table according to that index. The table also offers the population density of each region (normalised by the Spanish population density) and the average network density of a sample of European countries, in order to better illustrate the situation.[250]

Table 3.1
Density of transport networks in the Spanish regions (m per km^2)
A) 1870

	RWD			RD			RWD Norm.	RD Norm.	**weighted average**	Pop. density
	BG	NG	Total	SR	PLR	Total				
Basque C.	35	0	35	35	202	238	325	543	**401**	194
Rioja	27	0	27	68	24	91	245	209	**232**	108
Madrid	26	0	26	68	13	81	241	185	**221**	214
Navarre	21	0	21	0	102	102	194	234	**208**	90
Cantabria	21	0	21	83	4	88	190	200	**194**	130
Catalonia	20	0	20	41	16	57	182	129	**163**	166
Valencian C.	15	2	17	35	19	54	156	124	**145**	180
Balearic I.	0	0	0	35	91	125	0	287	**100**	174
Murcia	13	0	13	27	2	29	117	67	**100**	114
Castile-Leon	10	0	10	38	7	45	88	103	**93**	70
Andalusia	10	1	11	24	5	29	103	66	**90**	112
Castile-La M.	11	0	11	23	5	27	102	63	**88**	49
Asturias	0	4	4	43	25	68	33	154	**75**	161
Aragon	8	0	8	22	2	23	71	54	**65**	59
Extremadura	5	0	5	23	0	24	50	54	**51**	54
Galicia	0	0	0	58	2	61	0	139	**49**	195
Canary I.	0	0	0	13	6	19	0	43	**15**	112
SPAIN	**11**	**0**	**11**	**32**	**12**	**44**	**100**	**100**	**100**	**100**
EUROPE			25			351				
St Dev. (%)							77.79	78.73		
Correl.									**0.60**	0.45

[250] In the case of railways, the sample includes Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Portugal, Romania, Serbia (only in 1870 and 1900), Spain, Sweden, Switzerland and, in 1930, Czechoslovakia, Poland and Yugoslavia. For roads, it is not possible to hold a constant sample for the three periods. In 1870, the sample includes France, Netherlands, Norway and Spain; in 1900, Austria, Denmark, France, Hungary, Italy, Netherlands, Norway, Portugal and Spain and, in 1930, Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Hungary, Ireland, Norway, Portugal, Spain, Sweden, Switzerland and the UK. Data on the network density of the European countries come from a number of different sources that are described in detail in Chapter 4 (Tables 4.2 to 4.5).

B) 1900

	RWD			RD			RWD Norm.	RD Norm.	**weighted average**	Pop. density
	BG	NG	Total	SR	PLR	Total				
Basque C.	37	48	85	0	268	268	324	291	**311**	231
Cantabria	21	37	58	166	23	189	219	205	**214**	137
Madrid	38	16	54	128	61	189	206	206	**206**	263
Catalonia	35	7	42	86	36	122	160	132	**149**	166
Valencian C.	29	13	43	81	24	105	162	114	**144**	187
Rioja	27	0	27	152	14	165	101	180	**131**	102
Navarre	21	2	23	0	170	170	87	184	**124**	79
Balearic I.	0	24	24	70	91	161	91	174	**123**	169
Asturias	15	14	29	121	15	136	109	147	**123**	157
Castile-Leon	22	3	26	78	21	99	97	107	**101**	67
Andalusia	26	3	30	61	9	70	113	76	**99**	110
Galicia	18	0	18	97	21	119	69	129	**92**	184
Murcia	22	2	25	66	1	67	94	73	**86**	136
Castile-La M.	17	1	17	66	3	69	67	75	**70**	48
Extremadura	19	1	20	51	1	52	75	57	**68**	57
Aragon	15	1	16	66	2	68	62	74	**67**	52
Canary I.	0	0	0	37	0	37	0	40	**15**	134
SPAIN	**22**	**5**	**26**	**71**	**21**	**92**	**100**	**100**	**100**	**100**
EUROPE			58			413				
St Dev. (%)							62.98	50.14		
Correl									**0.80**	0.64

C) 1930

	RWD			RD			RWD Norm.	RD Norm.	**weighted average**	Pop. density
	BG	NG	Total	SR	PLR	Total				
Basque C.	37	75	112	94	293	387	344	207	**274**	269
Cantabria	21	44	65	258	80	338	199	181	**190**	143
Madrid	38	27	66	183	121	304	201	163	**182**	371
Asturias	15	33	48	198	71	269	148	144	**146**	156
Balearic I.	0	44	44	211	73	284	135	152	**144**	156
Catalonia	37	13	50	158	82	240	154	129	**141**	186
Valencian C.	32	19	50	149	81	229	154	123	**138**	176
Rioja	27	13	39	189	57	247	121	132	**127**	87
Navarre	21	19	40	45	192	237	123	127	**125**	71
Castile-L.	26	6	32	136	65	200	98	107	**103**	57
Murcia	22	8	30	130	71	201	92	108	**100**	120
Galicia	19	1	21	180	72	251	63	135	**100**	164
Andalusia	27	9	36	113	41	154	110	82	**96**	113
Aragon	19	6	25	122	20	142	77	76	**76**	47
Castile-M.	17	3	20	122	27	149	60	80	**70**	50
Extremadura	19	1	20	79	31	110	60	59	**59**	59
Canary I.	0	0	0	121	17	138	0	74	**38**	163
SPAIN	**23**	**9**	**33**	**130**	**56**	**186**	**100**	**100**	**100**	**100**
EUROPE			72			489				
St Dev. (%)							60.85	32.42		
Correl									0.86	0.65

RWD: Railway density (m per km^2).
BG: Broad gauge network.
NG: Narrow gauge network.
RD: Road density (m per km^2).
SR: State road network.
PLR: Provincial and Local road networks.
Correl: Correlation coefficient between RWD and RD (first figure) and between the average infrastructure endowment and the population density (second figure).
Sources: see text.

Although the high internal provincial diversity of certain regions, such as Andalusia or Castile-Leon, is hidden in Table 3.1, the impression that was obtained from Maps 3.1 to 3.6 is broadly confirmed. On the one hand, a number of Spanish regions seem to have benefited from relatively dense networks during the whole period under study. Always headed by the Basque Country, this group included Madrid, the Mediterranean regions of Catalonia and Valencia and the Northern areas of Cantabria, La Rioja and Navarre. Asturias and the Balearic Islands joined the group only in the first third of the twentieth century. At the other end of the range, the Canary Islands, the inland regions of Extremadura, Aragon and Castile-La Mancha and, especially for the first periods, Galicia, always had rather underdeveloped networks in the Spanish context.

The correlation coefficients included in the table indicate that the road and railway networks had rather similar geographical distributions, especially in 1900 and 1930. In addition, inequality among regional infrastructure endowments seems to have gradually diminished. In the case of railways, the standard deviation of the regional density figures decreased until the construction of the network came to an end by 1900 and, in the case of roads, the convergence process was much more intense and went on until the Civil War.[251] The table also shows that the transport network density of the Spanish regions was rather low in comparison with Europe as a whole. In fact, only the Basque country enjoyed a more dense railway network than the European average during the whole period, and no region at all reached the “European” road density.[252]

Of course, a high network density is not necessarily an indicator of a region’s advantage in infrastructure endowment, since the transport needs of an area vary depending on a large range of variables, and may exceed the service capacity of the available infrastructure even in the cases of the densest networks. Obviously, the most basic indicator of the transport needs of an area is population density. From a very general point of view, the most densely populated areas need denser networks than the most sparsely-populated ones. In that context, the comparison between infrastructure endowment indicators and population density figures in Table 3.1, which may also be seen

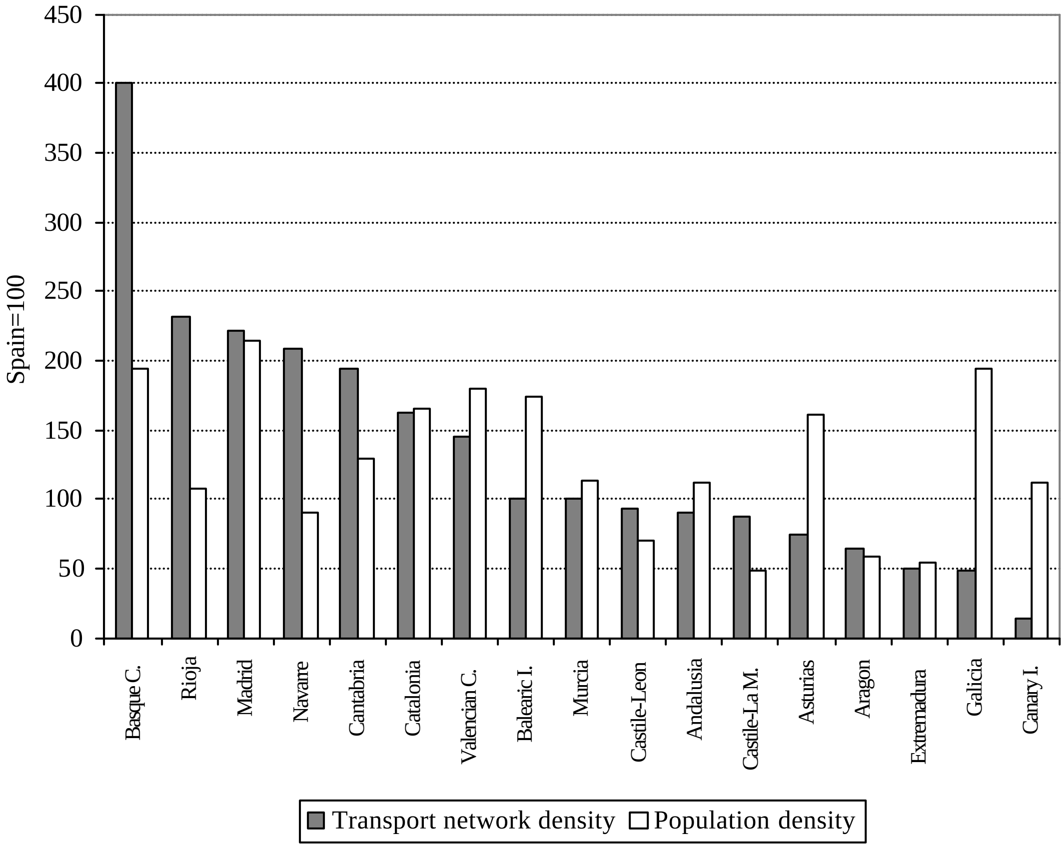
[251] Cubel Montesinos and Palafox Gamir (1999), p. 56, offer the evolution of the coefficient of variation of Cucarella’s estimates of the railway stock of the Spanish regions. According to those authors’ figures, convergence among regional railway endowments in stock terms was a constant process until the late 1910’s and stagnated thereafter, although it had very marked fluctuations during the whole period under study.

[252] The table reflects a gradual process of convergence between the Spanish and the “European” road network density, but it is to a large extent associated to changes in the European sample with which Spain is compared. On this subject, see below, Section 4.4.

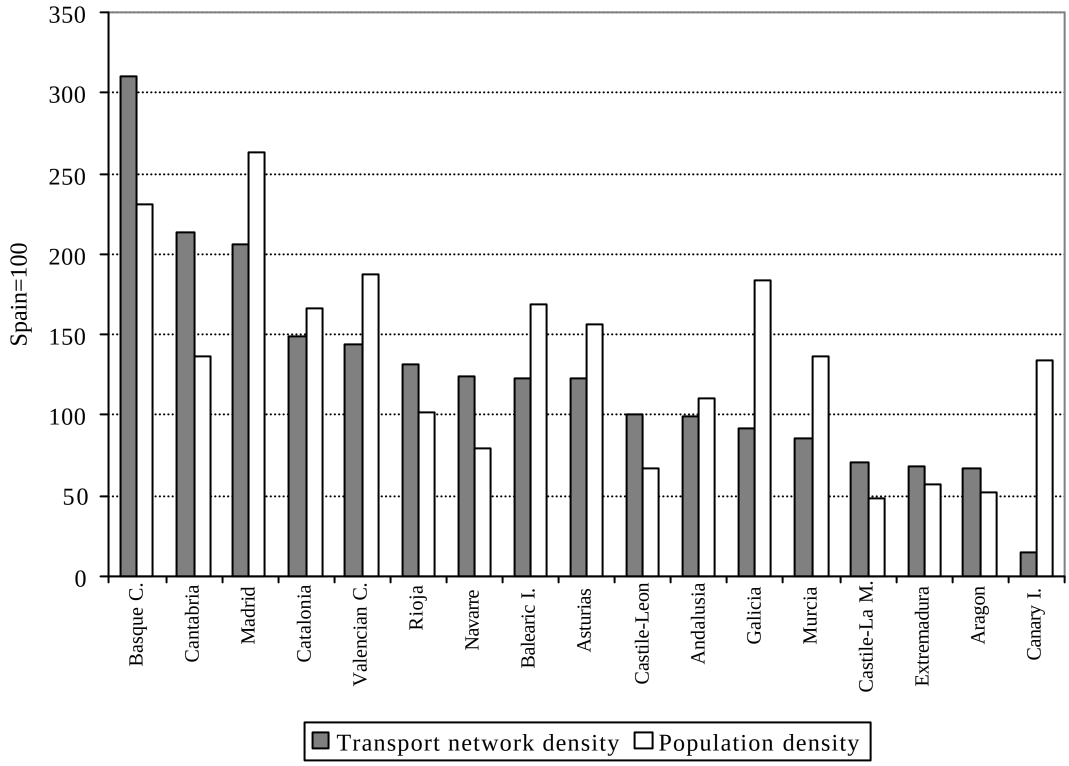
in Graph 3.1, provides a very preliminary picture of the situations of relative excess or shortage of infrastructure in each region.

Graph 3.1
Transport network and population density in the Spanish regions

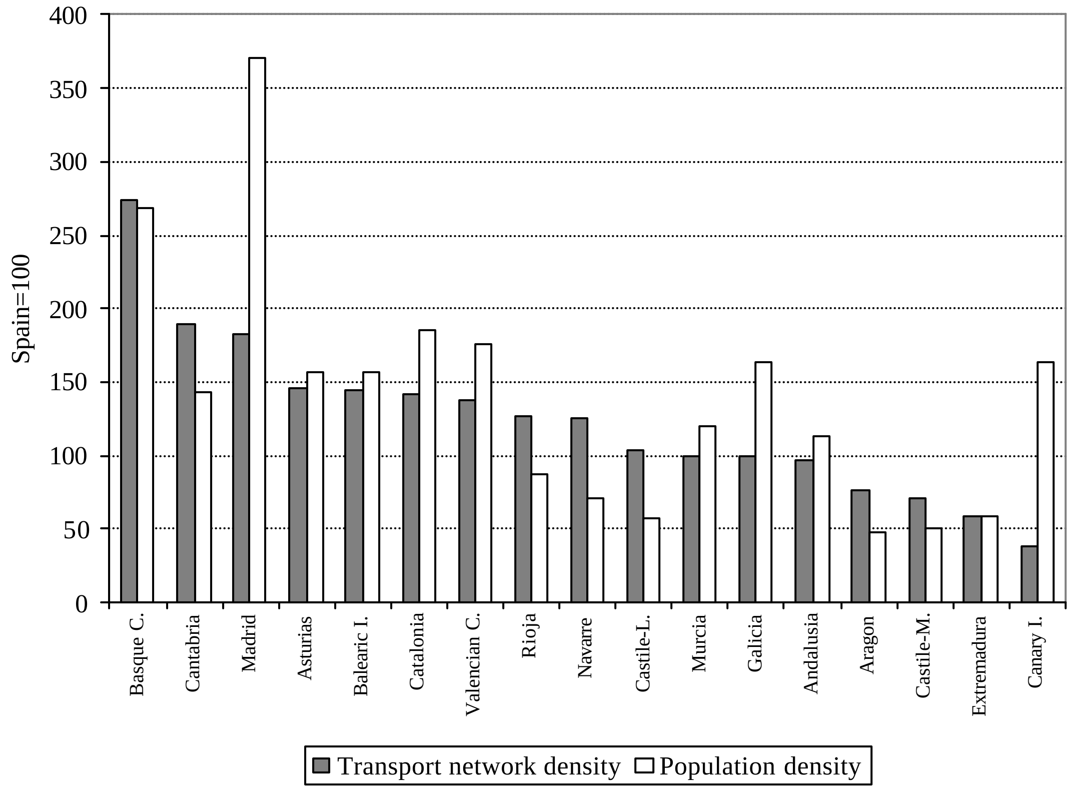
A) 1870



B) 1900


350
300
250
200
150
100
50
0
Spain=100
Basque C.
Cantabria
Madrid
Catalonia
Valencian C.
Rioja
Navarre
Balearic I.
Asturias
Castile-Leon
Andalusia
Galicia
Murcia
Castile-La M.
Extremadura
Aragon
Canary I.
Transport network density
Population density

C) 1930


400
350
300
250
200
150
100
50
0
Spain=100
Basque C.
Cantabria
Madrid
Asturias
Balearic I.
Catalonia
Valencian C.
Rioja
Navarre
Castile-L.
Murcia
Galicia
Andalusia
Aragon
Castile-M.
Extremadura
Canary I.
Transport network density
Population density

According to the graphs, some regions might have had an “excess” of infrastructure in relative terms, whereas other areas might have suffered situations of relative shortage. More concretely, the graphs seem to be consistent with the considerations of historians and contemporaries on the privileged situations of some Northern areas, such as Cantabria, Navarre or Castile-Leon, and on the disadvantage of other regions, such as Galicia and Asturias. However, situations of shortage do not seem to have been confined to those areas. Indeed, they appear to have also affected other regions, such as the Canary Island, the Valencian Community and, in the first decades of the twentieth century, Madrid, although in this case the extremely high spatial concentration of the population of the region makes the comparison with other areas difficult.

Table 3.2 offers information on the regional telecommunication endowments. For the telegraph network, the table shows a much more even distribution across the Spanish regions than in the case of railways and roads.[253] This may be related to the forces that were behind the development of each type of infrastructure. As has been indicated by historians, the expansion of the Spanish telegraph system was mainly driven by the State according to political criteria[254] and, as a result, its distribution across the territory was quite homogeneous. Nevertheless, the comparison between telegraph density and population density show virtually the same situations of regional advantage or disadvantage as in the case of railways and roads. As for the second part of the table, which reflects the geographical distribution of the telephone infrastructure, it tends to confirm the picture just described in the cases of railways, roads and the telegraph, although with some differences, such as the relatively good position of Castile-La Mancha and (in 1920) Aragon or the low number of urban networks in Madrid. However, the situation of the latter might again be largely explained by the high level of concentration of the population of the region in a single city.

[253] The European sample that has been used in the case of the telegraph network is made up by Austria, Belgium, Denmark, France, Germany, Hungary, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the UK. See Chapter 4, Table 4.7, for details.

[254] See Otero Carvajal (1995), pp. 133-136. According to this author, the good position of Madrid in 1900 was associated with the fact that the city was the centre of a network with a markedly radial structure, whereas during the first third of the twentieth century that radial pattern tended to be replaced by a more complex network much more balanced among provinces, within which Madrid had a much less prominent position.

Table 3.2
Regional distribution of Spanish telecommunication infrastructure
A) Telegraph network density (m per km^2)

	1900			1930		
	Absolute density	Norm. density	Pop. density	Absolute density	Norm. density	Pop. density
Madrid	141	245	263	99	110	371
Basque C.	118	206	231	168	187	269
Catalonia	77	134	166	105	117	186
Valencian C.	74	128	187	154	171	176
Murcia	70	123	136	88	98	120
Cantabria	70	122	137	144	160	143
Rioja	66	115	102	126	140	87
Galicia	64	111	184	101	112	164
Andalusia	62	109	110	95	105	113
Balearic I.	59	103	169	114	127	156
Asturias	55	96	157	97	108	156
Navarre	53	91	79	76	85	71
Aragon	52	91	52	87	97	47
Castile-Leon	48	84	67	77	85	57
Extremadura	45	79	57	76	84	59
Castile-La M.	44	77	48	69	77	50
Canary I.	24	41	134	61	68	163
SPAIN	**58**	**100**	**100**	**90**	**100**	**100**
EUROPE	124			na		
St Dev. (%)		41.65			29.75	
Correl.			0.78			0.45

B) Urban telephone networks per 100,000 pop.

	1920	1930
Basque C.	1.83	36.00
Catalonia	1.11	24.36
Navarre	1.82	23.13
Balearic I.	1.77	12.86
Castile-M	1.46	11.66
Cantabria	0.92	11.26
Rioja	2.07	10.80
Asturias	0.94	9.35
Valencian C.	0.80	8.91
Andalusia	0.59	7.96
Murcia	0.78	7.44
Aragon	1.30	6.98
Castile-Leon	0.98	6.90
Canary I.	0.87	6.85
Madrid	0.94	6.79
Extremadura	0.66	5.99
Galicia	0.71	4.53
SPAIN	**0.97**	**11.06**

na: not available.
Correl.: Correlation coefficient between telegraph network density and population density.
Sources: see text.

Finally, the largest differences among regional endowments can be found in the networks of urban and suburban transport. A first indication of that inequality is the fact that tramways and underground railways were only built in 23 out of the 49 Spanish provinces before 1936. Table 3.3 shows the length of urban and suburban transport lines relative to urban population in 1900 and 1930, for those provinces in which such infrastructure was built.[255] Provinces are arranged according to their relative endowment in each of those two years.

Table 3.3
Urban and suburban transport endowment in the Spanish provinces
(m of urban transport networks per 1,000 urban pop)

	1900		1930
Vizcaya	1,064	Pontevedra	1,199
Guipúzcoa	498	Castellón	579
Castellón	477	Granada	555
Valencia	234	Vizcaya	533
Madrid	233	Guipúzcoa	485
Canary I.	179	Asturias	481
Barcelona	159	Valencia	263
Cantabria	157	Cantabria	210
Pontevedra	152	Madrid	175
Valladolid	107	Coruña	164
Balearic I.	105	Saragossa	159
Asturias	104	Valladolid	107
Seville	91	Alicante	106
Saragossa	89	Seville	98
Alicante	81	Canary I.	95
Murcia	68	Murcia	95
Malaga	49	Barcelona	90
Tarragona	35	Balearic I.	72
Coruña	34	Cadiz	67
Badajoz	25	Malaga	66
Cadiz	18	Jaén	55
Granada	17	Tarragona	27
		Badajoz	11

Sources: see text.

Again in the case of urban transport, Madrid and the Northern and Eastern coastal provinces were among the best endowed in the country. On the other hand, most of the provinces of inland Spain are absent from the table, due to the absence of this type of infrastructure during the whole period. It is tempting to suppose that the geographical distribution of urban transport reflected the importance of urbanisation in each province.

[255] Urban population figures come from the Spanish official population censuses; see definition and estimation details in Section 3.3.

However, many examples indicate that this was not so. For instance, some predominantly rural provinces like Castellón (in the Mediterranean coast), or Pontevedra and Asturias (in Northern Spain) had very well developed urban and suburban transport networks, whereas highly urbanised provinces in the South of the country, such as Cadiz, Cordoba or Murcia, were relatively badly endowed.

These examples, as well as the lack of correspondence between network density and population density that has been described above, indicate that the access to infrastructure was not evenly distributed among the Spanish regions. Since some areas appear to have been unable to enjoy an adequate infrastructure endowment, this could have constituted a factor of regional divergence in the Spanish economy, as the historiography has often indicated. Analysing the role of infrastructure in the process of Spanish regional divergence is not possible here, since it would require the application of a growth model to the Spanish regional economies for which most necessary variables are not available. Instead, the next section analyses the main determinants of the actual provincial distribution of the main Spanish infrastructure during the late nineteenth and early twentieth centuries. By doing so, it tries to shed some light on the explanation of the inequality in factor endowments among the Spanish regions and, therefore, to help explaining regional divergence itself.

3.3 An explanatory model for the provincial distribution of Spanish railways and roads

The previous section has described a rather robust pattern of regional infrastructure distribution, which seems to have been in force nearly always and for all types of infrastructure. Throughout the whole period, the Northern and Eastern coastal provinces of the country and Madrid were always among the best-endowed areas, whereas the Canary Islands and a large number of inland provinces always remained at the bottom of the ranking. As has been indicated, the reasons for that distribution are not obvious. In the case of railways and roads, network density only had a weak relationship with the population density of each area. And, in the case of urban and suburban transport networks, highly urbanised provinces lagged behind some areas with a distinctly rural character. In that context, this section is an attempt to explore some alternative explanatory hypotheses for the geographical distribution of the railway and road networks, which were the main Spanish infrastructure of the period.

Within the existing regional analyses of infrastructure, little research effort has been devoted to this issue. Instead, most regional studies have had a markedly normative character, being mainly aimed at determining the optimal regional pattern for infrastructure investment, without paying attention to the explanation of its actual distribution at a certain point of time.[256] Recently, however, two studies carried out by Rietveld and Boonstra and Rietveld and Wintershoven have specified a model which may help to obtain such an explanation.[257]

Obviously, the design of such a model is a rather complex task, since it must include a complete set of assumptions about the investors' decision-making process. For the sake of clarity, the aforementioned authors divide the determinants of the regional endowment of infrastructure into "demand" and "supply" factors. On the one hand, from the demand point of view, construction of infrastructure is said to respond to the perceived need for infrastructure services or, in other words, to the *ex ante* expected level of use of the assets. In the case of transport, a region's need for infrastructure services depends on several variables. As has already been pointed out, the most obvious one is population density.[258] In sparsely-populated areas, the low expected level of traffic may not justify building certain infrastructure, especially if its construction is expensive, because it would entail a waste of resources and a very high opportunity cost. Transport infrastructure endowment is expected, therefore, to grow with population density. However, it is expected to do so at a decreasing rate, for two reasons. On the one hand, beyond a certain saturation point, increases in the density of transport networks may no longer be functional.[259] And, on the other hand, the indivisible character of most large-scale transport infrastructure necessarily produces some excess endowment in sparsely-populated areas.[260]

Secondly, the structure of the system of population centres also affects the level of expected traffic of a future transport link. If population is highly concentrated in a small number of large cities, traffic may also be expected to be concentrated on a few routes. On

[256] Typical examples of this approach are Biehl (1984) and De la Fuente et al (1994), pp. 176-195.
[257] Rietveld and Boonstra (1995) and Rietveld and Wintershoven (1998). These authors apply their conceptual framework to the analysis of the geographical distribution of railways and highways in the EU.
[258] On the link between population density and the demand for transport infrastructure, see Chu (1997).
[259] Laffut (1983), p. 206.
[260] Rietveld and Wintershoven (1998), p. 266.

the contrary, if the same amount of population is distributed throughout a large number of small villages, traffic will also be diverted to many different links. In that context, for a given level of population density, the construction of expensive transport infrastructure may be justified in the former case but not in the latter.

And, thirdly, income per capita and the structure of production also determine a region's need for transport services. On the one hand, the growth of income per capita raises the demand for transport in several ways, e.g. by increasing the share of market-orientated activities, the specialisation and concentration of production, or the purchasing power of individuals (which increases the demand for passenger transport services). On the other hand, some activities use transport services more intensively than others and, as a consequence, the demand for transport in an economy also depends on the share of each sector within total output.

Nevertheless, the expected use of infrastructure not only depends on the level of regional demand but also on the interregional need for transport. Some routes may cross an area just to connect two foreign regions, without meeting any internal need. In that context, international borders and the sea may reduce the demand for infrastructure in a region, because they diminish the potential number of interregional links that might cross the area. Obviously, the importance of interregional demand is higher in the case of longest haul transport infrastructure. Accordingly, it would be expected to be much more significant in the case of railways than in the case of roads.

From the point of view of the supply of infrastructure, there are also a number of factors that have a strong influence on the final level of investment. Firstly, the unit cost of infrastructure construction may show wide variations among regions, depending on the geographical characteristics of each area (i.e. its topographical difficulty), and also on the regional differences in prices of immobile resources.

Secondly, the final level of investment also depends on the financial capacity of the potential investors. In the case of a purely private investment, capital mobility across regions may partially eliminate the constraints associated with this factor. On the contrary, in the case of public or subsidised investment, the financial capacity of the public institutions which are in charge of either the investment or the subsidy may set a budget constraint on the process of construction. As a consequence, broad differences in the investment capacity of different regions may arise due to such factors as the institutional framework or the level of income per capita of each region (which would affect the level of regional tax returns).[261]

The aforementioned authors also include, among the supply factors, the possibility of the objective function of the public sector to include goals other than efficiency. Usually, those non-efficiency objectives are related to equity considerations (such as achieving a similar infrastructure endowment in all regions), a better political control of the territory, or short-term goals (i.e. stimulating stagnant regional economies through public work construction expenses). In addition, the public decision-making process may also be influenced by particular interests and rent-seeking strategies, or by regional differences in the socio-political structure and in the prevailing relationships between voters and politicians.

In the rest of this section the influence of those determinants on the geographical distribution of infrastructure is tested in the cases of Spanish railways and roads throughout the period 1860-1930, on the basis of a pool of cross-section and time-series data which is used to estimate a model through panel data techniques. All variables have been measured at the provincial level and in the first year of each decade. Finding indicators of all those variables has not been an easy task. Regarding the provincial demand for transport, information has been collected on population density, the degree of urbanisation and the level and structure of the industrial sector in each province. However, whereas the influence of population density on infrastructure demand is straightforward, urbanisation and industrialisation rates may allow different interpretations. On the one hand, the rate of urban population is an indirect indicator of the size and structure of population centres, but it may also be considered a proxy for the level of provincial development, since, *ceteris paribus*, urbanisation tends to increase with economic growth.[262] On the other hand, the level and structure of provincial industrialisation affect the demand for transport services because, as was indicated before, different industries use transport with different intensity. But, at the same time, the degree of industrialisation is also a proxy for the level of development, as was stressed by Kuznets in his classical approach to modern economic growth.[263] As no provincial estimates of income per capita are available, and the reliability

[261] The ways in which the institutional framework may alter the final level and structure of infrastructure investment are dealt with in Gramlich (1994), pp. 1189-1193.
[262] See, for instance, Bairoch and Goertz (1986), pp. 298-299.
[263] Kuznets (1957), pp. 10-11.

of the existing regional figures is uncertain,[264] urbanisation and industrialisation rates have also been taken here as second-best indicators of the Spanish provinces' level of development.

Information on population density and urbanisation rates at the provincial level has been obtained from the official Spanish population censuses.[265] In a first approach, population has been considered urban in the case of municipalities 10,000 or larger. However, urbanisation rates calculated in this way may be misleading for some provinces, due to the fact that Spanish municipalities were usually made up of a main population centre and some subordinated small hamlets. As a consequence, in some cases (especially in the Northern regions), large municipalities might contain no urban centre but only a great number of small villages. In order to make up for this problem, those municipalities with more than 10,000 population, but which lacked a significant number of high (i.e. 3 or more floors) buildings, or which included more than ten population centres, or whose main centre was smaller than 5,000 people, have not been considered as urban.[266]

Provincial industrialisation is not so easy to approach as the share of urban population, since no industrial censuses were carried out in Spain during the period under study, and no historical estimates of industrial output are available at the provincial level. As a second-best option, two alternative indirect approaches to the provincial degree of industrialisation are possible. Firstly, most population censuses tried to classify active population among sectors of activity. Those attempts, however, were not free from serious conceptual problems. Apart from the fact that aggregation criteria widely varied among different censuses, the sector of activity was not properly identified for numerous wage labourers and, especially, for women, for whom census data have been said to be totally

[264] Álvarez Llano (1986) offers estimates on the share of each region within Spanish GDP in 1802, 1849, 1860, 1901, 1921, 1930, 1940 and 1950, which would allow the calculation of figures of regional GDP per capita. Álvarez Llano's estimates, however, are described by the author himself as very rough, and other historians have been very reluctant to use them. Carreras, for instance, has indicated that, despite not being in conflict with the available evidence on the period, Álvarez Llano's figures can only be taken as mere suggestions, due to the lack of information on the estimation methods and the bizarre behaviour of certain regions; see Carreras (1990a), pp. 6-8, and also Zapata Blanco (2001), p. 562. Álvarez Llano's figures are included in Table 3.4 to offer a more complete picture of the economic characteristics of the Spanish regions, but they have not been used in the estimation of the model.

[265] Data from the 1860, 1877, 1887, 1900, 1910, 1920 and 1930 censuses has been used. For 1880 and 1890, data comes from the 1877 and 1887 censuses, respectively, and, for 1870, a geometric interpolation of the 1860 and 1877 figures has been calculated.

[266] All this information is available in Luna Rodrigo (1988). As this author warns, urbanisation rates calculated in this way are not completely free from shortcomings, mainly due to the technical problems of the Spanish censuses. However, with these three corrections, the most serious distortions are avoided.

meaningless.[267] Nevertheless, keeping in mind the shortcomings of those data, the percentage of industrial workers within total population has been calculated for the censuses that were carried out between 1877 and 1930.[268]

A second approach to the level and structure of industrialisation is available from data on the main industrial tax (the industrial section of the *Contribución Industrial y de Comercio*).[269] The collection of that tax was based on each company's holdings of a representative asset, so that the amount collected reflected the value added produced by the company. Unfortunately, the *Contribución Industrial* was not applied in the Basque Country and Navarre during the period of study, and this absence substantially reduces the usefulness of the indicator. In addition, data for the remaining provinces must be used carefully because there is not enough guarantee that the coefficients applied to the companies' assets properly reflected their relative productive capacity. That problem may cause the importance of certain sectors and regions within the Spanish industry to be different from their contribution to the tax returns.[270] Besides, fraud and exemptions could also increase the biases in sectoral and regional figures.[271] Finally, from 1910 onwards, the largest industrial (joint-stock) companies were burdened with a different tax (the *Contribución de Utilidades*), which had the additional problem that the firms' fiscal

---

[267] One of the main reasons for these problems was the fact that, very often, rural workers were simultaneously involved in several different sectors of activity in nineteenth and early-twentieth century Spain. On the shortcomings of Spanish census figures, see Nicolau (1989) or Pérez Moreda (1999), pp. 54-56.

[268] This would be equivalent to estimating the percentage of manufacture workers within active population because, according to Pérez Moreda (1999), p. 53, the importance of the "active age cohorts" within total population did not change during the period under study.

[269] There is abundant research into the structure of Spanish industry that relies on those data. See, for instance, Nadal Oller (1987), Betrán Pérez (1997), Sudrià Triay (1997b), as well as most articles in Nadal Oller and Carreras (1990).

[270] Differences could increase gradually as time went by, due to the high inflexibility of the Spanish fiscal system, which was to a large extent based on the administrative determination of the amounts to be collected (the so-called *cupos*), with very little consideration of statistical information. On this subject see, for instance, Artola (1986), or Comín Comín (1996), p. 81. However, from Sudrià's point of view, the influence of this problem on the picture of the Spanish industrial structure resulting from the *Contribución Industrial* data would not be very serious, because "*it is plausible that calculation mistakes tended to be distributed in a random way*"; see Sudrià Triay (1997b), p. 405.

[271] Some local studies, however, have found quite a low level of fraud in the statements of the firms' assets, which can be explained for two reasons. On the one hand, statements were signed by Local Councils. And, on the other hand, the fiscal weight of the *Contribución Industrial* was always lower than the share of the industrial sector on Spanish GDP, which may be considered an indication of the relatively low importance of the *Contribución Industrial* for producers; see Comín Comín (1996), p. 117. Insofar as exemptions are concerned, according to Sudrià Triay (1997b), pp. 405-406, the most important ones were tobacco production (which was a public monopoly during the period under study) and some cotton firms, which were classified as agrarian due to their rural location. However, Carreras (1983), pp. 55-56, has indicated that the second of these two problems seems to have been irrelevant.

address did not always coincide with the location of their factories.[272] Keeping all these problems in mind, provincial data on the returns of the *Contribución Industrial* up to 1905, and Betrán's estimates of the joint returns of the *Contribución Industrial* and the *Contribución de Utilidades* in 1913 and 1929 have been gathered to proxy the geographical structure of Spanish industry between 1860 and 1930.[273]

Regarding supply factors, provincial differences in the cost of infrastructure construction may be approached through the information on road construction costs in each province which was published in *MAEOP* for most years between 1873 and 1924.[274] Unfortunately, these figures again exclude Navarre and the Basque Country, where the main road networks were not constructed by the State but by the Provincial *Diputaciones*.

Other supply variables are more difficult to approach than construction costs. Regarding the financial capacity of local investors, information on provincial and local public institutions' budgets is only available for the period before 1886 and for a few years between 1917 and 1927.[275] For the whole period under study, it has only been possible to take into account the particular fiscal situation of the Basque provinces and Navarre. Those four provinces benefited from a great fiscal autonomy, as they were responsible for the management of the whole tax system. The Spanish State only took part in the process as a passive recipient of a previously established yearly amount of money. According to the available data and some contemporary opinions, that system enormously improved the

[272] On the other hand, the *Contribución de Utilidades* had the advantage that it was also applied in the Basque Country and Navarre.

[273] See Betrán Pérez (1997). This author's estimates are the result of exhaustive research into the actual location of the companies that were affected by the *Contribución de Utilidades* in 1913 and 1929. Betrán's data has been used as representative for the structure and level of provincial industry in 1910 and 1930, respectively. For 1860, 1880 and 1890, the returns of the *Contribución Industrial* in 1856, 1878/1879 and 1889/1890, have been used. For 1870 and 1900 geometrical interpolations of the returns of 1863 and 1878/1879, and 1895/96 and 1905, respectively, have been calculated. All this data comes from *EACI*.

[274] Only cost figures for "third category" roads have been used, due to the scarce construction activity in other categories during the time sample. They cannot be directly aggregated by provinces throughout the whole period under study, due to price changes and the heterogeneity among cost figures for different years (as expropriation is included only in some cases). Therefore, for each year, provincial unit costs have been normalised by the Spanish figure and a weighted average of all normalised yearly values has been obtained for each province, in which weights are based on the number of km that were constructed each year. Differences among provinces in construction costs have been assumed to be the same in railways and in roads, since the most important cost determinants were the same in both networks (i.e. topography and land and labour prices).

[275] That information is available in *AEE* and *Reseña Geográfica y Estadística de España* (1888).

financial situation of the provincial and local public institutions of those four provinces, compared with the rest of the country.[276]

Finally, still from the "supply" point of view, in an aggregate analysis it is virtually impossible to measure deviations of public policy from geographically optimal investment criteria and, as a consequence, some unexplained residual of the provincial distribution of investment would be related to a hypothetical uneven distribution of those deviations among the Spanish provinces.

Table 3.4 compares the regional relative endowment of railways and roads (which has already been presented in Table 3.1) with the main characteristics of each region at three points of time. Regions are arranged according to their average infrastructure endowment, and the correlation coefficients between each variable and the endowment of railways and roads are presented in the last two rows of the table. According to those figures, there was quite a high correlation between the railway endowment of each region and its main economic characteristics during the whole period under study, with the only exception of the rate of urbanisation. On the contrary, the distribution pattern of the road network was rather independent from most economic variables at the beginning of the period and it only gradually converged with population density, the level of industrialisation and income per capita although, similar to railways, it remained unrelated to regional figures of urbanisation.

[276] See, for instance, Alzola y Minondo (1979), p. 41. This opinion seems to be confirmed by the information available on provincial and local institutions' budgets (see below, Table 3.4).

Table 3.4
Infrastructure endowment and structural characteristics of the Spanish regions
A) 1870

	RWD Norm.	RD Norm.	Weigh. average	Pop. density[1]	Urb. rate (%)[1]	Industrial tax p.c.[2]	Ind. A.P. (%)[3]	Income p.c.[4]	Fiscal capacity p.c.[5]	Unit cost
Basque C.	325	543	**401**	62	15	na	22	109	19	na
Rioja	245	209	**232**	35	7	117	14	98	9	112
Madrid	241	185	**221**	69	66	129	21	307	27	74
Navarre	194	234	**208**	29	10	na	12	99	13	na
Cantabria	190	200	**194**	42	16	94	16	107	10	133
Catalonia	182	129	**163**	53	31	272	29	124	11	141
Valencian C	156	124	**145**	58	27	90	18	70	8	108
Balearic I.	0	287	**100**	56	32	101	23	87	9	69
Murcia	117	67	**100**	37	68	57	17	78	5	84
Castile-L.	88	103	**93**	23	7	85	10	86	8	81
Andalusia	103	66	**90**	36	39	95	20	114	10	113
Castile-M.	102	63	**88**	16	8	73	11	94	8	64
Asturias	33	154	**75**	52	11	56	7	61	4	184
Aragon	71	54	**65**	19	11	68	13	102	9	102
Extremadura	50	54	**51**	17	8	68	9	81	8	97
Galicia	0	139	**49**	63	7	44	9	51	4	95
Canary I.	0	43	**15**	36	12	13	11	53	4	166
SPAIN	**100**	**100**	**100**	**32**	**22**	**100**	**16**	**100**	**9**	**100**
St Dev. (%)	77.79	78.73		41.63	89.13	63.88	39.34	56.32	57.42	32.31
Correl RW				0.25	0.20	0.58	0.48	0.52	0.72	-0.11
Correl R				0.52	-0.05	0.31	0.39	0.16	0.53	-0.09

B) 1900

	RWD Norm.	RD Norm.	Weigh. average	Pop. density	Urb. rate (%)	Industrial tax p.c.[6]	Ind. A.P. (%)	Income p.c.	Unit cost
Basque C.	324	291	**311**	85	29	491	35	123	na
Cantabria	219	205	**214**	51	25	87	20	129	133
Madrid	206	206	**206**	97	74	97	23	219	74
Catalonia	160	132	**149**	61	41	300	27	154	141
Valencian C.	162	114	**144**	69	37	85	16	90	108
Rioja	101	180	**131**	38	10	86	16	94	112
Navarre	87	184	**124**	29	9	80	11	103	na
Balearic I.	91	174	**123**	62	34	46	22	81	69
Asturias	109	147	**123**	58	15	84	14	95	184
Castile-L.	97	107	**101**	25	9	44	9	92	81
Andalusia	113	76	**99**	41	41	90	17	88	113
Galicia	69	129	**92**	68	9	24	8	67	95
Murcia	94	73	**86**	50	81	51	10	72	84
Castile-M.	67	75	**70**	18	15	63	13	87	64
Extremadura	75	57	**68**	21	16	43	11	71	97
Aragon	62	74	**67**	19	15	54	13	104	102
Canary I.	0	40	**15**	49	27	13	16	66	166
SPAIN	**100**	**100**	**100**	**37**	**29**	**100**	**16**	**100**	**100**
St Dev. (%)	62.98	50.14		46.76	75.28	115.39	42.78	37.29	32.31
Correl RW				0.63	0.30	0.79	0.77	0.62	-0.03
Correl R				0.59	0.02	0.63	0.66	0.54	-0.02

C) 1930

	RWD Norm.	RD Norm.	Weigh. average	Pop. density	Urb. rate (%)	Industrial tax p.c.[7]	Ind. A.P. (%)	Income p.c.	Fiscal capacity p.c.[8]	Unit cost
Basque C.	344	207	**274**	126	45	291	51	143	na	na
Cantabria	199	181	**190**	67	31	162	40	87	95	133
Madrid	201	163	**182**	173	81	174	51	119	214	74
Asturias	148	144	**146**	73	19	108	46	82	82	184
Balearic I.	135	152	**144**	73	42	52	37	98	76	69
Catalonia	154	129	**141**	87	54	322	50	180	175	141
Valencian C.	154	123	**138**	82	44	88	35	121	96	108
Rioja	121	132	**127**	40	23	116	32	90	106	112
Navarre	123	127	**125**	33	15	74	21	111	na	na
Castile-M.	60	107	**103**	26	23	27	25	83	69	64
Murcia	92	108	**100**	56	80	30	32	71	71	84
Galicia	63	135	**100**	77	12	17	26	64	52	95
Andalusia	110	82	**96**	53	50	51	27	76	90	113
Aragon	77	76	**76**	22	21	115	31	102	100	102
Castile-L.	98	80	**70**	23	13	34	27	90	88	81
Extremadura	60	59	**59**	28	26	20	28	76	73	97
Canary I.	0	74	**38**	76	33	15	49	62	na	166
SPAIN	**100**	**100**	**100**	**47**	**38**	**100**	**34**	**100**	**96**	**100**
St Dev. (%)	60.85	32.42		60.18	58.90	92.50	28.49	31.22	43.88	31.35
Correl RW				0.61	0.34	0.78	0.52	0.64	0.65	0.02
Correl R				0.66	0.29	0.62	0.43	0.41	0.33	0.06

RWD Norm: railway density (m per km^2), normalised by the Spanish average.
RD Norm: road density (m per km^2), normalised by the Spanish average.
Ind. A.P.: share of male active population engaged in the secondary sector.
Fiscal capacity p.c.: total expenses of local and provincial public institutions per capita (pesetas).
Unit cost: average of the normalised road construction costs of the provinces within each region.
Correl RW and R: correlation coefficient between each variable and railway and road density, respectively.
Notes: na: not available; (1) population figures for 1870 are obtained by geometrical interpolation of data from the 1860 and 1877 censuses; (2) industrial fiscal returns in 1870 are obtained by geometrical interpolation of data on 1856 and 1878/1879; (3) in 1877; (4) in 1860; (5) in 1865/66; (6) for 1900, industrial tax information is completed with Parejo's estimates for the Basque Country and Navarre (see Zapata Blanco (2001), p. 579); (7) in 1929; (8) in 1927.
Sources: for railway and road density see above, Section 3.2; population density and urbanisation rate from the official population censuses and Luna Rodrigo (1988); industrial tax per capita from *EACI*, Zapata Blanco (2001), p. 579, and Betrán Pérez (1997); industrial active population from Zapata Blanco (2001), p. 568; income per capita, from Álvarez Llano (1986); local and provincial fiscal capacity from *AEE*; unit construction cost from *MAEOP*.

As has been indicated, these variables have been used to estimate a model of the geographical distribution of Spanish railways and roads for the period 1860-1930. Tables 3.5 and 3.6 show the outcomes of the estimation of that model for the whole railway and road systems, and also for their main components, i.e. broad and narrow gauge railways, and State and non-State roads.

Demand variables (i.e. population density and the rates or urbanisation and industrialisation) have been included in the specification with one lag. Otherwise, the estimation might have problems of reverse causation, since a more abundant infrastructure endowment may foster economic and demographic growth. In the case of population density, a quadratic term has also been incorporated to account for the fact that infrastructure density is expected to increase at a decreasing rate with population density.

For each network (i.e. total, broad gauge and narrow gauge railways, and total, State and non-State roads), Tables 3.5 and 3.6 offer the estimation of three different versions of the model, depending on the information that is taken as a proxy for provincial industrialisation. The first version uses the share of industrial active population as explanatory variable, whereas the other two specifications are based on the fiscal data of the *Contribución Industrial*, which are firstly taken aggregated and secondly disaggregated into four sectors (food processing, textile industries, metal and chemical industries, and other industries).

All estimations include the construction cost variable.[277] In addition, as has already been indicated, a dummy variable that reflects the particular fiscal situation of the Basque Country and Navarre has been included, although only in the first specification. As noted earlier, the *Contribución Industrial*, which is used as a proxy for industrialisation in the second and third specifications, was not applied in the four autonomous provinces and, therefore, in those two specifications it is not possible to incorporate the "fiscal" dummy because the Basque provinces and Navarre are excluded.

In order to account for the hypothetical influence of interregional demand (or, in other words, for the presence of interregional spillovers) a spatial autoregresive model has been incorporated in the specification. As is customary in this sort of exercises, the spatial AR model has been specified as:

$$Ay = X\boldsymbol{b} + \boldsymbol{e}$$

$$A = I - g\,W$$

where W is a "rowsum=1 standardised" weight matrix that reflects the spatial structure of the data. In this case, the entries of W equal 1 if two provinces are contiguous and 0 otherwise. In the same direction, in order to take into account the contiguity of the province to the sea or to the French or Portuguese borders, two additional dummy variables

[277] In the cases of the Basque Country and Navarre, the construction cost levels of similar contiguous provinces have been applied.

have been included that take the value 1 in coastal and border provinces, respectively, and the value 0 otherwise.

Estimates in Tables 3.5 and 3.6 are feasible generalised least squares, which are robust to the presence of cross-section heteroskedasticity.[278] Given the large number of provinces compared with the short number of time periods, no individual effects have been included in the model, and the individual residuals have been assumed to be randomly distributed. Otherwise, the number of parameters to estimate would have grown disproportionately. However, all specifications incorporate time effects when they are significant, in order to correct for the fact that the networks were in different stages of construction throughout the sample period. Finally, given the extreme inertia of infrastructure series, most specifications include one or several lags of the dependent variable.

[278] Despite including a spatial autorregresive term, the model has not been estimated by maximum likelihood because this estimation method is not recommended in panel data models such as this one, with a relatively small number of observations; see Anselin (1988).

Table 3.5. The determinants of the provincial distribution of Spanish railways

	Total Network			Broad Gauge Railways			Narrow Gauge Railways		
Variable	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Constant	0.735 (0.737)	2.594* (2.006)	3.332** (2.660)	2.247** (3.427)	1.696* (2.371)	1.920* (2.438)	-0.869* (-2.284)	-2.338** (4.839)	-0.888** (-2.727)
Population density	0.151** (3.892)	0.166** (4.435)	0.185** (5.430)	0.042* (2.148)	0.117** (3.597)	0.130** (3.307)	0.046 (1.880)	0.102** (5.506)	0.060** (4.479)
Population density sq.	-0.001* (-2.571)	-0.001** (-4.844)	-0.002** (-7.451)	-0.0002* (-2.144)	-0.001** (-2.857)	-0.001** (-2.720)	-0.0001 (-0.633)	-0.001** (-4.359)	-0.0004** (-3.852)
Urbanisation rate	-0.029* (-2.339)	0.020 (1.866)	0.029** (2.789)	0.014* (2.190)	0.017* (2.193)	0.026** (2.661)	-0.004 (-0.550)	-0.003 (-0.525)	0.007 (1.137)
Industrial active population.	0.015* (2.225)			0.003 (0.984)			0.008* (2.078)		
Industrial tax returns per capita		0.004** (7.380)			0.002** (2.690)			0.001** (5.752)	
Food processing			-0.002** (-3.383)			-0.0003 (-0.724)			-0.0005 (-1.567)
Textile industries			0.002** (5.260)			0.001 (2.900)			0.0004** (4.883)
Metal and chemical industries			-0.0002 (-0.234)			-0.0001 (-0.210)			0.0004 (1.616)
Other industries			0.003** (2.718)			-0.0003 (-0.326)			-0.0001 (-0.334)
Construction cost	-0.007 (-0.767)	-0.014 (-1.095)	-0.020 (-1.644)	-0.007 (-1.623)	-0.019** (-3.099)	-0.020** (-2.653)	-0.003 (-0.779)	0.002 (0.581)	-0.003 (-1.092)
Fiscal dummy	5.105 (1.065)			-0.970** (-2.964)			5.527 (1.099)		
Railway density in contiguous provinces	0.047* (1.986)	-0.051 (-1.588)	-0.031 (-0.943)	0.061** (3.053)	0.077** (2.843)	0.098** (3.153)	0.070** (2.861)	0.230** (4.988)	0.145** (3.972)
Sea	-1.036 (-1.362)	-0.142 (-0.145)	-0.143 (-0.146)	-0.132 (-0.282)	-0.626 (-0.180)	-0.576 (-0.947)	-0.416 (-0.207)	-1.159** (-4.050)	-0.272 (-1.062)
Border	0.209 (0.511)	0.755 (1.156)	0.998 (1.559)	0.846** (3.294)	1.553** (4.735)	1.627** (4.509)	0.008 (0.094)	-0.188 (-1.855)	-0.218** (-2.853)
Adj R^2	0.94	0.95	0.96	0.99	0.98	0.97	0.85	0.93	0.86
Durbin-Watson statistic	1.92	1.79	1.80	1.83	1.81	1.80	2.29	2.17	2.23
No of lags of the dependent variable	1	1	1	3	2	2	1	3	3
T	5	5	5	5	4	4	5	4	4
No of observations	245	225	223	245	180	178	245	180	178
Time sample	1890/1930	1870/1920	1870/1920	1890/1930	1890/1920	1890/1920	1890/1930	1890/1920	1890/1920

Table 3.6. The determinants of the provincial distribution of Spanish roads

	Total Network			State Roads			Provincial and Local Roads		
Variable	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Constant	22.978** (5.168)	-2.522 (-0.699)	-1.574 (-0.736)	23.094** (5.901)	17.769** (4.342)	11.261** (4.256)	13.315** (8.535)	-5.368** (-4.193)	-3.310* (-2.309)
Population density	0.562** (5.261)	0.448** (3.518)	0.226 (1.681)	0.007 (0.048)	0.253** (3.507)	0.341** (4.385)	0.373** (3.666)	0.150* (2.516)	0.276** (3.870)
Population density sq.	-0.002** (-3.175)	-0.003** (-2.745)	-0.001 (-1.196)	0.001 (0.582)	-0.001** (-2.887)	-0.002** (-2.981)	-0.002* (-1.997)	-0.0002 (-0.292)	-0.001 (-1.920)
Urbanisation rate	-0.132 (-3.907)	-0.017 (-0.315)	0.007 (0.251)	-0.075** (-2.724)	-0.073* (-2.154)	-0.115** (-2.797)	-0.090** (-4.255)	-0.033* (-2.372)	-0.054** (-3.368)
Industrial active population.	0.014 (1.102)			-0.005 (-0.821)			0.019** (3.287)		
Industrial tax returns per capita		0.004 (0.823)			0.001 (0.438)			0.004** (5.130)	
Food processing			-0.001 (-0.872)			0.002 (1.752)			-0.0004 (-0.682)
Textile industries			-0.002** (-1.043)			0.001 (0.868)			0.002 (1.626)
Metal and chemical industries			-0.0002 (-0.152)			-0.001 (-0.687)			0.001 (1.460)
Other industries			0.013** (5.162)			0.003 (1.161)			0.003* (2.592)
Construction cost	-0.020 (-0.883)	-0.066** (-2.781)	-0.046** (-4.168)	-0.028* (-2.157)	-0.054** (-3.156)	-0.052** (-3.133)	0.000 (0.002)	-0.004 (-0.573)	-0.037** (-3.655)
Fiscal dummy	-4.709 (-0.540)			-1.555 (-0.298)			7.633 (0.563)		
Road density in contiguous provinces	0.060** (2.674)	0.091** (2.836)	0.108** (5.156)	-0.011 (-0.656)	-0.055 (-1.952)	-0.039 (-1.728)	0.005 (0.278)	0.088** (3.225)	0.145** (3.972)
Sea	-5.489 (-2.680)	-0.670 (-0.317)	-4.115** (-3.468)	2.058** (2.963)	1.788 (1.505)	0.011 (0.009)	-5.079 (-5.281)	-3.071** (-3.775)	-3.251** (-3.466)
Border	-1.750 (-1.564)	4.077** (2.736)	3.142** (3.879)	-2.835 (-1.764)	-1.712 (-1.905)	-1.940* (-2.342)	-0.707 (-1.079)	1.950** (5.159)	1.798** (3.199)
Adj R^2	0.98	0.99	0.99	0.98	0.97	0.98	0.92	0.88	0.90
Durbin-Watson statistic	2.08	1.94	1.96	1.88	1.69	1.77	1.71	1.75	1.72
No of lags of the dependent variable	3	3	3	2	3	2	2	1	2
T	4	3	2	5	4	4	5	4	4
No of observations	196	135	90	245	180	178	245	180	178
Time sample	1900/1930	1900/1920	1900/1910	1890/1930	1890/1920	1890/1920	1890/1930	1890/1920	1890/1920

Notes to Graphs 3.5 and 3.6: t-ratios in brackets; * 5 per cent significance level; ** 1 per cent significance level.

Regarding the original hypotheses of the model, the outcomes of the estimation are mixed. The most robust results are associated with the impact of population density on infrastructure, which is positive, significant and decreasing in virtually all cases. In contrast, the coefficients of the urbanisation and industrialisation rates vary broadly among the different specifications of the model. On the one hand, urbanisation rates only have a positive impact on the distribution of broad gauge railways, whereas they have a negative effect on road investment. On the other hand, the level of industrialisation has a positive and significant impact on railways and local and provincial roads, but no effect on the provincial distribution of the main road network. When industry is divided into different sectors, food processing seems to have a negative impact on railway density, and textile industries and the residual category of "other" industries seem to stimulate both railway investment and the construction of local and provincial roads. No significant impact associated with the most advanced industries (i.e. metal and chemical manufacturing) is found for any of the networks.[279]

As for the so-called "supply" variables, differences in construction costs are only significant in the cases of broad gauge railways and State roads, and the special fiscal situation of the Basque Country and Navarre did not seem to have any positive effect on their infrastructure endowment. Finally, spatial spillovers are found in nearly all cases, with the only exception of State roads. The coastal nature of the province has a negative effect only in the case of local and provincial roads and, surprisingly, the proximity to the French or Portuguese borders seems to have a positive influence on the development of broad gauge railways and secondary roads.

On the basis of these estimates, a number of explanations may be suggested for the geographical pattern of Spanish railway and road networks during the period under study. Starting with the railway system, provincial levels of infrastructure endowment appear to have responded quite closely to demand stimuli. They clearly increased with population density (although at a decreasing rate, as expected) and adapted quite well to the level of industrialisation of each area, except in those cases in which food processing was predominant, possibly reflecting the traditional nature of a large share of this sector. Therefore, insofar as the level of industrialisation is a proxy for the level of income per capita

[279] At least in part, the lack of significance of the variable "metal and chemical industries" may have been produced by the absence of the Basque Country from the respective regressions, since a large share of the Spanish metal industry was situated in that area during the period under consideration.

of each province, it is possible to suggest the presence of a direct relationship between economic growth and railway density.

A high level of spatial autocorrelation is present in the railway network as a whole and in each one of its components. This may be easily understood in the case of broad gauge railways, which had a marked long-haul orientation. In that case, spatial autocorrelation might be an indication of the importance of interregional demand, because sparsely-populated or poor provinces which were situated in the proximity of rich or highly-populated areas would have been crossed by interregional links. However, the strength of spatial spillovers in the endowment of narrow gauge railways is more difficult to account for, because most narrow gauge lines were short-distance oriented. In this case, spatial autocorrelation might reflect the fact that provinces with a high level of economic development and, therefore, with a rich infrastructure endowment, tended to be clustered in certain locations throughout the Spanish geography, such as the Mediterranean and the North, as was described in Section 3.1.

There are some interesting differences between the estimation outcomes for broad and narrow gauge railways. On the one hand, urbanisation had a positive effect on the endowment of broad gauge railways but it had no influence on the narrow gauge network. On the other hand, high construction costs seem to have discouraged the construction of broad gauge railways,[280] but not of narrow gauge ones. These differences between the two railway networks are consistent with the relative cheapness of the construction of narrow gauge lines, which were therefore better adapted to areas with difficult terrain and a predominantly rural population (i.e. where transport demand was distributed among a relatively large number of links). The predominance of narrow gauge in mining railways, which were mainly constructed through rural and topographically difficult areas, is an illustration of that situation.

The determinants of the spatial distribution of Spanish roads appear to have been different. As in the case of railways, network density increased at a decreasing rate with population density. But other demand variables had a less positive effect. Firstly, the coefficients of the level of urbanisation are negative and significant in the regressions for the main and secondary networks. This negative relationship might probably reflect the public effort to bring the road network to the largest possible number of people. In the

[280] This outcome is consistent with the importance that is given to construction costs in the explanation of the regional distribution of broad gauge railways by Cordero and Menéndez (1978), pp. 183-184.

provinces where population was disseminated, and in which railway construction was prevented by the dispersion of transport demand, the road network had to be denser just to serve the same share of population as in urban provinces. This situation was to be found particularly in some Northern areas of the country, such as Galicia, Asturias, Cantabria, the Basque Country or Navarre, where people used to live in relatively small centres and where, as a result, the road network had to be denser if it was to serve the transport needs of the population of the area.

Secondly, the influence of the level of industrialisation can only be noticed in the case of the provincial and local road networks, which seem to have adapted to the level of development of each area much better than State roads. This is consistent with the fact that the growth of the secondary networks depended on local resources during most of the period under study. Probably, if a better fiscal variable had been available to account for differences in public budget constraints among provinces, it would have partially absorbed the effect of the level of industrialisation. In addition, this confirms the presence of political aims in the design of the State network, which was much more oriented to serve the largest possible share of population than to adapt to regional differences in transport demand.

Finally, it is possible to observe some additional disparities between the estimates for the main and secondary road networks. On the one hand, the degree of spatial autocorrelation was much higher in the latter. This is again surprising, because road transport was mostly short-haul oriented, especially in the case of the secondary networks. Probably, as in the case of narrow gauge railways, the similarity in provincial and local road density among contiguous provinces reflects the better adaptation of those networks to the level of development of each area, since provinces with similar development levels tended to be geographically close. On the other hand, as happened in the case of railways, provincial differences in construction costs only had an effect on the more expensive State road network, but they did not affect the provincial distribution of the much cheaper secondary roads.

3.4 Conclusions

The modern Spanish economy has been characterised by the divergent evolution experienced by the advanced and the backward regions of the country. The explanatory factors for that divergence are numerous, and infrastructure has often been included among them, for two reasons. Firstly, the geographical distribution of infrastructure would have been rather uneven in Spain, and some regions would have been favoured at the expense of others. Secondly, the radial structure of the national networks and the importance of vote-catching aims within the investment criteria of the public sector might have introduced serious inefficiencies in the geographical distribution of most infrastructure. In that context, this chapter has had two main aims. On the one hand, it has described in detail the geographical distribution of the main Spanish infrastructure during the period of study. On the other hand, it has tried to explain the differences among regional infrastructure endowments by analysing the main determinants of the provincial distribution of the most important transport networks (i.e. railways and roads).

Generally speaking, the regions that were best endowed with all kinds of infrastructure during the period under study were situated on the Northern and Mediterranean coastlines and in the strip of land between the North and Madrid. In virtually all cases, the Basque Country was the most favoured area in Spain, and its infrastructure endowment was rather close to the European average. At the other end of the scale, the inland provinces of Aragon, Extremadura or Castile-La Mancha, as well as the Canary Islands, were much worse endowed.

To some extent, that pattern reflected the regional population density of each region. However, there are numerous cases of mismatch between infrastructure endowment and population density. For instance, the North-West of the country (Galicia and Asturias) or the Canary Islands, seem to have been relatively deprived of infrastructure investment given the size of their population, whereas the situation in other Northern areas such as Cantabria, Castile-Leon or Navarre seems to have been the opposite.

In order to further explore the determinants of the uneven availability of infrastructure among regions, I have estimated a panel data model for the provincial endowments of railways and roads in 1860-1930. As could be expected, the outcomes of the estimation show that regional population density was one of the most important determinants of the geographical distribution of Spanish infrastructure. However, apart from this common feature, different variables have been found to be relevant for the provincial distribution of the railway and road networks, reflecting the technical and institutional differences between them. Railways appear to have been much better adapted than roads to each region's level of development. In addition, within the railway system, broad gauge railways were mainly oriented to serve urban markets and were much more sensitive to differences in construction cost among provinces, whereas narrow gauge lines were much more flexible regarding those two aspects, and spread throughout rural markets and areas with difficult terrain.

Unlike railways, the response of road investment to the level of development of each province was far from perfect. In fact, the State network does not appear to have been affected by differences in the level of industrialisation. On the contrary, it seems to have been much more oriented by political than by economic criteria, trying to serve the largest possible number of people in each province. As a consequence, the road network was relatively denser in less urbanised areas, in which population was less concentrated and the number of necessary links was higher. Within the road system, however, secondary networks appear to have been slightly more flexible. Local and provincial road construction seems to have responded, to some extent, to each province's level of development, and to have overcome much better than State road construction the pressure of difficult terrain.

These outcomes help to explain the geographical distribution of Spanish railways and roads, and throw some light on the reasons why some areas remained relatively neglected by public and/or private investors during the late nineteenth and early twentieth century. For instance, the economic structure and the difficult terrain of regions such as Asturias, Galicia or the Canary Islands would have condemned them to a low infrastructure endowment relative to their population.

On the other hand, the importance of each region's demographic density and level of development in the construction of infrastructure networks may have reinforced the process of regional economic divergence that started in Early Modern times. As described in the introduction of this chapter, differences among Spanish regional economies before 1800 were associated, to a large extent, with each area's population density. From 1850, infrastructure was concentrated in the most populated and (in the case of railways) the most developed regions of the country and therefore became a reinforcing factor of the previous regional divergence. In that context, it would be interesting to analyse the potential balancing effects that an institutional setting other than the actual one (for instance, the construction of the railway network by the State) would have had on the geographical distribution of Spanish infrastructure and on its effects on each region's economic evolution.[281]

The descriptive effort that has been carried out in this chapter and the previous one is taken a step further in Chapter 4. The Spanish infrastructure endowment, whose main characteristics have been outlined in these pages, is analysed there in the European context. That international comparison constitutes the starting point of the study of the role of infrastructure in the Spanish industrialisation, since it will provide information on the relative level of infrastructure shortage that the Spanish economy had to face in the nine decades running up to the Civil War. That comparative approach is followed in Chapter 5 by an attempt to measure the real impact of infrastructure on Spanish economic growth during that period.

[281] On this subject see below, Sections 6.4 and 7.2.

CHAPTER FOUR

THE SPANISH INFRASTRUCTURE IN THE EUROPEAN CONTEXT: A COMPARATIVE APPROACH

4.1 Introduction

This chapter compares Spain's infrastructure endowment with that of other European countries. It is aimed at obtaining a preliminary impression of the degree of infrastructure shortage that burdened the Spanish economy during the period 1845-1935. In other words, it is intended to ascertain if the infrastructure stock that was examined in the previous two chapters was large or small, enough or insufficient for the needs of the Spanish economy.

Such a comparison is essential in the analysis of the role that infrastructure performed in Spanish industrialisation. The econometric estimation of the response of the Spanish economy to infrastructure investment which is carried out in Chapter 5 cannot be properly interpreted without knowing if infrastructure was scarce or abundant in relative terms. For instance, if a low response by the economy to infrastructure increases is found, it might be the consequence of excess investment, but it could also result from institutional factors, scarcity of other sorts of capital, or other constraining elements, which could be preventing the economy from fully benefiting from new infrastructure. International comparisons therefore provide information that is crucial for the interpretation of the estimates of the impact of infrastructure on economic growth.

However, comparison among historical infrastructure endowments is not an easy task. Firstly, there is an extreme paucity of historical estimates of infrastructure stock, and the available ones are hardly comparable, due to differences in definitions and in estimation techniques. As a consequence, international comparisons must mainly rely on physical indicators. However, this is also problematic due to issues such as the insufficiency of the information provided by physical indicators, and the differences among countries in the criteria applied to classify and describe infrastructure assets. Besides, in order to know a country's relative infrastructure shortage, physical indicators must be measured against each economy's need for infrastructure. This varies depending on a complex series of geographic and economic features, which are quite difficult to deal with in a multi-country study.

Keeping all these *caveats* in mind, this chapter compares the infrastructure endowment of Spain with that of other European economies between the mid-nineteenth century and 1930, providing preliminary conclusions about the relative shortage of infrastructure in the Spanish case. The chapter is organised as follows. The next section compares the new Spanish infrastructure database with the available historical estimates of infrastructure stock for other countries. Later on, Sections 4.3 and 4.4 carry out comparisons among physical infrastructure indicators for the European economies. Firstly, Section 4.3 is devoted to railways, which constituted the core infrastructure of the period, and, secondly, Section 4.4 examines the available physical indicators for other infrastructure. The main conclusions of the analysis are summarised in the last section of the chapter.

4.2 An international comparison of infrastructure stock estimates

Historical estimates of capital stock are not abundant, and some of them do not distinguish between infrastructure and other stock and, therefore, cannot be used in a comparison of national infrastructure endowments. As a consequence, the analysis in this section is constrained to a very small sample of countries. Table 4.1 compares the infrastructure stock estimates of a few economies for which appropriate information is available. The first part of the table shows the ratio between infrastructure stock and GDP in each country, and the second part, the share of infrastructure within total capital stock.

Table 4.1
International comparisons of infrastructure endowments
A) Net infrastructure stock/GDP (%)

	1850	1860	1870	1880	1890	1900	1910	1920	1930
Spain	**4.60**	**13.28**	**24.54**	**20.29**	**25.45**	**29.15**	**29.62**	**28.57**	**29.06**
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]

B) Net infrastructure stock/net total capital stock (%).

	1850	1860	1870	1880	1890	1900	1910	1920	1930
Spain	**na**	**na**	**na**	**na**	**na**	**22.42**	**19.24**	**18.29**	**15.45**
UK	21.10	23.00	24.69	24.01	24.66	24.02	22.86	20.93	18.83
Germany[c]	14.10	15.30	17.00	19.20	17.50	15.60	15.20	na	15.60
Japan	na	na	na	5.92	8.31	11.99	14.38	14.98	18.52
Italy	na	na	na	na	27.45	28.23	26.57	28.21	27.31
Russia/USSR	na	na	na	na	na	na	17.00[d]	na	19.73[a]
US	Na	na	na	na	na	na	na	na	21.64

Sources:
Spain: GDP from Prados de la Escosura (forthcoming), net total capital stock from Cubel Montesinos and Palafox Gamir (1997) and my own infrastructure stock figures.
Netherlands: Groote (1996), Maddison (1995b) and Centraal Bureau voor de Statistiek (1994).
UK: Capital stock from Feinstein (1965), (1972) and (1988), and GDP from Deane (1968) and Maddison (1995b).
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*.
Germany: Hoffmann (1965).
Russia/USSR: Kahan (1978) and Moorsteen and Powell (1966), p. 50.
Notes: na: not available; (a) in 1928; (b) in 1929; (c) gross infrastructure stock/gross total capital stock; (d) in 1913.

Figures in Table 4.1 are not perfectly comparable for two reasons. On the one hand, there are differences in the distribution of capital among categories and in the level of detail of the estimates for different countries. Therefore, infrastructure measures do not have exactly the same coverage in all cases, although deviations do not seem to be serious enough to produce misleading conclusions.[282] On the other hand, there are also differences among the calculation methods of the capital estimates for different countries, since some of the series that are included in Table 4.1 are the result of the direct assessment of the

[282] The cases in which this problem seems to be more troublesome are, on the one hand, Russia in 1910, because Kahan's estimate is not exhaustive and, on the other hand, the German infrastructure indicator, which only includes railways and "other public structures" and excludes therefore all private infrastructure other than railways. In all other cases, coverage is quite similar to my figures for Spanish infrastructure. In railways, telecommunications or electricity, non-infrastructure assets (such as machinery and rolling stock) have been excluded. When there was not enough information on the importance of those assets in the total stock of each sector, similar coefficients to the Spanish ones have been assumed.

existing stock, or have been elaborated on the basis of physical indicators,[283] but others result from the application of the perpetual inventory method.

There may arise some problems of comparability among the estimates obtained through the perpetual inventory method because, given an investment series, different useful lifetimes may produce very different stock estimates in absolute terms, as well as different shares of each asset within total stock.[284] As the assumptions on useful lifetimes for both the Dutch and the Spanish estimates of infrastructure stock (in those cases in which the perpetual inventory method has been applied) are mostly inspired by Feinstein's assumptions for the UK, the most serious problems of comparability might lie in the cases of the Japanese, the Italian and the US stock estimates, and also when the Spanish total capital stock series is involved. Firstly, in the case of the Japanese and US estimates and the Spanish total stock, useful lifetimes of around 50/60 years have been assumed for most structures, which are substantially below those used to estimate the British, Dutch or Spanish infrastructure stock.[285] As a consequence, in Table 4.1 the Japanese and US ratios between infrastructure and GDP may be lower, and the Spanish ratio between infrastructure and total stock higher than if similar assumptions had been made in all cases.[286] Secondly, in the Italian case, a useful life longer than 100 years is assumed for most structures, which may have brought the Italian ratios upwards relative to other countries.[287]

Due to these comparability problems and the small size of the sample, conclusions drawn from the ratios in Table 4.1 must be taken with caution. Keeping this *caveat* in

[283] This is the case of the German and Russian estimates, part of the British and Dutch series and also, as has been described in Chapter 2, most of the Spanish estimates. The Soviet figure for 1928 is an intermediate case, because it results from the combination of physical inventories of the early 1920's with the accumulation of investment flows up to 1928; see Moorsten and Powell (1966), p. 49.

[284] See Paccoud (1983), p. 22, and also Maddison (1995a), p. 141, who provides an example of the consequences of this problem. He indicates that the useful lives applied in the existing official estimates of post-war capital stock are the following: Germany, 57 years for non-residential structures and 14 years for equipment; US, 39 years for non-residential structures and 14 years for equipment; and UK, 66 years for non-residential structures and 25 years for equipment. He estimates new stock figures by applying the same standard useful lives to all countries. Differences with the official estimates are strikingly high and, for instance, the new estimate of British capital stock in 1950 is 48 per cent lower than the official one.

[285] For the Spanish total capital stock, see Cubel Montesinos and Palafox Gamir (1997), p. 124. For Japan, see Ohkawa et al. (1966), p. 138, and, for the US, see Bureau of Economic Analysis (1999), p. 30.

[286] However, in the cases of Japan and the US, it must be remembered that shorter useful lives might be the result of a higher level of utilisation of the assets than in Spain, which would reduce the problems of comparability. This situation may be illustrated by British roads, for which Feinstein assumes a useful life that decreased from 80 to 50 years due in part to the increase in the level of utilisation; see Feinstein (1988), p. 319.

[287] As the authors indicate, assumptions on the useful lifetimes of the assets in Rossi et al (1993) are based on previous research by Vitali (1975), p. 526.

mind, however, those figures might reflect a situation of mild relative infrastructure shortage in Spain during the period of study. On the one hand, regarding the share of infrastructure within total capital stock, Spain stood in an intermediate position at the beginning of the twentieth century, but showed a gradual tendency to lose ground as time went by.[288] On the other hand, if the ratio between infrastructure stock and GDP is examined, the Spanish economy always appears to have been in the lowest ranks of the table. Nonetheless, the uncertainty of this exercise and the small size of the sample make it convenient to shift the attention towards physical indicators, which are analysed in the remaining sections of this chapter.

4.3 The physical development of railway networks in the European countries

Railways were the core of infrastructure in the European countries at least until 1914, accounting for more than 50 per cent of the infrastructure stock in Spain, and for similar percentages in those countries for which stock estimates are available.[289] As was indicated in the previous chapter, the density of the railway system, i.e. the ratio between the length of the railway network and the surface of the country, is probably the best preliminary way to measure national endowments of railway services. As was discussed there, increases in railway density bring about reductions in the average distance from production or consumption points to railways, as well as decreases in the average length of detours in railway journeys. Those two effects substantially decrease transport costs in the economy. However, railway density cannot grow indefinitely. On the contrary, beyond a certain saturation point, density increases are not functional anymore and the capacity of the system to provide transport services can only be expanded by alternative means, such as the extension of double track.[290]

[288] The Spanish situation would be even worse if the aforementioned possible downward bias in the estimates of Spanish total net stock were taken into account.
[289] Percentages in 1900 were the following: Spain, 61 per cent; UK, 69 per cent; Germany, 58 per cent; Japan, 42 per cent; and the Netherlands, 32 per cent. See sources in Table 4.1 and, for the low Dutch percentage, see below.
[290] According to Laffut (1983), p. 206, the saturation point in nineteenth century European railway systems emerged at around 150 km of line per 1,000 km^2, although the railway network in Belgium or in some of the French *départements* were in the 1910's twice that density and, even in Spain, the Basque province of Guipúzcoa had in 1930 181 km per 1,000 km^2. The early saturation of the Belgian network is confirmed by the fact that, already in 1860, 51 per cent of its length was double track; see Avakian (1936), pp. 457 and 480.

Network density and the percentage of double track are therefore the indicators essential to study the service capacity of nineteenth century European railway systems. However, as was pointed out above, this information only allows a preliminary measurement of railway endowments, for two reasons. Firstly, the service capacity of each railway system also depends on a large series of technical features, such as: i) the number of access points to the system (stations, halts, stops, etc.), which reduces the average distance to population centres; ii) elements such as gauge, curves, grades or electrification, which affect speed and the average train load. Secondly, national figures on density and double track usually conceal large imbalances in the regional distribution of railway infrastructure.[291] Probably, comparing regional endowments would be much more appropriate. However, given the difficulty of tracing systematic and comparable information on the regional distribution of the European railway systems, countries seem to be the only feasible unit of comparison.

Table 4.2 shows the density of the European railway networks between 1860 and 1930, and Table 4.3 offers information about the extension of double track in some countries after 1900. Differences in density among national networks were considerable, especially at the end of the period, when the Belgian system was 20 times as dense as the Norwegian one. Spain, in spite of the early start of railway construction, always had one of the least dense networks in Europe, lagging behind some economies with a lower level of income per capita, such as Hungary or Ireland. It was even overtaken by a very sparsely-populated country like Sweden in the 1870's, and by some of the poorest economies of Europe, such as Romania or Portugal, at the end of the period. The table also shows that Spain, after the first wave of intense railway construction in the late 1850's and early 1860's, did not converge with the average European density, but remained at very similar levels in relative terms to those of 1870.

The low density of the Spanish network involved a substantial circuitousness of journeys and quite long average distances between the population centres and the railway

[291] For instance, as was described in the previous Chapter, provincial railway endowments in Spain (excluding the Canary Islands, which had no railway line) ranged in 1930 from 8 km per 1,000 km^2 in Cuenca, (Castile-La Mancha) to 181 km per 1,000 km^2 (a density which was above the average British figure) in Guipúzcoa (the Basque Country). In France, in 1907, the network density of the *départements* (excluding Seine), ranged from 34 km per 1,000 km^2 in Corse to 337 km per 1,000 km^2 in Nord; see Price (1983), pp. 222-223.

system, especially when compared with the situation in the core European countries.[292] In addition, as the Spanish network density was far below the "saturation point" in nearly the whole country, the percentage of double track in Spain was also very small, as can be observed in Table 4.3.

Table 4.2
Railway density in the European economies (m per km^2)

	1860	1870	1880	1890	1900	1910	1920	1930
Belgium	58.70	98.35	139.60	177.62	216.67	283.25	303.32	316.02
Great Britain	53.45	78.78	91.87	102.84	112.01	119.82	142.29	141.96
Switzerland	25.50	34.40	61.04	75.16	88.84	111.48	127.05	129.17
Germany	21.39	36.41	62.57	79.27	95.56	113.19	122.77	124.12
Denmark	2.85	19.75	40.63	51.43	74.75	88.37	97.64	119.43
France	17.80	33.43	48.21	69.38	81.02	93.45	99.76	115.73
Netherlands	9.79	41.46	53.80	76.27	80.97	93.21	105.37	107.45
Czechoslovakia							95.66	96.94
Hungary	4.97	10.70	21.79	34.56	52.55	63.42	87.50	93.25
Austria	9.76	20.45	38.38	51.52	65.48	77.79	85.47	85.47
Ireland[a]	26.00	37.91	45.20	53.25	60.70	64.86	65.64	78.38
Sweden[b]	2.30	7.54	25.64	34.99	49.32	60.34	64.88	72.10
Italy	8.39	21.94	29.69	45.70	55.28	58.71	66.69	71.42
Poland							35.44	50.46
Serbia/Yug.	0.00	0.00	0.00	5.24	11.18	11.82	37.43	40.33
Romania	0.00	2.18	7.01	18.45	23.60	26.17	16.85	37.75
Portugal	0.72	7.70	12.34	20.84	23.38	26.40	35.25	36.75
Spain	**3.80**	**10.85**	**14.76**	**19.78**	**26.17**	**28.96**	**30.94**	**33.07**
Bulgaria	na	na	2.32	8.33	16.25	19.69	21.38	23.67
Finland[b]	0.00	2.12	3.89	8.46	12.87	16.03	18.80	23,64
Greece	0.00	0.19	0.19	11.02	16.34	24.88	18.87	21.09
Russia/USSR[c]	0.33	2.19	4.68	6.26	10.89	13.62	17.04	18.54
Norway[b]	0.27	1.44	4.24	6.27	7.95	11.94	13.19	15.39
All countries[d]	*13.21*	*24.11*	*35.27*	*47.21*	*57.84*	*66.99*	*63.25*	*71.73*
Spain (% European average)	**28.76**	**45.00**	**36.46**	**41.90**	**45.25**	**43.23**	**48.92**	**46.10**
St. Dev. (%)	134.46	111.37	100.09	92.21	86.81	92.01	86.60	81.26

Sources: Mitchell (1998) and Statistical Yearbooks of each country.
Notes:
(a) Ireland always includes Northern Ireland.
(b) In order to get a more real impression of the railway density of each country, the Northern areas of Finland, Sweden and Norway, with population densities per km^2 lower than 4 during the period under study, have not been included in the calculation. Those areas are Oulun and Lapin in Finland, Troms and Finnmark in Norway, and Jämtlands, Västerbottens and Norrbottens in Sweden, which account, respectively, for 47, 23 and 49 per cent of the total surface of those countries.
(c) Only European territories.
(d) European average weighted according to the surface of each country.

[292] For instance, by 1908, the longest distance between a Belgian population centre and a railway line was 23 km, whereas some Spanish villages were more than 200 km away from the closest railway station. See Laffut (1983), pp. 208-209, and Gómez Mendoza (1999a), p. 723.

Table 4.3
Extension of double track in the European railway networks (%)

	1900	1910	1920	1930
Great Britain	54.03	54.08		
France		43.00[a]		
Germany		37.09[b]		
Russia		22.20		
Ireland	19.65	19.74		
Italy		17.00[c]		
Switzerland		15.36	17.88	19.44
Hungary	5.27	5.64	12.04	23.21
Austria				21.43
Czechoslovakia			13.49	13.62
Spain		**2.85**	**6.21**	**9.27**
Romania				1.96

Notes: (a) only "general interest" lines; (b) only broad gauge lines; (c) 1905.
Sources: For Spain, see the Appendix of Chapter 2; for other countries, National Statistical Yearbooks, Cambó Batlle (1918-1922), Vol. 5, p. 467, and Giuntini (1999), p. 89.

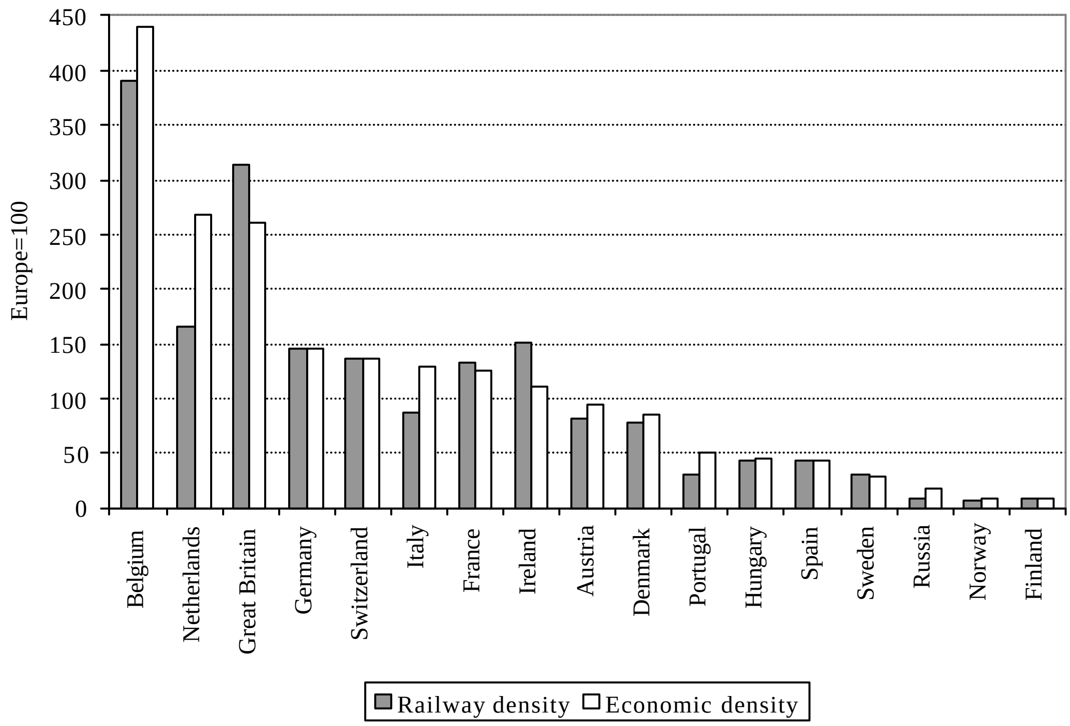
Nevertheless, it must be reminded that a low network density is not necessarily proof of infrastructure shortage, but it may just be the response to the structural characteristics and the needs of a particular economy. As was indicated in the previous chapter, a railway network will only yield positive social and private returns if its density and other technical features are well adapted to the expected level of traffic. In a poor or sparsely-populated country, the construction of a very dense network would involve a waste of resources and a very high opportunity cost, as it would remain under-utilised.

According to the discussion in Section 3.3, the expected level of traffic in a transport system primarily depends on the number of people living in the country (i.e. the population density) and their production capacity (which might be roughly measured by the level of income per capita). Population density and income per capita can be combined in order to obtain an indicator of the country's "economic density" (output per km^2), which would keep a direct relationship with the expected level of traffic in its transport networks. Graph 4.1 compares the railway density of the European countries, which has been presented in Table 4.2, with their economic density for the years 1870, 1900 and 1930. Countries are arranged in the graph according to their economic density, and all figures are normalised by the weighted average of the sample.

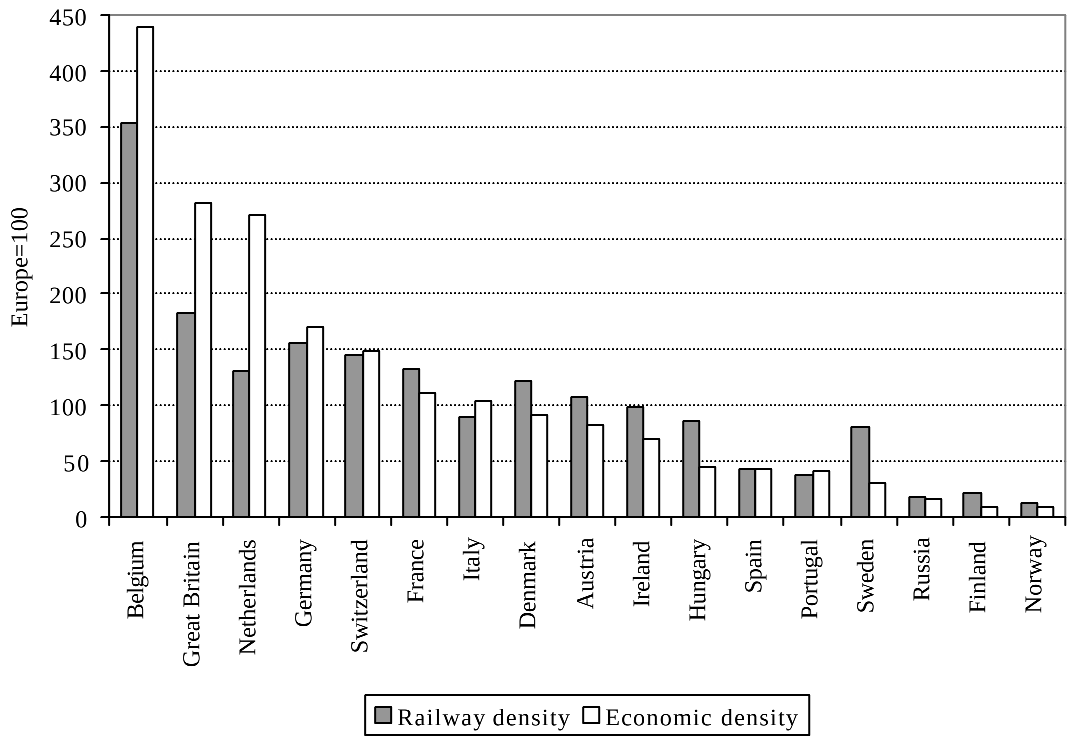
Graph 4.1

Railway density and economic density in the European countries

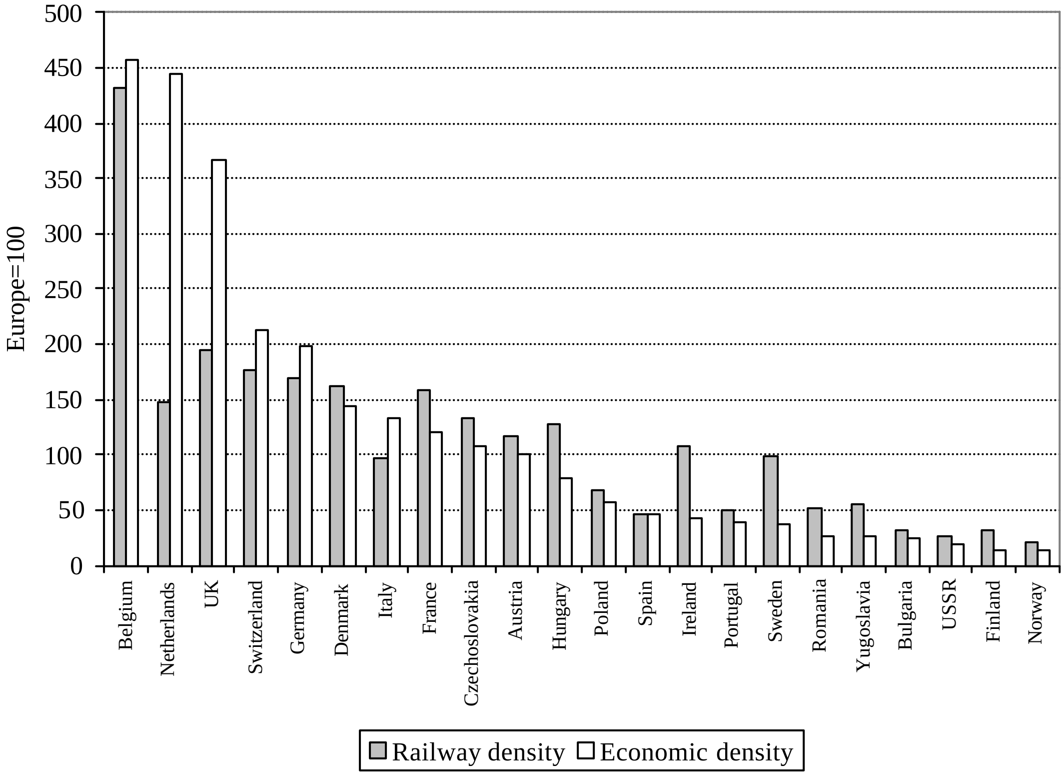
A) 1870



B) 1900



C) 1930



Sources and notes:

a) Railway density figures come from Table 4.2. For railway density in Finland, Norway and Sweden, see note (b) of Table 4.2. In 1930, the railways of Northern Ireland have been included in the Irish figure of railway density. Russia/USSR (whose data only refer to the European territories) has been excluded from the calculation of the European average densities.

b) For 1930, GDP figures come from Maddison (1995b) and, for 1870 and 1900, they come, in the case of Austria and Hungary, from Schulze (2000) and for all other cases they are the result of multiplying Maddison's income per capita estimates by each country's population, taken from Mitchell (1998), because Maddison's GDP database cannot be used since it refers to post-1913 national borders.

Despite the numerous factors that may make the density of a national railway network not adapt to the level of expected traffic,[293] the graphs show quite a remarkable

[293] On the one hand, excess density in a network may have been fostered by an inadequate regulation of the construction process (e.g. by the encouragement of useless competition through the concession of several lines over the same route), a speculative bubble, or the wish to foster the economic development of poor regions, whereas too low density levels might result from factors such as a difficult terrain, which would have increased construction costs, or, once more, inadequate regulation. The importance of some of these aspects in nineteenth century Europe has been examined from a comparative point of view by Girard (1966), pp. 212-214. On the other hand, as was indicated in the previous chapter, different types of production may have different levels of transport intensity, and each country's demand for transport would have depended therefore not only on its economic density but also on its economic structure. For instance, according to Krantz (1972), p. 27, industrial output is more railway-intensive than agricultural production. Similarly, Bairoch and Goertz (1986), pp. 301-302, indicate that the level of use of railway transport in nineteenth century Europe was very different depending on industrialisation being more disperse or more concentrated. And, finally, urban output might also be expected to have been more transport-intensive than rural production, because the agglomeration of activities in cities depended to a large extent on the availability of

correlation between railway density and economic density of the countries in the sample, which was higher in the earliest decades of the period under consideration. The correlation coefficients between those two variables were 0.96 in 1870, 0.92 in 1900 and 0.82 in 1930. That gradual decrease might have been associated with the fact that the railway systems of the densest European economies were gradually reaching their saturation point, and it might also have been related, in 1930, to the incipient competition of road transport, which would have prevented the railway network from adapting to the growth of the economy, since the road system could be expanded at much lower costs.

However, despite the high correlation between railway density and economic density, some European countries fit badly within the global picture, reflecting some situations of relative excess or shortage of infrastructure. The most striking case is probably the Netherlands, whose railway network density always seems to have been rather low compared with their economic needs. The late and slow construction of Dutch railways has concerned transport historians for a long time and, whereas some researchers have considered railway shortage as a serious bottleneck that hindered the industrialisation of the country, other scholars have pointed out that the high quality of the existing waterway and road networks at the beginning of the railway age, as well as their further improvement from 1865, were enough to cope with the economy's transport needs.[294] Although less markedly than in the Netherlands, the density of the railway network in the UK during the British climacteric, and in Italy in 1870 and 1930 was also much lower than in other countries with similar economic density. Historians have also searched for explanations for this anomalous situation in the Italian case, and some authors have suggested that the need for railway services in the country could have been mitigated by the good waterway endowment of Northern Italy, and also by the fact that hardly any city

---

broad markets of inputs and outputs. Nevertheless, the correction of national economic density figures with each country's urbanisation rate has been attempted here without increasing the correlation between economic and railway density. This is probably due to the importance of the transport of bulky primary products in nineteenth century European railway systems (see, for instance, Comín Comín et al (1998), Vol. 1, pp. 225-238, or Katus (1983), pp. 198-199), as well as to the high functional diversity of European urban systems at that time. An example of the latter is provided by Lévy-Leboyer (1978), pp. 260-261, who points out that, in spite of the intense growth of the French urbanisation rate during the nineteenth century, the small average size of French cities (pop 7,500 in 1880) prevented the extension of the French railway network after 1860 from being profitable.

[294] The debate is summarised in De Jong (1992), pp. 16-20. See also Groote (1996), p. 71, and Girard (1966), p. 236, who also points out that the minor presence of heavy industries in the Netherlands led the country to remain "*for a long time indifferent to the possibilities of railways*".

in Central and Southern Italy was more than 120 km away from the coastline, an explanation that might also be relevant for Britain.[295]

Regarding the Spanish case, the graphs offer a mixed impression. Interestingly enough, Spain is one of the countries that fits best in the European picture, with very similar levels of railway and economic density relative to the European average during the whole period under study. However, if this might be considered as an indicator of adequate endowment, other evidence is not so positive. More concretely, in the graphs for 1900 and 1930, countries with a similar economic density to the Spanish one always benefited from a better position than Spain in terms of railway density. Actually, with the exception of Spain, the graphs for those two years suggest that the relationship between economic density and railway density was not linear, and for levels of economic density lower than the European average (100 in the graphs), countries tended to have higher (relative) levels of railway density than of economic density. Accordingly, the development of the Spanish railway network after 1870, although rather adapted to the European average pattern, might have been insufficient in the context of the group of European countries with lower economic density.[296] That conclusion is consistent with the reflections of some Spanish historians, who have stressed the insufficiency of railway investment from the 1870´s onwards, in contrast to the great construction effort of the earlier period.[297] The next section offers some information about the long-term evolution of other infrastructure assets.

4.4 Other infrastructure: physical indicators

During the railway age, roads and waterways played indispensable roles as complementary transport means to the railway system. They were especially crucial in sparsely-populated countries with low railway density, where there were no feasible ways other than roads and inland navigation to integrate large shares of the country's population into the national economy. Unfortunately, international comparisons of road and waterway

[295] Toniolo (1983), p. 227.
[296] The picture offered by Graph 4.1 would be similar if Prados de la Escosura's alternative estimates of international output were used instead of Maddison's ones. On the contrary, Bairoch's income per capita data would suggest a much better situation in the Spanish case; see Bairoch (1976) and Prados de la Escosura (2000).
[297] See specially Tortella Casares (1973), p. 339. In fact, this author considers that, before 1866, there was a process of excess investment in the Spanish railways. See more details on the process of railway construction in Spain in Chapters 6 and 7 of this thesis.

endowments are even harder to carry out than in the case of railways. On the one hand, data on roads and waterways are much scarcer and much more difficult to trace than railway information. And, on the other hand, the range of quality levels, technical characteristics, service capacity, and criteria for the elaboration of statistics are much wider and, therefore, international comparisons are much more troublesome in the case of roads and waterways than in the case of railways.[298]

The main limit to international comparisons of road endowment indicators comes from differences among the criteria of road classification that were followed in different countries. Roads were usually divided into main (State and, in some cases, regional) networks and secondary (rural) paths. However, the concept of "rural road" varied widely among countries. While in the most developed economies, it usually referred to proper roads well adapted to cart traffic, in the poorest countries, it often included traditional narrow bridle paths, which were not accessible to wagons in most cases. The heterogeneity that resulted from this problem appears to have been more serious during the second half of the nineteenth century and, therefore, comparisons among the national road networks of different countries before 1900 must be taken with caution.

Table 4.4 presents the road density of a sample of European countries for which this information is available. In order to account for the problems of definition of secondary networks that have just been described, for 1870 and 1900 two different figures are presented in the table. The first one only refers to main roads, whereas the second one includes the whole road network. By 1930 problems of comparability among countries seem to have become less serious and, therefore, only figures for the whole network are offered. Road density is presented both in absolute terms and as a percentage of the sample weighted average, and countries are arranged in the table according to their economic density.

[298] The difficulty to account for international differences in road quality on the basis of the available public statistics is not exclusive of historical research, but it also hinders the analysis of present economies. For instance, Canning et al (1994), p. 144, attribute to this problem their failure to observe a clear economic impact of road construction in a cross-country regression, and they mention a case in which a change in the process of elaboration of national road statistics led a country's road endowment to triple in one year.

Table 4.4
Road density and economic density in some European countries
A) 1870

	RD I	RD II	RD I Norm.	RD II Norm.	ED
Belgium	250.86		243.73		439.17
Netherlands	313.51	343.20	304.59	97.74	268.93
France	151.89	770.24	147.57	219.36	125.07
Austria	211		205.00		94.33
Hungary	43.53		42.29		45.27
Spain	**41.34**	**44.73**	**40.16**	**12.74**	**42.78**
Norway[a]	24.48	80.50	23.78	22.93	8.76
Weighted av.[b]	102.93	350.99			
Correl.			0.80	0.46	
St. Dev. (%)			111.84	95.34	196.78

B) 1900

	RD I	RD II	RD I Norm.	RD II Norm.	ED
Belgium	317.92		204.25		438.83
Netherlands		423.06		102.46	270.46
France	160.81	1,069.70	103.31	259.07	110.43
Italy	159.91	348.83	102.74	84.51	103.77
Denmark	173.91	1,082.59	111.73	262.19	91.84
Austria	250.47	369.13	160.92	89.40	83.56
Hungary	116.18	173.40	74.64	42.00	45.63
Spain	**84.86**	**92.06**	**54.52**	**22.30**	**43.35**
Portugal		110.45		26.75	41.79
Norway[a]	42.83	114.74	27.52	27.79	8.31
Weighted av.[b]	155.65	412.90			
Correl.			0.83	0.34	
St. Dev. (%)			54.02	93.11	123.33

C) 1930

	RD II	RD II Norm.	ED
Belgium	1,459.26	298.36	456.87
UK	484.74	99.11	366.20
Switzerland	362.27	74.07	213.41
Germany	429.26	87.77	198.60
Denmark	1,161.69	237.52	144.95
France	1,126.84	230.40	119.75
Czechoslovakia	480.64	98.27	108.08
Austria	750.53	153.46	101.61
Hungary	206.31	42.18	78.96
Spain	**188.29**	**38.50**	**45.77**
Ireland	410.16	83.86	42.47
Portugal	151.49	30.97	39.91
Sweden[a]	332.50	67.98	37.20
Finland[a]	217.01	44.37	13.97
Norway[a]	150.27	30.72	13.45
Weighted av.[b]	489.09		
Correl		0.65	
St. Dev. (%)		78.02	98.50

RD I: Density of the road network (excluding rural roads) (m per km^2).
RD II: Density of the road network (including rural roads) (m per km^2).
ED: Output per km^2 normalised by the European weighted average.
Correl.: Correlation coefficient of RD I or RD II with ED.
Sources: RD I and II from Vieira (1980), Laffut (1983), Katus (1983), Price (1983), De Jong (1992), Istituto Centrale di Statistica (1976), Mitchell (1988), Statistisk Sentralbyrå (1978), and Statistical Yearbooks of each country. For ED, see Graph 4.1.
Notes:
(a) Finland, Norway and Sweden surface figures exclude the less populated Northern areas of those countries (see Table 4.2).
(b) European average weighted according to the surface of each country.

Figures in Table 4.4 show that the density of the road networks had a direct relationship with the density of the economy, as in the case of railways. The level of correlation, however, was not so high. Apart from the comparability problems that have been described before, the mismatch between the figures of road and economic density is probably associated with the fact that road construction was much more dependent on political decisions and less sensitive to the evolution of the economy than railway investment. As a consequence, differences in the degree of the State's activism are fundamental to explaining certain facts, such as the permanently high position of France in the European ranking.[299]

The scarcity and heterogeneity of the available data makes it difficult to draw conclusions about the relative shortage of roads in different countries. However, data

[299] See, for instance, Price (1975), p. 12, and Girard (1966), p. 214. In addition, French figures do not include a large share of French local roads (around 38 per cent of the total by 1880), which were excluded from the

seems to be consistent with the widespread contemporary opinion that the Spanish endowment of roads was adequate in the case of the main network, but very insufficient regarding secondary networks, and that this inadequacy would have prevented the economy from fully benefiting from the construction of railways.[300] This deficiency becomes also evident when figures for 1930 are analysed. In that year, the Spanish road system was less dense than the networks of Ireland, Sweden or Finland, showing, as in the case of railways, the disadvantage of Spain within the group of European countries with low economic density.[301]

In fact, the possible disadvantage of Spain regarding transport infrastructure was more serious than information on railways and roads may suggest, due to the virtual absence of alternative transport means in the country. Table 4.5 offers data on the endowment of waterways in a sample of European economies. Unfortunately, in the case of waterways, comparability problems are even more serious than for secondary roads, as figures of network length include a large variety of waterways, ranging from the largest European rivers to the oldest and tiniest canals which were only accessible to very small barges.

However, in spite of those problems, figures in the table illustrate the fact, as has been stressed by historians, that waterways played very different roles in the European countries. The best-endowed economy, the Netherlands, constituted, of course, an exception in Europe, as the extraordinary development of its waterway network was one of the factors responsible for the modest position of railways within the Dutch transport system, which has been described above.[302] However, in other countries, although waterways did not play such a central role as in the Netherlands, they were also a key component of the transport sector. They were especially relevant in those sparsely-populated economies where railway density had to remain at low levels. For instance, in Sweden, waterways integrated some regions into the national market and enlarged the

---

official statistics because they were not regularly maintained by the public sector during the second half of the nineteenth century; see Price (1983), p. 267.

[300] See Alzola y Minondo (1979), pp. 451-473, Pascual Domènech (1991), pp. 269-272, or Gómez Mendoza (1999a), pp. 722-723. According to Sánchez de Toca (1911), pp. 297-298, 5,000 Spanish population centres had no road connection al all still in 1910.

[301] Some shortage may also be observed in the case of Portugal and Hungary although, in contrast, the latter benefited from a much larger railway endowment and a richer waterway system than Spain in relative terms (see Graph 4.1 above and Table 4.5 below).

[302] De Jong (1992), p. 20.

hinterland for the main transport lines.[303] By contrast, in the Spanish case, the harsh geography prevented the construction of a waterway network complementary to railways, and led large areas of the country, which were badly endowed with railway lines, to depend on a rather underdeveloped network of secondary roads.

Table 4.5
Waterways in Europe in 1913

	(A)	(B)
Netherlands	142.86	153.26
Belgium	71.43	25.22
UK	30.30	25.29
Finland	28.98	180.77
Germany	28.57	25.24
France	25.64	27.44
Sweden	15.15	25.11
Italy	10.31	17.56
Hungary	9.52	15.02
Austria	9.43	12.13
Spain	**1.44**	**4.86**

(A) km of waterways per 1,000 km^2 of surface.
(B) km of waterways per 100 km of railways.
Sources: Milward and Saul (1977), p. 542, Hadfield (1986) and, for Spain, my own figures.

Finally, Tables 4.6 and 4.7 offer information about the development of telecommunication networks in Europe. Those networks constituted an additional essential instrument of market integration during the period under study, being complementary to the transport system as the main means of information exchange. Table 4.6 is analogous to Table 4.4, and compares the density of the national telegraph networks with the economic density of each country in 1870 and 1900.[304] Table 4.7 shows the ratios between the number of telegraph and telephone stations and the population of each country, and compares those ratios with the national level of income per capita.

[303] Kunz (1994), p. 198; Krantz (1995), p. 98.
[304] After 1900, the heterogeneity of the official telecommunication statistics increased with the laying of inter-urban telephone networks, because the relationship between the telephone and telegraph systems varied widely among countries, ranging from superimposition to independence. In addition, the new technology increased the complexity of the telegraph networks and led to the introduction of different description criteria among countries. As a consequence, it has not been possible to offer comparable data of network density for the first third of the twentieth century.

Table 4.6
Density of European telegraph networks
A) 1870

	TD	TD Norm.	ED
Belgium	147.41	308.32	439.17
Netherlands	87.34	182.68	268.93
UK	71.68	149.93	236.63
Germany	46.75	97.78	145.81
Switzerland	124.91	261.26	136.50
Italy	57.82	120.94	128.14
France	77.28	161.64	125.07
Austria	54.91	114.85	94.33
Denmark	50.99	106.65	85.68
Portugal	34.54	72.24	49.23
Hungary	29.60	61.91	45.27
Spain	**23.52**	49.19	42.78
Sweden[a]	29.89	62.52	29.25
Norway[a]	22.87	47.84	8.76
Weighted av.[b]	47.81		
Correl.			0.84
St. Dev. (%)		58.26	111.70

B) 1900

	TD	TD Norm.	ED
Belgium	217.35	142.34	438.83
UK	228.61	149.72	282.40
Netherlands	180.15	117.98	270.46
Germany	241.95	158.45	171.09
Switzerland	167.14	109.46	148.62
France	266.21	174.34	110.43
Italy	150.47	98.55	103.77
Denmark	99.62	65.24	91.84
Austria	111.41	72.96	83.56
Hungary	69.43	45.47	45.63
Spain	**71.28**	**46.68**	43.35
Sweden[a]	40.23	26.29	30.13
Norway[a]	46.27	30.32	8.31
Weighted av.[b]	152.61		
Correl.			0.69
St. Dev. (%)		53.70	115.03

TD: Density of the telegraph network (m of line per km^2 of surface).
ED: Output per km^2 normalised by the European weighted average.
Correl.: Correlation coefficient of TD with ED.
Sources: TD: Statistical Yearbooks of each country. ED: see notes to Graph 4.1.
Notes: see Table 4.4.

Table 4.7
Communication Networks. Points of access
A) Telegraph networks. Stations per million people

	1870		1900	
	TS	**Income p.c.**	**TS**	**Income p.c.**
Great Britain			304.93	4,593
Belgium	87.94	2,640	167.86	3,652
Netherlands	33.06	2,640	127.71	3,533
Switzerland	203.73	2,172	638.79	3,531
Germany			436.32	3,134
Denmark			202.06	2,902
Sweden			413.09	2.561
Spain	**12.28**	**1,376**	**80.46**	**2,040**
Austria	59.55	1,421	211.94	1,836
Italy	46.48	1,467	182.07	1,746
Weighted av.	50.47		286.21	
Correl.	0.32		0.40	
St. Dev. (%)	92.80	31.10	62.32	30.25

B) Telephone networks. No. of telephones per 10,000 people

	1900		1930	
	TS	**Income p.c.**	**TS**	**Income p.c.**
Switzerland	126.67	3,531	735.63	6,160
Netherlands	34.88	3,533	389.28	5,467
UK			435.14	5,195
Denmark	111.11	2,902	1,000.00	5,138
Belgium	22.68	3,652	362.62	4,873
France	17.99	2,849	267.48	4,489
Germany	54.59	3,134	498.92	4,049
Sweden	101.56	2,561	852.29	3,937
Austria	12.67	1,836	350.30	3,610
Norway	161.43	1,762	683.27	3,377
Czechoslovakia			98.09	2,926
Ireland			91.40	2,883
Italy	5.83	1,746	107.61	2,854
Spain	**7.03**	**2,040**	**95.09**	**2,802**
Finland			327.59	2,589
Hungary	9.73	1,436	132.95	2,404
Poland			61.65	1,994
Portugal			61.58	1,536
Yugoslavia			27.58	1,325
Bulgaria	6.72	na	33.16	1,284
Romania	4.81	na	27.98	1,219
Weighted av.	24.87		275.63	
Correl	0.18		0.74	
St. Dev. (%)	98.90	26.23	63.90	29.59

TS: Ratio between the number of telegraph/telephone stations and population.
Sources: Mitchell (1998), Maddison (1995b), Schulze (2000) and Statistical Yearbooks of each country.
Note: Income p.c. is expressed in 1990 Geary-Khamis $.

Table 4.6 shows a much lower level of dispersion among the national telegraph density figures than in the case of roads and railways, which may be related both to the relatively cheap construction cost of this type of infrastructure and to the essential political role that was performed by the telegraph systems in nineteenth century European countries. These two factors also help to explain the fact that the fit between telegraph density and economic density was lower than in the cases of railways and roads.

In the Spanish case, the density of the telegraph network was always quite adapted to the country's relative economic density. However, the gradual development of the telegraph network length does not seem to have been accompanied by a sufficient increase in the number of stations. As has been indicated by other researchers, the Spanish telegraph equipment was very poor and, in this aspect, Spain lagged behind most European economies. That deficiency, together with the high level of the Spanish telegraph rates, led the degree of utilisation of the Spanish telegraph system to be one of the lowest in Europe.[305]

In contrast, in the case of the Spanish telephone system, such a relative disadvantage in terms of access points is not so clear or, at least, it was common to a large number of European peripheral countries. As may be observed in table 4.7, in 1930 all European countries with an income per capita lower than 3,000 Geary-Khamis 1990 dollars, with the exception of Finland, were at a huge distance from all countries richer than that level. So, according to the table, the relationship between European national telephone endowments and income per capita was not linear, but responded to some sort of threshold process, in which the Spanish case fitted quite closely.[306]

4.5 Conclusions

This chapter has analysed the Spanish infrastructure endowment from a comparative point of view, trying to draw some conclusions about the degree of

[305] Calvo Calvo (2001).

[306] Finland and, at a higher level, Sweden and Norway stand out in the table for having a very high telecommunication endowment in relative terms. Actually, those countries resorted to telecommunications as a way to improve welfare and the level of integration within the national economy of their least populated areas. To that purpose, their governments stimulated the involvement of co-operatives and local councils in the development of the network, a strategy that contrasts with the changing and counter-productive Spanish regulation of the telephone system during the period under analysis; see Calvo Calvo (1998), pp. 61 and 67, and, on the development of the Nordic telephone networks, H.L. Webb (1911).

infrastructure shortage that the Spanish economy might have suffered before the Civil War. Comparison among national infrastructure endowments in stock terms is not easy, due to the scarcity of estimates for other countries and the problems of comparability among them. However, the available evidence might be consistent with a mild situation of relatively low infrastructure endowment in Spain, as measured by the stock per unit of output. In addition, it is possible to observe a decreasing trend in the share of infrastructure within the Spanish capital stock from levels similar to other countries to relatively low positions.

That analysis in stock terms has been complemented by a number of comparisons in physical terms. In the case of the railway system, infrastructure construction was very intense before 1870, and the Spanish economy seems to have had a network quite adequate to its needs by that date. However, during the following decades, railway construction slowed down, and Spain gradually lost ground in the context of the group of European countries with similar economic density. On the other hand, the construction of complementary transport networks in Spain also seems to have lagged behind other countries with similar characteristics. Although the absence of waterways gave Spanish roads a more crucial role in the global integration of the market than in other economies, the construction of secondary roads seems to have been very slow in relative terms, which would indicate that contemporary complaints about the insufficiency of the Spanish road construction policy were well founded.

Finally, regarding Spanish telecommunication networks, the analysis has offered mixed results. On the one hand, compared with other European countries, the Spanish telegraph system seems to have been well developed in terms of network density, but rather underdeveloped as far as the points of access to the system were concerned. On the other hand, the growth of the Spanish telephone system seems to have adapted quite well at the (rather disappointing) evolution of telephone infrastructure in most European peripheral countries.

In summary, information presented in this chapter has shown that infrastructure endowment in Spain tended to be similar or, in some cases, lower than in other countries with comparable infrastructure needs. The next question to address is to what extent that situation hindered the process of growth of the Spanish economy. The apparent shortage of some types of infrastructure would be consistent with the existence of bottlenecks in the economy and, therefore, increases in infrastructure endowment might be expected, under certain circumstances, to have provoked a dynamic response in terms of economic growth. However, as was described in Chapter 1, the elasticity of production with respect to infrastructure investment depends not only on the previous level of endowment, but also on a large number of structural features. Therefore, increases in infrastructure might have been unable to stimulate growth if other constraints were not removed. The following chapter is intended to address this issue by measuring the response of the economy to infrastructure stock growth during the period 1850-1935.

CHAPTER FIVE

INFRASTRUCTURE AND ECONOMIC GROWTH IN SPAIN (1850-1935): AN AGGREGATE ANALYSIS

5.1 Introduction

Chapter 4 has compared the Spanish infrastructure endowment between the mid-nineteenth century and the Civil War of 1936 with that of other countries and has offered some indications of an apparent shortage of some types of assets in the Spanish case. This chapter is intended to complement that information with a first approach of the impact of infrastructure investment on Spanish economic growth from an aggregate point of view.

For that purpose, this chapter analyses the relationships that linked the evolution of infrastructure with the main variables of the Spanish economy both in the short and in the long term. The first part of the chapter adopts a mere short-term perspective, and offers a comparison between the cyclical fluctuations of infrastructure investment, gross output and machinery investment. Although such an approach does not allow testing the existence of causality relationships among the variables, it offers a number of interesting hints on the forces that might have been behind their evolution, as well as on the possibility of short-term associations among them.

Later on, an exercise is carried out to measure the aggregate long-term impact of infrastructure on Spanish economic growth, through the econometric estimation of a vector autoregressive system for the years 1850-1935. Although the paucity of the available quantitative information and the shortcomings of the model raise some doubts about the outcomes of the estimation, the analysis seems to indicate that the impact of infrastructure investment on Spanish economic growth was nil in the short term and very low and slow in the longer term.

Apparently, that conclusion might be in conflict with the evidence that has been presented in the previous chapter. *A priori*, it would be likely that the apparent shortage of infrastructure might have provoked some bottlenecks in the Spanish economy and, as a consequence, increases in infrastructure would be expected to have a positive impact on economic growth through the elimination of those constraints. However, there are a number of possible explanations for that apparent conflict. As was indicated in Chapter 1, infrastructure is a necessary but not a sufficient condition for growth. In the Spanish case, infrastructure might have been unable to foster economic growth if other essential factors were lacking in the economy. In addition, infrastructure investment might have been ill-oriented from a spatial or sectoral point of view, and its inadequate regulation or management after construction might have substantially diminished its final impact.

All those aspects, however, can only be dealt with at a disaggregated level, through the analysis of the design, regulation and management of each type of infrastructure. Chapters 6 and 7 constitute a first step in that direction. Given the centrality of railways within infrastructure and the attention that has been paid to them by historians, those chapters are devoted to the study of the main features of the Spanish railway system, in order to find out possible explanations for its low and slow impact on the economy. That analysis should be followed by similar works for other branches of infrastructure, which are left for future research.

Within this chapter, Section 5.2 is devoted to the description of the short-term fluctuations of infrastructure investment, which are compared with the cyclical behaviour of the main variables of the Spanish economy. Section 5.3 describes the model that has been used to analyse the long-term impact of infrastructure on Spanish economic growth and offers the main results of the estimation, together with some possible explanations for them. Section 5.4 summarises the main conclusions of the chapter.

5.2 The cyclical behaviour of infrastructure investment

This section compares the cyclical behaviour of infrastructure investment with the available series of production and investment in machinery and equipment. The analysis is merely descriptive, and tries to observe the degree of association between the movements of those variables in the short run. Although no inferences on causality may be drawn from this approach, the similarities and differences among the cyclical behaviour of those variables offer interesting insights on the possible relationships among them.

The cyclical components of Spanish gross infrastructure investment, GDP, industrial production and gross investment in machinery and equipment have been isolated through the application of the Hodrick-Prescott Filter to the logarithms of the four variables in the period 1850-1935.[307] The resulting cyclical fluctuations of each variable are shown in Graphs 5.1 to 5.4, and their main features are summarised in Table 5.1.[308]

---

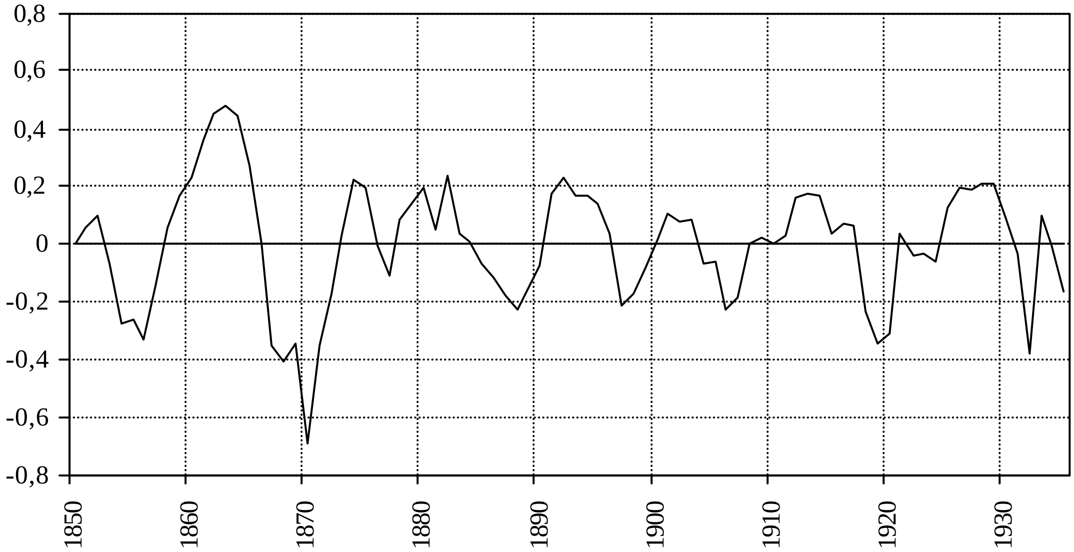
[307] The Hodrick-Prescott Filter is a smoothing method that extracts both deterministic and stochastic trends of the series. This property transforms it into one of the best means to detrend non-stationary series, given the low power of the available unit-root tests. It calculates a smoothed series *s* of a variable *y* by minimising the variance of *y* around *s*, subject to a penalty λ that constrains the second difference of *s*. In other words, the HP Filter choose s_t to minimise:

$$\Sigma (y_t - s_t)^2 + \lambda \Sigma ((s_{t+1} - s_t) - (s_t - s_{t-1}))^2.$$

The penalty parameter λ controls the smoothness of the series *s*: the larger is λ, the smoother is *s*. In this research, λ has been set at the most usual level in the case of yearly data (100). The cyclical component is the result of subtracting the smoothed series *s* from the original variable *y*. One problem of the HP Filter is that it is unable to eliminate fluctuations at the highest frequencies. Therefore, the resulting cyclical component keeps the so called "noise component" that does not belong to the business cycle. This is mainly reflected in higher levels of volatility in Table 5.1. For the HP Filter see, for instance, Canova (1999), p. 129, or Englund et al (1992), p. 349.

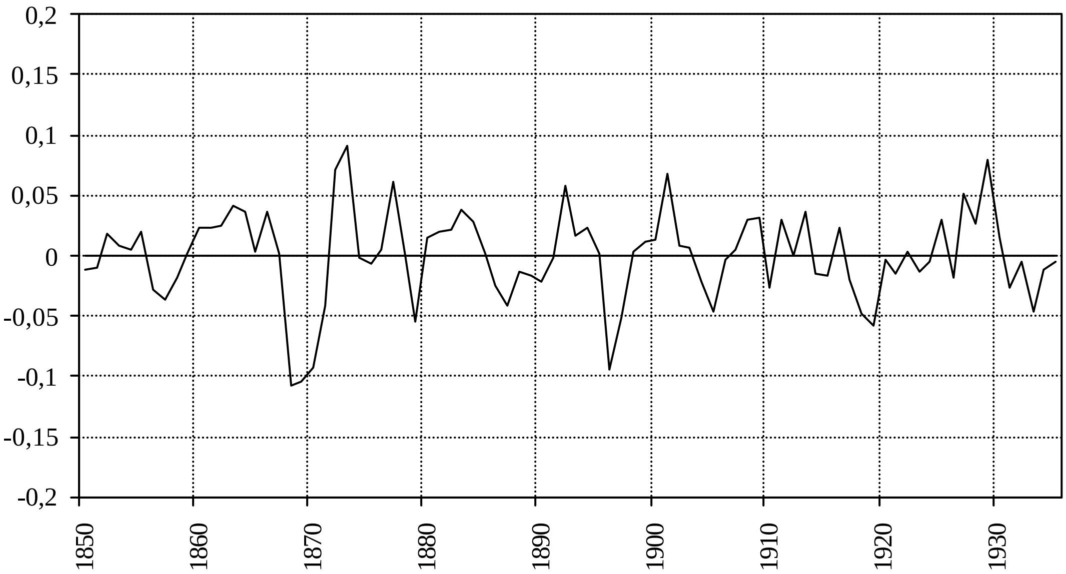
[308] Given the importance of the agrarian sector in the Spanish GDP during the period under study, it is convenient to include industrial production in the analysis, because GDP fluctuations may reflect to some extent the evolution of climate variables.

Graph 5.1
Cyclical fluctuations in Spanish infrastructure investment (1850-1935)



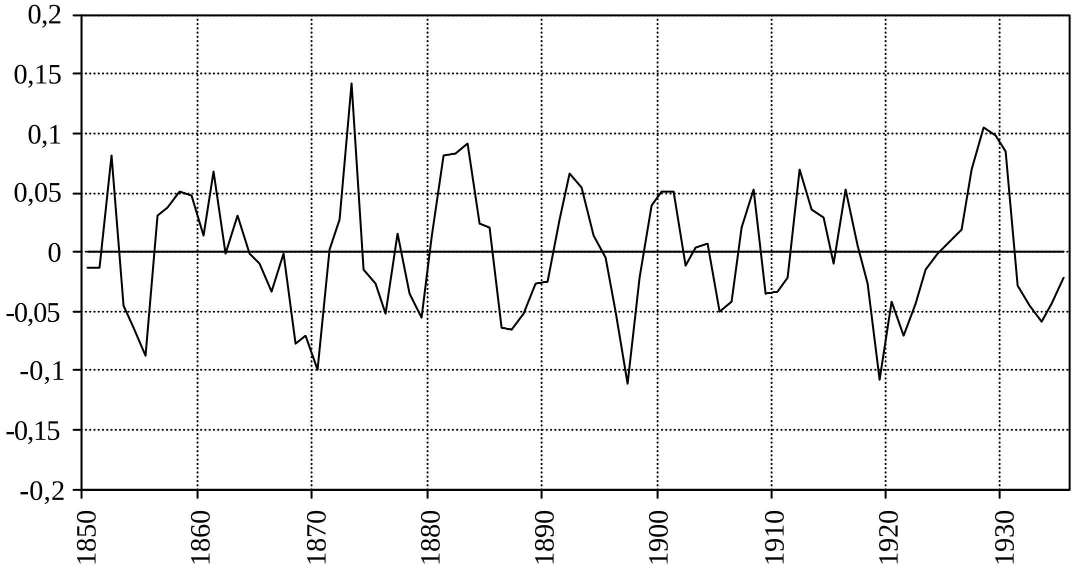
Source : see Appendix of Chapter 2.

Graph 5.2
Cyclical fluctuations in Spanish GDP (1850-1935)



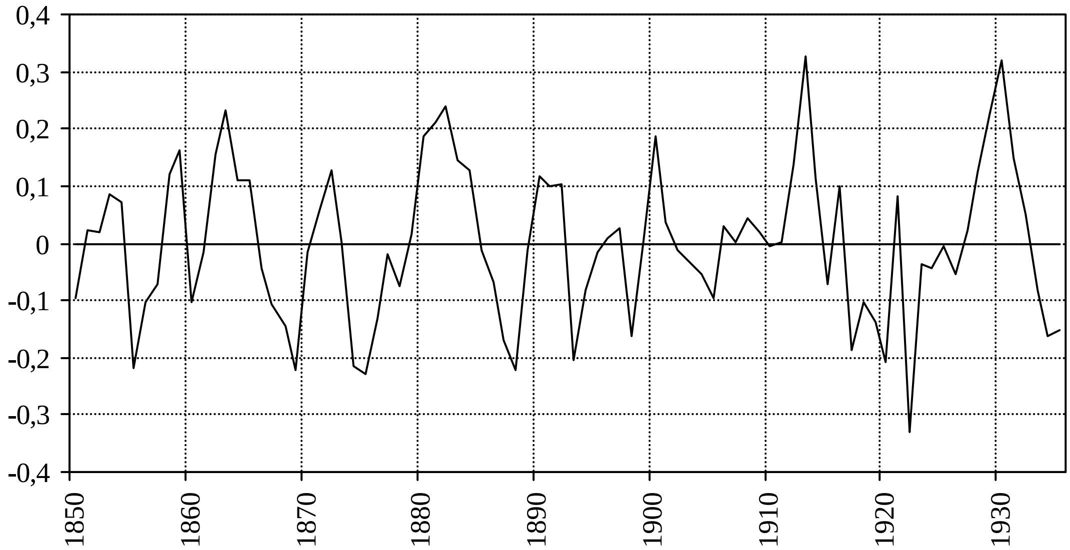
Source : Prados de la Escosura (forthcoming).

Graph 5.3
Cyclical fluctuations in Spanish industrial production
(1850-1935)



Source: Prados de la Escosura (forthcoming)

Graph 5.4
Cyclical fluctuations in Spanish machinery investment
(1850-1935)



Source : Prados de la Escosura (forthcoming)

Table 5.1
Cyclical behaviour of gross infrastructure investment, GDP, industrial production and gross machinery investment in Spain (1850-1935)

	Persist.	Volat.	Comov. with inf. (lagged)	Comov. with inf. (same period)	Comov. with inf. (next period)
Gross infrastructure investment	0.73	20.85			
GDP	0.44	3.74	0.41	0.51	0.55
Industrial production	0.50	5.25	0.32	0.52	0.56
Gross machinery investment	0.48	13.39	0.31	0.40	0.38

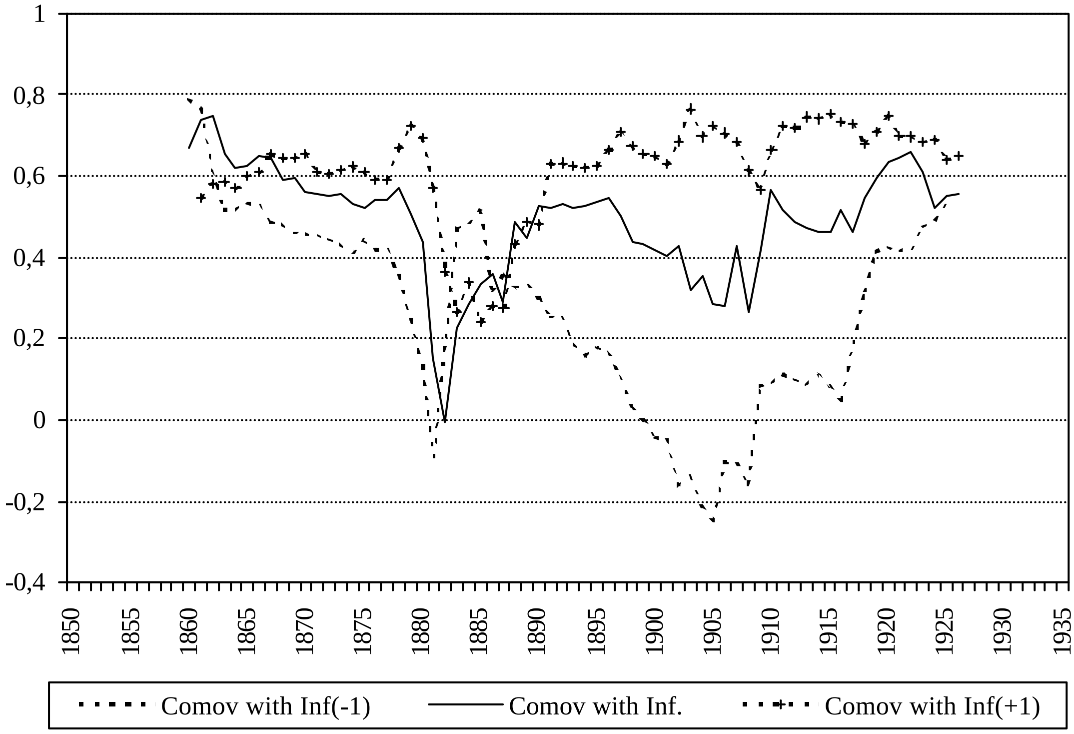
Persist: persistence (first-order autocorrelation coefficient).
Volat: volatility (standard deviation, %).
Comov: correlation coefficient between each variable and gross infrastructure investment in the previous, the same and the following period.
Sources: GDP, industrial production and gross investment in machinery and equipment from Prados de la Escosura (forthcoming); gross infrastructure investment from Appendix of Chapter 2.

As might be expected, both infrastructure and machinery investment fluctuations present much higher levels of volatility than GDP and industrial output. Infrastructure investment has also the highest degree of persistence, which reflects the indivisibility and long period of construction of many infrastructure projects.

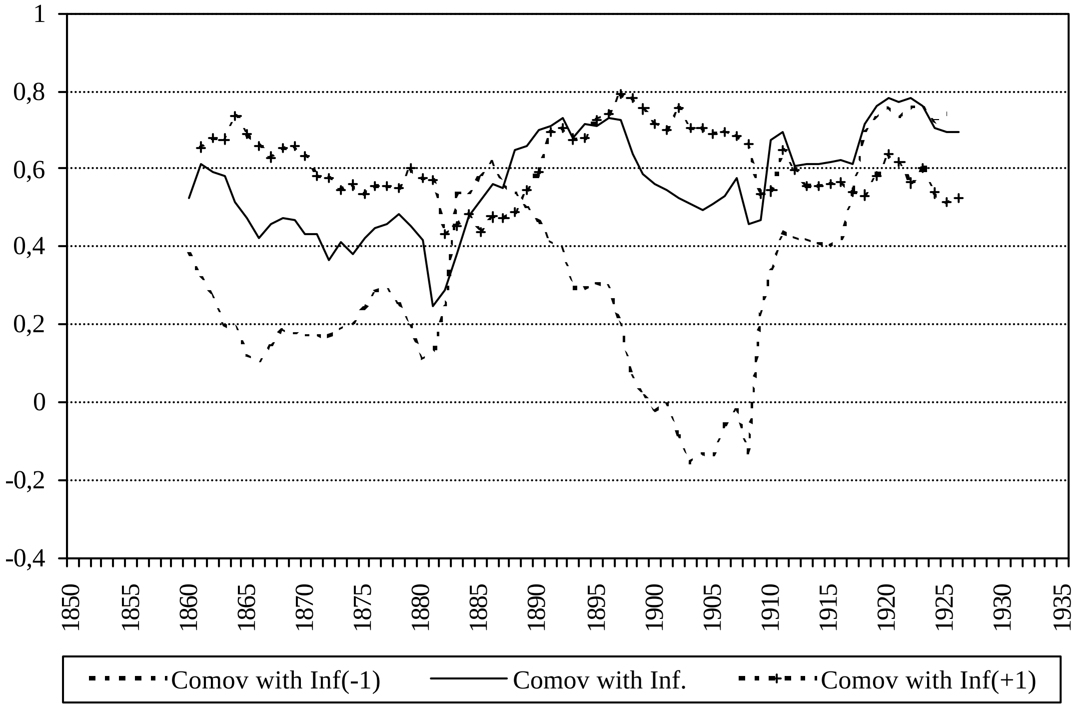
Regarding the comovements among the fluctuations of the series, infrastructure investment cycles are positively correlated with the production variables, and the level of association is always higher when infrastructure is taken in the following period than in the same or in the previous one. The link between the fluctuations of infrastructure and machinery investment is lower, and reaches its maximum intensity when both variables are taken in the same period.

Nevertheless, figures in Table 5.1 are just average indicators of relationships that were highly variable throughout the period. Graphs 5.5 to 5.7 capture that variability through the 20-years moving correlation coefficients between the cyclical components of infrastructure investment and the other three variables. As in Table 5.1, in these graphs infrastructure investment is taken in the previous, the same and the next period as the other three variables.

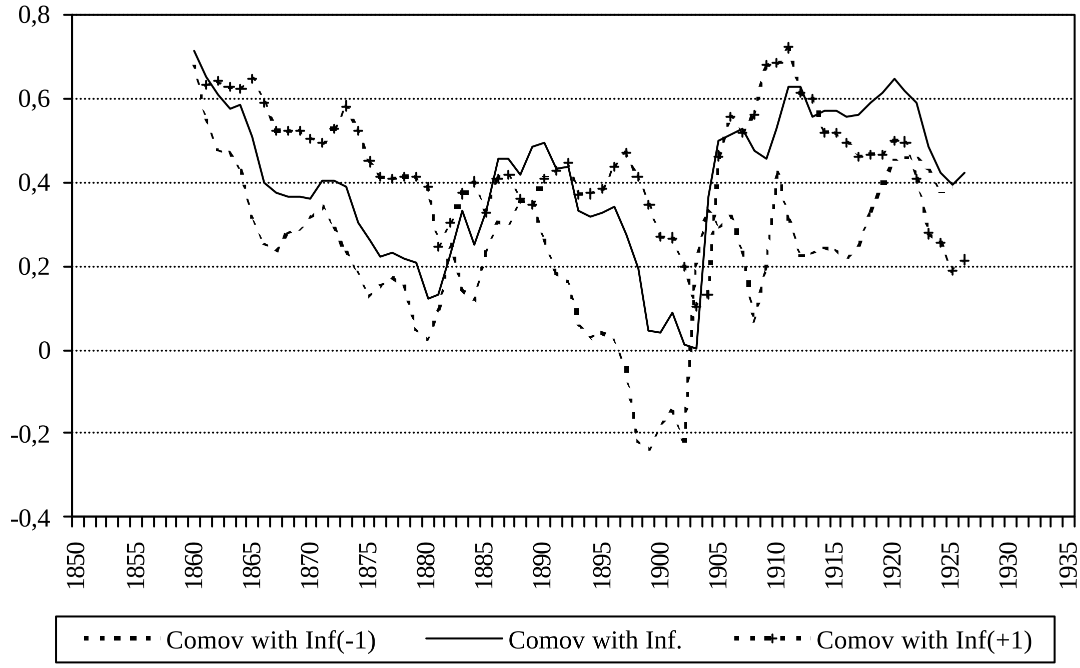
Graph 5.5
Comovements between GDP and infrastructure investment



Graph 5.6
Comovements between industrial production and infrastructure investment



Graph 5.7
Comovements between machinery investment and infrastructure investment



Graphs 5.5 and 5.6 confirm that the association between infrastructure and production is always higher when infrastructure is taken in the following period. On the other hand, Graph 5.7 shows very similar correlation levels between the two investment variables when infrastructure is taken in the same and in the next periods as machinery investment. The lowest levels of correlation always appear when infrastructure investment is taken with one lag.

The strong association between the main variables of the economy and gross infrastructure investment in the following year indicates that fluctuations of the latter followed with some lag the movements of the rest of the economy. Apparently, during the period of study, episodes of high economic growth fostered infrastructure investment. That situation would be 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, although it might also reflect reactions to the upsurge of bottlenecks in the economy. The relationship was especially intense from the 1890's onwards, which may be related to the importance of small scale and local-scope infrastructure during that period. In other words, during the last few years of the nineteenth century and the first third of the twentieth century, infrastructure investment seems to have accommodated better to the immediate needs of the economy, because the amounts involved in each project were smaller and the link of infrastructure assets with production activities was closer than in the previous period.

Infrastructure investment was much more independent of the fluctuations in the rest of the economy between the late 1870’s and the early 1890’s. This would be consistent with the high importance of railway investment during those years. Unlike other sorts of infrastructure, railways were large scale projects of interregional scope and, therefore, their degree of accommodation to the short-term fluctuations of the economy was lower. The construction of railways took a relatively long time, and the bottlenecks 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, railway construction cycles were to some extent self-sustained and did not adapt well to the global fluctuations of the economy.[309] Only during the railway mania of 1855-1866 and the further crisis, is it possible to find a stronger link between infrastructure investment and the rest of the economy, which was probably associated with the central role that railway construction performed in the intense fluctuations of the economy during those years.

Finally, correlation between production variables and lagged infrastructure investment is rarely significant. This might be evidence of the little importance of the elimination of bottlenecks by infrastructure and the irrelevance of its short-term “backward effects” on the evolution of the Spanish economy.

The only case in which this association was stronger was in the case of industrial production during the 1920’s and 1930’s. This seems to confirm Jordi Palafox’s considerations on the importance of public investment in the evolution of the Spanish industrial sector during those years. As he indicates, the military regime established in the country in 1923 was very sensitive to the interests of the Spanish heavy industries, which

[309] That particular behaviour of railway investment fluctuations has been pointed out for numerous countries. 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. Carreras (1999), pp. 41-45, considers the succession of long railway construction waves in Europe as a continental phenomenon. On the other hand, the independent nature of railway investment fluctuations may be related not only to technology but also to political factors, as is stressed by Fenoaltea (1983), pp. 53-54, or Lévy-Leboyer (1978), pp. 249-250, and also to the railway companies’ strategic behaviour within the railway oligopoly, as is suggested in Harley (1982), p. 797.

had suffered an intense oligopolisation process in the previous period. During the dictatorship of 1923-1930, public investment in certain sorts of infrastructure (such as the railway and road systems and hydraulic works) was four times as large as in the years 1917-1923 and became essential for the growth of sectors such as the machinery, iron or concrete industries. 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.[310]

The end of the dictatorship and the establishment of a democratic republic in 1931 involved the end of that policy. During the early 1930's, public investment in infrastructure was slightly reduced and, more importantly, was much more aimed at decreasing unemployment than at promoting the growth of Spanish heavy industries, being therefore concentrated on labour-intensive works, such as the construction of rural paths and other local assets. That change in the State infrastructure policy seems to have been influential on the negative evolution of the Spanish industrial production that may be clearly seen in Graph 5.3.[311]

In summary, three different periods can be distinguished in the short-term relationship between infrastructure and the rest of the economy. Firstly, throughout the violent fluctuations of 1855-1875, infrastructure investment and production evolved in a very similar fashion. Secondly, during the last decades of the nineteenth century, infrastructure investment, which was still dominated by railways, behaved in a very independent way. And, finally, in the first third of the twentieth century, increases in infrastructure adapted to the previous evolution of the economy. In all those three periods, the short-term backward impact of infrastructure construction on the economy was not noticeable, the only exception being its effect on industrial production in the 1920’s and early 1930’s due probably to the changes in the State policies of industrial promotion during those years.

All this evidence suggests some hypotheses about the relationships that were in force between infrastructure and production in the Spanish economy during the period under study. Whereas infrastructure seems to have responded quite closely to the growth of

[310] Palafox Gamir (1980), pp. 23-31; see also Palafox Gamir (1991).

[311] Palafox Gamir (1980), pp. 32-33. However, unlike this author, Comín 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.

the rest of the economy at least during part of the period, the hypothetical impact of infrastructure on growth would only be noticeable in the medium-to-long run, and would be much more associated with changes in the overall conditions of the economy than to immediate "backward effects" or to the breaking-up of short-term bottlenecks. Obviously, these are mere hypotheses, since the correlation coefficients shown in this section are not proof of causal relations, and a comprehensive model is necessary to estimate the actual links among those variables. The next section discusses the models that are available in the literature to carry out this kind of exercise, and presents the concrete specification that has been applied to the Spanish economy.

5.3 The impact of infrastructure on Spanish economic growth

5.3.1 Description of the model

Since the late 1980's a large amount of research effort has been devoted to the estimation of the economic impact of infrastructure, in the context of attempts to explain the contemporary slowdown in Western economies' productivity growth. The most common methodology in that type of research has been the estimation of restricted forms of the aggregate production function, which allows the inference of the effect of infrastructure stock on production or productivity through the elasticity coefficients.[312]

The earliest examples of elasticity measurements were based on the OLS estimation of standard Cobb-Douglas or translog production functions, on the basis of the available time-series for the US and other economies. Those first analyses obtained very high estimates of the elasticity of production with respect to infrastructure increases, which, in some cases, were even higher than the elasticity to private capital formation.[313] However, those studies immediately faced several criticisms. On the one hand, the value of the elasticity estimates was said to change too much from one exercise to another, even when referring to the same economy. For instance, estimates for the US were much lower if data

[312] However, there are several methods that provide alternatives to the standard estimation of production functions. Firstly, some researchers have measured the impact of accessibility on regional development. That kind of analysis was initiated by Hansen (1959) and Clark et al (1969); a recent example may be seen in Vickerman et al (1999). Secondly, Biehl has developed a model that is aimed at observing if infrastructure acts as a limiting factor for regional growth, on the basis of the estimation of the development potential of each region; see, for instance, Biehl (1991). Thirdly, a recent body of literature has focused on the intertemporal efficiency of infrastructure investment, in order to detect the presence of periods of over- or under-investment; see Otto and Voss (1998) and Boscá et al (2000).

[313] See especially Aschauer (1989).

were taken at the state level than at the federal level.[314] On the other hand, those initial exercises contained serious technical shortcomings. For instance, the functional forms that they used were criticised because they did not allow for the possibility of reverse causation from GDP to infrastructure, for the existence of relevant missing variables (such as human capital or input prices), or for more complex relationships than the standard Cobb-Douglas or translog frameworks, in which not only the direct impact of infrastructure, but also its long-term indirect and external effects could be estimated. In addition, in the case of research based on time-series data, those problems were made worse by the usual non-stationarity of economic variables, which led to the possibility of spurious correlations.[315]

Regarding the first problem, a number of explanations have been produced to account for the diversity of estimation outcomes among different analyses. On the one hand, Alice Munnell has explained it precisely on the basis of the differences in the geographical scope of the studies. From her point of view, the existence of spatial spillovers prevents analyses with a narrow scope (e.g. those carried out for the US at the state level) from capturing the share of infrastructure impact which benefits regions that are far away from the area where infrastructure is located.[316]

On the other hand, John G. Fernald has indicated that the low value of the elasticity estimates that are based on US data at the state level might be the result of the time sample. In his analysis of the growth impact of road transport infrastructure, this author has observed that the effects of road construction on the US economy were much larger during the 1950's and 1960's, when the main US highway network was constructed, than afterwards. According to Fernald, that temporal concentration of the impact of road construction was related to the importance of network economies in the US long-distance transport system. However, as US infrastructure data at the state level is only available for 1970 onwards, analyses carried out at that level are not able to capture those network effects, and must focus instead on a period in which the elasticity of production with

[314] This is illustrated by the works of Holtz-Eakin (1994), Garcia-Milà et al (1996) and Balmaseda (1996), who obtain very low or even zero estimates of the elasticity of production or productivity with respect to public capital in the US, just by carrying out the estimation at the state level and controlling for individual state effects.

[315] Those criticisms have been summarised, among others, by Munnell (1992), pp. 193-195, Hulten and Schwab (1993), Gramlich (1994), pp. 1187-1189, Hakfoort (1996), p. 65, or Kessides (1996), pp. 214-215.

[316] See Munnell (1992), pp. 193-194. Similarly, Vickerman et al (1999), p. 12, indicate that the importance of leakages in infrastructure impact is much larger if small regions are taken as the unit of analysis.

respect to transport infrastructure had substantially diminished, because the main highway system had already been established.[317]

In the last analysis, those two different views reflect the high complexity of the relationship between infrastructure and growth, which may be different for each sector, each spatial unit and each type of infrastructure, and may change with the level of development of the economy, the previous level of infrastructure endowment and the efficiency in the regulation and management of the stock. As a consequence, elasticity measurement exercises should allow for the largest possible level of complexity in the specification and in the underlying assumptions if they are to provide meaningful conclusions.

There have also been a large series of attempts to improve the specification and estimation procedures, as a response to the technical *caveats* that were raised about the first elasticity estimation exercises. For instance, in order to allow for the possibility of reverse causation from GDP to infrastructure, some authors have applied simultaneous equations or instrumental variables estimation methods, and other researchers have estimated cost functions instead of production functions, or have allowed for different effects of infrastructure on each sector of the economy (under the assumption that individual industry productivity is not likely to determine the overall stock of public capital).[318]

Also to address the technical problems of the early specifications, a number of researchers have applied a vector autoregressive (VAR) framework to the analysis of the economic impact of infrastructure.[319] VAR systems are multivariate models, in which each variable is explained by its own lags and lags of the other variables. Those models help to overcome some of the shortcomings of the typical Cobb-Douglas estimations of

[317] See Fernald (1999), who indicates that: "*Thus, the data seem consistent with a story in which the massive road building of the 1950's and 1960's offered a one-time boost to the level of productivity, rather than a path to continuing rapid growth in productivity. This conclusion (…) is consistent with simple network arguments*" (pp. 620-621). See similar considerations in Hulten and Schwab (1993), p. 262, and, for Spain, in Mas et al (1996), pp. 647-648.

[318] For the application of simultaneous equations methods see, for instance, Duffy-Deno and Eberts (1991). Instrumental variables estimation methods have been used not only to address the problem of reverse causation but also to allow for measurement errors in the public capital stock figures; see, for instance, Finn (1993) or Baltagi and Pinnoi (1995). Cost functions have been estimated, among others, by Berndt and Hansson (1992), Lynde and Richmond (1992), Morrison and Schwartz (1996) and, especially, Moreno et al (2002) and Boscá et al (1999) and (2002), who try to capture not only the direct effect of infrastructure but also its indirect long-term impact by allowing adjustments in the quasi-fixed inputs towards their optimum levels. Finally, the assumption of different impacts among industries is made by Fernald (1999), who focuses on roads, and classifies the manufacturing sectors according to the use they make of the road system.

[319] See, for instance, Garcia-Milà (1990), Clarida (1993), McMillin and Smith (1994), Otto and Voss (1996) and Roca Sagalés and Pereira (1998).

infrastructure impact, because they are specifically designed to analyse time series and to deal with problems of non-stationarity. In addition, they are highly unrestricted systems that do not impose any constraints on the functional form of the model, and allow for the presence of mutual causation among the variables and for indirect long-run effects among them.

The VAR framework is especially appropriate in the case of historical research, in which the paucity of data prevents from using more sophisticated methods, and has already been applied by Groote, Jacobs and Sturm to the analysis of the impact of infrastructure on the Dutch economy in the period 1853-1913.[320] As was indicated in the previous chapter, the Netherlands might have suffered from a comparative shortage of infrastructure during the late nineteenth and early twentieth century. Apparently, that shortage might have been the origin of bottlenecks in the economy, and infrastructure investment might be expected to have had a strong influence on Dutch economic growth through the removal of those bottlenecks. The results of the VAR analysis carried out by those three researchers unambiguously indicate a very positive short-to-medium term influence of infrastructure increases on growth, which would be consistent with that expectation.

In this section, I present the outcomes of the estimation of a VAR system for the Spanish economy in the period 1850-1935.[321] *A priori*, similar results to the Dutch case could be expected, since Spain also might have suffered some relative shortage of infrastructure during the period under study. However, apart from this general expectation, some additional hypotheses may be tested which are suggested by the evolution and fluctuations of infrastructure construction. As has been repeatedly indicated, until the last few years of the nineteenth century, infrastructure investment was dominated by the building of the main railway system, whereas during the first third of the twentieth century "local-scope" infrastructure became more important than large-scale networks. Accordingly, different relationships between infrastructure and growth might be expected in those two periods. In the first one, infrastructure investment may be expected to be independent of GDP fluctuations in the short term and, in addition, its long-term impact on

[320] Groote et al (1999). See also Groote (1996), pp. 59-75, and Sturm et al (1999).

[321] Cubel Montesinos (1997) has also estimated a VAR system to analyse the impact of infrastructure on Spanish economic growth in the years 1900-1935, and has observed a clearly positive effect of infrastructure on industrial production. Cubel's exercise, however, is different from mine, for two reasons. On the one hand, he does not use infrastructure figures but public capital data. As was indicated in Chapter 2, those two variables were not equivalent before 1936. On the other hand, he expresses the capital variables in stock

growth may be expected to be very large, since it would involve the integration of the Spanish economy. On the contrary, in the first third of the twentieth century, infrastructure investment would be expected to respond closely to the evolution of the economy in the short run, and its long-term impact would be expected to be lower than before 1900.

Keeping these expectations in mind, a VAR system has been set out which is made up of three variables: industrial output, infrastructure investment and machinery and equipment investment. Unfortunately, there is not enough information to obtain continuous series of Spanish industrial labour inputs. Although there are some figures for census years, it is not possible to make interpolations among them due to the absence of a reliable yearly series of total active population. As a consequence, this variable, which is essential in a production function framework, has been left out of the system, and this absence reduces to some extent the interest of the results, which do no longer refer to productivity growth but to output growth in absolute terms.[322]

Industrial production has been selected as the output variable instead of GDP, because, during the period of study, aggregate production was still very sensitive to agricultural fluctuations. On the other hand, investment data have been preferred to capital stock figures. Although capital is usually included in stock terms in the standard production function framework, the use of variables in stock terms in a VAR analysis raises some problems, since they are usually integrated of second order, whereas production is highly unlikely to be so.[323] Therefore, investment figures have been preferred here to keep the homogeneity among the time-series properties of the data.[324] However, this choice means losing information on the longest term relationships between the

---

terms and, therefore, does not take into account the differences in the level of integrability of the series of production and capital stock (see below).

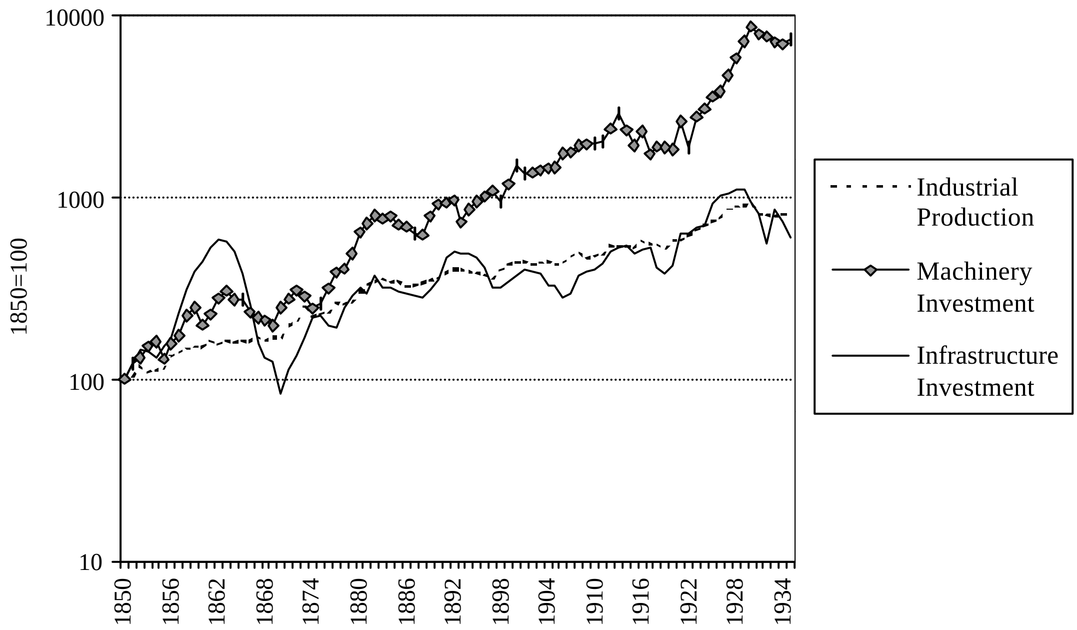
[322] In other words, the absence of labour may lead to the overestimation of the growth impact of the investment variables in the model for periods (such as the current one) of population increase. Groote et al (1999) also exclude labour from their estimation for the Netherlands in 1853-1913. From their point of view, there is a theoretical basis for this procedure, because the high level of indivisibility and the presence of IRS in infrastructure makes its economic effects to pay off at the aggregate macro level. According to these authors, "*those aggregate effects would only partially be taken into account if population were used as a scaling factor*" (p. 237). However, a more appropriate way to deal with IRS in infrastructure would be expressing production and machinery investment in per capita terms and infrastructure in absolute terms, as is described in Aschauer (1989), p. 180, or in Otto and Voss (1996), p. 724.

[323] See Haldrup (1998) and Otto and Voss (1996), p. 725. The application of unit root tests has indicated that both infrastructure stock and the stock of machinery and equipment are I(2) or near-I(2) variables.

[324] The same procedure is applied to the Dutch case in Sturm et al (1999), p. 360, also because of the better time-series properties of investment variables. Alternatively, stock series in first-differences could have been used. However, investment has been preferred because Spanish non-infrastructure stock figures are only available for the period 1900-1935.

variables, which must be kept in mind when interpreting the outcomes of the estimation.[325] The series that make up the system are expressed in logs and can be seen in Graph 5.8.

Graph 5.8
Variables of the model



Sources : Industrial production and machinery investment from Prados de la Escosura (forthcoming); and my own infrastructure investment figures (see Appendix of Chapter 2).

The series do not appear to contain any structural breaks in the period 1850-1935.[326] In this context, Augmented Dickey-Fuller and Phillips-Perron tests have been

[325] More concretely, using investment instead of stock variables is to some extent equivalent to consider only the influence of the pace of growth of capital on output, independently of the stock level. Therefore, the presence of DRS or IRS in the relationships under study is missing in the analysis. Nevertheless, the use of investment variables in growth analyses has been given some support by Scott (1993) or, from a different perspective, by Levine and Renelt (1992).

[326] The Vogelsang test has been applied to infrastructure investment, industrial production and machinery investment and no significant structural break has been found in any case. Cubel Montesinos and Palafox Gamir (1998) observe the same absence of breaks before 1936 in the series of Spanish GDP estimated by Prados de la Escosura (1995) and in the series of private investment estimated by Carreras (1990b). However, they detect the presence of a structural break in 1870 in this author's series of industrial production. That break, however, has not been found in the most recent series of industrial production estimated by Prados de la Escoura (forthcoming), which is used here. The comparison between the profiles of those two alternative estimates of industrial production shows that the trough that may be observed in Carreras' series in 1870 is much more moderate in Prados de la Escosura's estimate, which may explain the different outcomes of the Volgesang test.

applied to the series, in order to know the best way to deal with their non-stationarity. The results of those tests are shown in Table 5.2.

Table 5.2
Unit root tests

Variable	*ADF t-stat.*	*PP t-stat.*
Industrial production	-2.49	-2.52
Machinery investment	-3.01	-3.21
Infrastructure investment	-3.66*	-2.38

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

According to the test results, in the case of industrial production and machinery investment, the hypothesis of the presence of a unit root cannot be rejected, whatever the test applied. In the case of infrastructure, the results are not so straightforward. The presence of a unit root in the series cannot be rejected when the Phillips-Perron test is applied, but it is rejected at the 5 per cent level when the Augmented Dickey-Fuller test is used. In any case, given the marginal character of the rejection, this variable could be considered as a "near-unit-root" process.

On the basis of these results, two options are available for the specification of a VAR system with these three variables. Firstly, the three series may be differenced or detrended in order to obtain stationary variables. In the case of industrial production and machinery investment, which clearly appear to be I(1) variables, data should be differenced. On the contrary, in the case of infrastructure investment, data should be detrended to get a stationary process.

However, as a second option, the three series in levels could be dealt with as I(1) variables. This procedure would be justified by the fact that the available unit root tests are not thoroughly able to disentangle the "true" character of the data. As has been said above, in the case of infrastructure investment the rejection of the hypothesis of the presence of a unit root is marginal and depends on the test applied. Some authors have indicated that, given the low power of the available tests, unit-root processes and near-unit-root processes should be treated as equivalent.[327] Therefore, the use of the series in levels has been

[327] See Granger (1993), pp. 309-310, Pesaran and Smith (1998), p. 473, or Doornik et al (1998), p. 536.

preferred here, since it has the advantage of keeping all the information that is contained in the original data.

5.3.2 Estimation outcomes

The estimation of a VAR system with non-stationary series in levels only makes sense if the variables are cointegrated. Before testing for cointegration, the number of lags and the exogenous variables to include in the system must be selected. In the selection process, multivariate generalisations of the Akaike and Schwarz information criteria have been used, together with the observation of the residuals of each equation of the system. The selected model contains seven lags, a constant and a trend. In addition, the possibility of structural changes in the relationships among the series has been allowed for in the specification for several reasons. On the one hand, the behaviour of infrastructure investment during the railway mania of the 1860's had nothing to do with the further evolution of the variable. On the other hand, as has been indicated above, from the end of the nineteenth century the decreasing importance of railways within total infrastructure investment might have altered the causal relationship between infrastructure and economic growth. In this context, the values of the Akaike and Schwarz criteria indicate that a change in the constant in 1865 and a shift in the trend in 1895 significantly improve the estimation. In addition, a dummy variable for the year 1933 has been included in the system in order to account for the positive behaviour of infrastructure investment that year, which was completely anomalous in comparison with the evolution of industrial production and machinery investment, as can be seen in Graph 5.8.

The resulting system has been subjected to the Johansen test for the presence of cointegration among the variables. The results of the test are shown in Table 5.3.

Table 5.3
Johansen cointegration test

H_0: No. of Coint. Relationships	Likelihood Ratio
None	67.82**
At most 1	17.37*
At most 2	2.64

* Rejection of the null hypothesis at the 5 per cent level.
** Rejection of the null hypothesis at the 1 per cent level.

According to the outcomes of the Johansen test, the presence of two cointegration relationships among the variables cannot be rejected. This result allows the estimation of the model with the variables in levels, as well as the interpretation of the estimates as structural relationships. It is also consistent with the I(1) or near-unit-root character of the variables under study. However, the existence of two cointegration relationships, instead of one, makes the error correction representation of the model meaningless and, therefore, only the unrestricted representation is presented here.

Table 5.4 summarises the results of the estimation of the model. The applied misspecification tests (Breusch-Godfrey and Jarque-Bera) indicate that the residuals of all three equations are serially uncorrelated and normally distributed. For each of the three equations, the table shows the sum of the coefficients of the lagged values of each variable.[328] In addition, in order to approach the possible causal relationships among the variables, it includes the result of the Wald test for the joint significance of the lagged coefficients of each variable (χ^2, which can be interpreted as a Granger-causality test), and also the outcomes of the neutrality test, i.e. the Wald test of significance of their sum (χ^2 sum, which tries to capture causality relationships in the long run). Obviously, Granger-causality is not proof of real causality but of time precedence or predictability, and hypotheses on causality based on these tests must also have a theoretical basis.

Table 5.4
VAR model: summary of the estimation results

	Equation								
	Y			**M**			**I**		
	c^2	*Sum*	c^2 *sum*	c^2	*Sum*	c^2 *sum*	c^2	*Sum*	c^2 *sum*
Y	64.37**	0.76	50.00**	8.32	0.71	4.24*	17.56*	0.55	3.65
M	27.47**	-0.13	6.14*	56.43**	0.30	2.96	12.26	-0.21	2.17
I	7.03	0.09	1.17	5.35	-0.06	0.43	127.27**	0.58	63.10**
Constant		4.29**			-2.17			-0.65	
Trend		0.01**			0.02			0.01	
d1865		-0.01			-0.32*			-0.55**	
d1895		-0.001*			0.00			0.00	
d1933		-0.05			-0.14			0.60**	
BG		0.01			1.57			5.67	
JB		0.54			0.29			5.16	
Adj R^2		0.99			0.98			0.96	

Y: Industrial production.
M: Machinery investment.
I: Infrastructure investment.
BG: Breusch-Godfrey test of absence of serial correlation in the residuals.
JB: Jarque-Bera test of normality of the residuals.
* 5 per cent significance level.
** 1 per cent significance level.

[328] Individual coefficients are not reported, since the overparametrisation of VAR models makes many of them redundant and meaningless.

According to the results of the Wald tests that are reproduced in Table 5.4, there are three causal relationships among the variables that cannot be rejected, which go, on the one hand, from industrial production to infrastructure investment and machinery investment and, on the other hand, from machinery investment to industrial production. According to the neutrality test, the impact of production on infrastructure investment has a mere short-term character. On the contrary, the mutual relationship that links industrial production and machinery investment has a long-term nature.

The model, therefore, captures the effect of Wagner's Law, i.e. the positive impact of economic growth on infrastructure investment, as was already suggested by the analysis of the short-term fluctuations of these two variables in Section 5.2. It also reflects the positive impact of economic growth on investment in machinery and equipment.

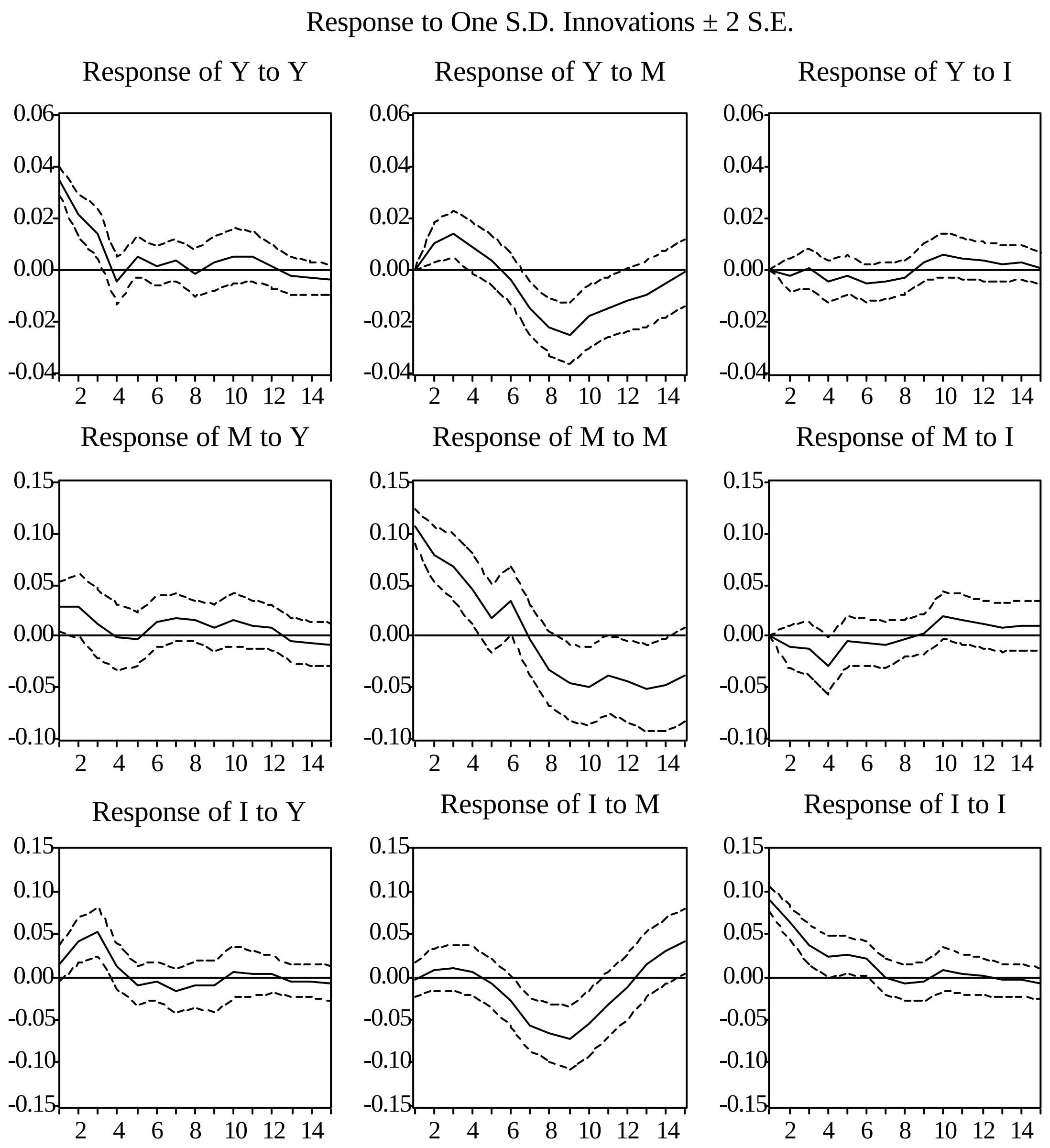
On the contrary, neither investment variable appears to have positive effects on growth. In the case of infrastructure, no evidence at all of a positive (direct or indirect, through machinery investment) impact on economic growth is found, either in the short or in the long run. This outcome would again be consistent with the findings of the short-term analysis in Section 5.2.

Secondly, and more surprisingly, a slight negative influence of machinery investment on growth is observed in the long run. The absence of a positive effect of machinery investment on growth has also been observed for the Netherlands in 1853-1913. In that case, it has been attributed to the fact that, in the early stages of the industrialisation process, machinery investment could only have an influence on economic growth after a previous period of investment in infrastructure and after the integration of the national market.[329] Nevertheless, those considerations are in conflict with the strong association between machinery investment and growth that has been found by Bradford De Long in his cross-country analysis for the late nineteenth and twentieth centuries. It is true that this author has indicated that machinery investment might have played a less important role in poor than in rich countries during the period, which might be relevant to understand the Spanish case.[330] However, this would explain the absence of a distinct positive impact of machinery investment on growth, but not the presence of a negative influence.

[329] Groote et al (1999), p. 240.
[330] De Long (1992), p. 322.

That striking result may be better understood by looking at the outcomes of the impulse-response analysis of the system, which are shown in Graph 5.9. This analysis shows the gradual reaction of each variable to shocks coming from the others when all the relationships in the system are considered. Therefore, it allows the observation not only of the long-term effects that are reflected in the estimates of Table 5.4, but also of the short-term relationships among the variables.[331]

Graph 5.9
Impulse-response analysis



[331] To carry out this analysis, the usual ordering of the variables from the most to the least pervasive has been applied. According to the results of the Wald tests in Table 5.4, the selected order has been: 1) industrial production, 2) machinery investment, and 3) infrastructure investment. However, given the low level of the correlation coefficients among the residuals of the equations of the system, the selected order is not likely to change the conclusions of the analysis.

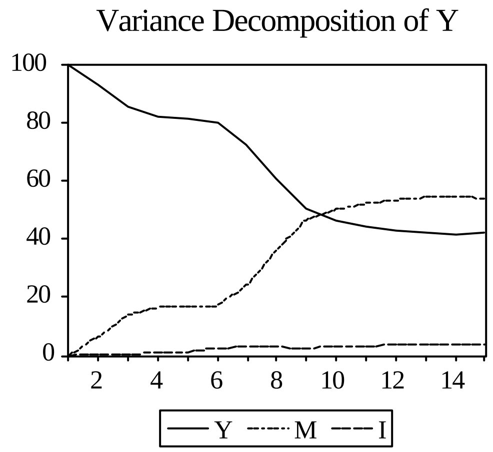
These graphs show that the impact of machinery investment on industrial production was clearly positive in the short term, reaching its maximum level three years after the shock. However, this unmistakable positive impact was overcome in the medium run by an influence in the opposite direction, which helps to explain the estimation results presented in Table 5.4. That process seems to be directly related to the behaviour of machinery investment. As can be observed in the graphs, and unlike the other two variables, the response of machinery investment to its own shocks is positive at first but highly negative after seven years. This could be the result of the violence of investment fluctuations, or the consequence of some sort of overshooting dynamics. Whatever the reason, the intensity of that process dominates the response of the other two variables to shocks coming from machinery investment after six years. So, the apparent lack of positive influence of machinery investment on growth in the estimates presented in Table 5.4 seems to be a statistical by-product of the anomalous behaviour of this variable.

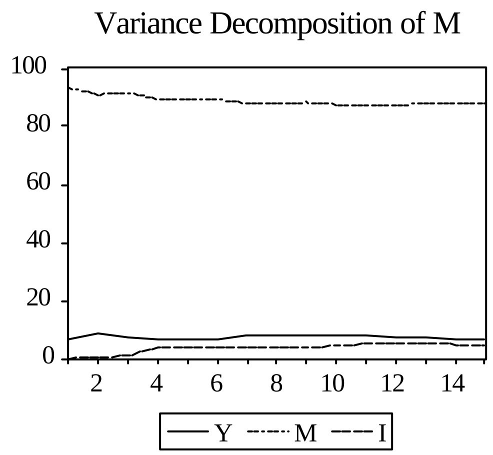
The graphs also confirm the importance of production in the short-term evolution of infrastructure investment, which was already pointed out in Section 5.2 and corroborated by the estimates in Table 5.4. And, finally, they also show the total absence of positive impacts of infrastructure investment either on industrial production or on machinery investment, in the short or in the long run. Therefore, the growth impact of infrastructure, which was the main interest of the exercise, turns out to be absent from the estimation outcomes. Obviously, this result should not be interpreted as a sign that infrastructure increases were immaterial to the process of Spanish economic growth, but instead as an evidence of the inability of the VAR system to capture their effects. In the last analysis, this would indicate that the growth impact of Spanish infrastructure was too low and slow to be observable in the model estimates.

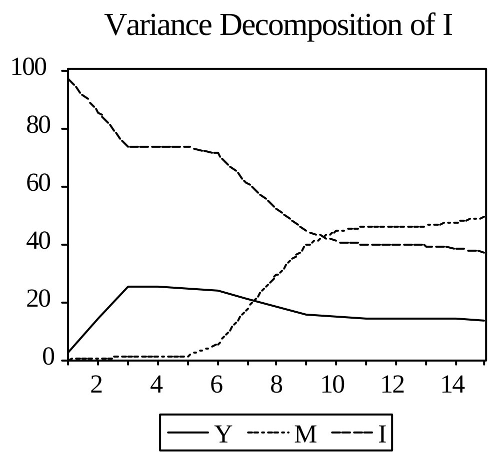
Finally, Graph 5.10 offers the variance decomposition analysis for the three variables of the system. In other words, it shows the shares of the movements of each series that are provoked by its own shocks and by shocks in the other variables.[332]

[332] The same order of variables as in the impulse-response analysis has been applied.

Graph 5.10
Variance decomposition of the variables







The results of this analysis are consistent with previous considerations. Starting with industrial production, most of its forecast error variance is explained by its own lags in the first years, as is usual in variance decomposition analysis. However, as time goes by, an increasing share is accounted for by machinery investment. Although the meaning of that influence is not clear from the seventh period, due to the anomalous behaviour of the model that has been detected in the Impulse-Response graphs, before the seventh year the variance analysis confirms the importance of machinery investment in the short-to-medium run evolution of industrial production.

On the other hand, machinery investment shows a much higher degree of autonomy than industrial production during all the time horizon, which is consistent with its anomalous influence on the behaviour of the whole system. And, finally, regarding infrastructure investment, the analysis confirms the importance of production in its short-run variation, as well as the prominence of machinery investment from the sixth or seventh year, although this second result must be interpreted cautiously.

5.4 Conclusions

This chapter has examined the relationships between infrastructure investment and the main variables of the Spanish economy. The analysis has been carried out in two stages. Firstly, the short-term fluctuations of infrastructure investment, production and machinery investment have been compared. As a result, infrastructure investment has been found to follow with some lag the evolution of Spanish GDP during the period under study.

Secondly, a VAR system with three equations corresponding to infrastructure investment, industrial production and machinery investment has been estimated, in order to investigate the presence of causal relationships among those variables both in the short and in the long term. Unfortunately, several shortcomings of the exercise raise some doubts about the outcomes of the estimation. Firstly, labour is absent from the system due to the lack of sufficient data. Secondly, in the case of infrastructure and machinery, capital stock has been replaced by investment, due to the time-series properties of the series, which prevent the estimation of a system that combines stock and production variables. Thirdly, the system has resulted highly sensitive to the violent behaviour of machinery investment and, as a consequence, some actual relationships may have been disguised in the final estimates.

Keeping these problems in mind, as far as infrastructure is concerned the estimation has provided two main findings. On the one hand, as the short-term analysis had previously shown, infrastructure investment seems to have responded closely to output fluctuations, in a Wagner's Law-type process. On the other hand, the model is totally unable to capture the impact of infrastructure on Spanish economic growth. This anomalous result admits several possible interpretations. Obviously, it might be associated with the features of the infrastructure building cycle. The lack of coincidence between the railway construction waves and the behaviour of the whole economy during the last decades of the nineteenth century might have made it difficult for the model to capture structural relationships between the variables.

However, the incapacity of the model to reflect the growth impact of infrastructure might also indicate that this impact was too low and took place too slowly to be captured by standard time-series analysis. There are several reasons that might explain the hypothetical low level and slowness of the impact of infrastructure on growth. On the one hand, as has been repeatedly indicated, the numerous mistakes in the design, regulation and management of infrastructure that have been described both by contemporaries and historians might have substantially reduced its growth effects. But, on the other hand, the slowness of the impact might also reflect that infrastructure was not acting as a binding constraint for Spanish economic development. In other words, during the period under study other shortcomings might have had a stronger influence on Spain's economic growth than the apparent shortage of some types of infrastructure that was described in the previous chapter, and might therefore have prevented the economy from reacting quickly to infrastructure increases.

In fact, the inability of the model to capture the growth impact of infrastructure in Spain might be considered as an extreme expression of what happened in the case of the Netherlands. The results of the aforementioned model for that country indicate that the impact of infrastructure increases on Dutch economic growth only peaked three to five years after the investment had taken place. In order to interpret that outcome, the authors of that exercise decomposed the medium-term growth impact of infrastructure increases into a positive influence, the so-called "forward linkages" (i.e. the reduction in costs brought about by new infrastructure), and a negative one, the so-called "transitional dynamics" (which would reflect the costs of adapting the economic system to structural changes).[333]

[333] Groote et al (1999), p. 242-246. The concept of transitional dynamics is also suggested in Button et al (1995), and is similar to the notion of costs of adjustment to infrastructure increases, which is described, for instance, by Lakshmanan (1989), p. 245, or Capello and Gillespie (1993), p. 44.

The concrete time pattern of the growth impact of infrastructure increases (in other words, the shape of the Impulse-Response graphs) would depend on the relative timing of each one of these two components.

"Transitional dynamics" may be related to the costs of relocation of economic activity, and also to phenomena such as crises in the industries of the less developed regions when they are connected to more advanced areas. Obviously, it would be expected to be larger in the case of the construction of a new system, such as the railway network. The presence of that negative effect explains the low level of the growth impact of Dutch infrastructure in the very short-term. In that country, the strength of "transitional dynamics" partially overcame the short-term benefits of cost reduction, especially during the first two to four years after the construction of new assets.

Indeed, in a country with a lower level of development than the Netherlands, the costs of adaptation of the economy to the availability of new infrastructure had to be higher. Due to the presence of growth constraints of different kind in the economy and to the subsequent lack of incentives, Spanish investors would have been much slower to adapt to new situations. In that context, "transitional dynamics" would have overcome the "forward linkages" of new infrastructure during a much longer period of time. And this may help to explain why the results of the estimation of a VAR system with a limited time perspective do not show any positive impact of infrastructure increases on production.[334]

In summary, the outcomes of the analysis that has been carried out in this chapter may be explained on two grounds. On the one hand, the inadequate design, regulation or management of infrastructure might have reduced or delayed the fulfilment of their growth impact. And, on the other hand, infrastructure might not have acted as a growth binding constraint during the period under study, in spite of the relative shortage of some assets, due to the higher importance of other limits to economic growth. These two problems, however, would be to be found in very different degrees among different types of infrastructure. It must be kept in mind that the estimates that have been presented in this chapter are just average indicators of many different relationships. They mix the growth impact of those types of infrastructure that act in a rather immediate way, such as urban transport, with the effects of some assets that may take many decades to reach their

[334] However, it does not seem convenient to expand the lag length of the VAR system, because this expansion results in a substantial worsening of the behaviour of the estimation residuals.

maximum potential impact, such as irrigation systems. As has been indicated in Section 5.1, an adequate understanding of the reasons for the hypothetical low level and slow character of the growth impact of Spanish infrastructure may only be obtained by adopting a sectoral perspective and by analysing the specific features of each component of infrastructure stock. Chapters 6 and 7 constitute an initial step in that direction, and suggest some hypotheses on the growth impact of the Spanish railway system, which was the country's most important infrastructure during most of the period under study.

CHAPTER SIX

THE IMPACT OF RAILWAYS ON THE SPANISH ECONOMY BEFORE 1936

6.1 Introduction

This chapter reviews the evidence on the economic impact of Spanish railways before the Civil War of 1936-1939. It constitutes a first step towards a more disaggregated study of Spanish infrastructure, which may help to explain the negative outcomes of the growth analysis that was carried out in Chapter 5. Out of the total infrastructure stock, railways have been selected because they were the most important part of Spanish infrastructure during most of the period under study, and also because they have been a privileged object of attention for historians.

As was described in Chapter 1, the early highly pessimistic historical analyses of the Spanish railway system were followed in the 1980's by a much more optimistic perspective coming from Antonio Gómez Mendoza's research. Among other contributions, this historian provided estimates of the social saving of the Spanish railway freight transport for the years 1878 and 1912. The figures he obtained were remarkably high compared with the available estimates for other European countries. This result was considered by the author as evidence of the strongly positive impact of railways on nineteenth century Spanish economic growth, and was attributed to the high dependence on roads that would have characterised the Spanish transport system in the absence of railways. The lack of alternative transport means would already have given rise to serious bottlenecks in the Spanish economy by 1850 and would also have caused freight transport to be extraordinarily expensive after that date in a hypothetical counterfactual economy without railways.

Spanish historians, however, have been rather reluctant to accept Gómez Mendoza's main conclusions. Some of them observe a contradiction between his high social saving estimates and the poor private returns of the Spanish railway companies. In Tortella's words, for instance:

> "*the question must be raised that, if transport was so badly needed and its shortage was constraining growth, why demand was so insufficient, traffic so scarce, and financial results so poor once railway lines and networks had been constructed*."[335]

According to Tortella, the low density of use of the lines and the financial failure of the companies constitute powerful evidence that the economic effects of the Spanish railways were lower that expected. Although recognising that the potential benefits of the railway system were very high, he insists that a number of factors, such as the poverty and excessive dispersion of Spanish markets or the State's mistakes in the regulation of railway construction, prevented the complete fulfilment of that high potential. As a result, although so far virtually no technical criticisms have been made of Gómez Mendoza's social saving estimates, they have been said to be unlikely, and much closer to potential benefits than to the real economic impact of the railway system.[336]

However, the companies' poor financial results do not prove that the economic impact of Spanish railways was lower than expected. As Sánchez de Toca pointed out in 1917:

> "*(…) even in those lines (…) without enough traffic to pay back the invested capital (…) the State's gain in cheapness and improvement of public services (…)*

[335] Tortella Casares (1999), p. 250 (my translation).
[336] Ibidem, pp. 250-253. See also Comín Comín et al (1998), Vol. 1, pp. 140-141.

may be enormous, and the benefits spread over the economy that travels on them even higher".[337]

Actually, even in the case of unprofitable railway companies, the gains accrued to transport users could have been very substantial, as has been pointed out in the case of England and Wales.[338] And, in addition, the railway system could also have made some external economies available to people or firms acting as other than transport users or producers.[339]

In that context, this chapter aims at testing Tortella and other historians' hypotheses on the low impact of Spanish railways and the implausibility of Gómez Mendoza's social saving estimates not through the analysis of the companies' performance, but by reviewing direct evidence on the overall economic effects of the railway system.

The chapter is organised as follows. Firstly, Section 6.2 reassesses Gómez Mendoza's social saving estimates and suggests a number of possible adjustments, which result in lower figures. This outcome would be inconsistent with the importance of road transport in a counterfactual Spanish economy without railways, and Section 6.3 tries to account for that inconsistency. Finally, Section 6.4 combines the results of the social saving analysis with other evidence, in order to offer a more complete picture of the economic impact of Spanish railways. The main conclusions of the chapter are summarised in Section 6.5.

6.2 The social savings of Spanish railway freight transport: alternative estimates

In the last few decades, estimates of social savings have often been used as an indirect approach to the impact of a technological innovation on economic growth. In the case of railways, social savings can be defined as the additional cost of transporting a country's railway output of one year by the next best alternative means. This measure is claimed to provide an indicator of the resource saving brought about by railways. It is actually an upper bound of the real resource savings, since the elasticity of transport demand is assumed to be zero in the estimation, and the

[337] Sánchez de Toca (1917), p. 48 (my translation).
[338] Hawke (1970), p. 360.
[339] Ibidem, p. 381. In Robert Fogel's words: "*an investment which is unprofitable for the firm can be strategically important for the growth of the economy -for the increase in per capita income- only if it*

volume of output is therefore fixed at the level that it had in the railway economy.[340] Although social savings constitute just a preliminary approach to the growth effects of the railway system, their use in railway history has been widespread, because they provide a comparable indicator both of the economic impact of railways and of the reduction in transport barriers within a country.[341]

In the case of Spain, in the early 1980's Gómez Mendoza estimated the social savings on freight transported by Spanish railways for the years 1878 and 1912.[342] As a result of his exercise, he offered several alternative figures. Firstly, he presented an "interim" estimate, according to which railway social savings would have amounted to 516.4 million pesetas in 1878 and 2,336 million pesetas in 1912, i.e. 11.8 per cent and 18.5 to 23 per cent of Spanish national income respectively.[343] Secondly, he corrected the 1878 estimate for the presence of idle resources in the economy,[344] in two stages. In the first one, which he called the "inventory solution", he assumed that, in the absence of railways "*any increase in the level of transportation demand will be entirely satisfied by the pool of unemployed peasant carriers*".[345] This assumption reduced the opportunity cost of road transport in the counterfactual economy and, as a consequence, brought the social saving estimate down to 40.3 million pesetas in 1878, i.e. 0.92 per cent of national income.[346] In the second stage, which he called the "intermediate solution", he assumed that the transport demand generated by the closure of railways would be supplied by unemployed carriers only during the four off-peak months of the agricultural working year in which men and animals were idle. In that case, which the author

---

simultaneously serves to increase the productivity of labor and capital in firms other than the one in which the investment is made"; Fogel (1960), p. 94

340 See Fogel (1979), p. 5.

341 On the differences between the social savings and the "true" growth impact of railways, see below (Section 6.4).

342 Gómez Mendoza (1981), pp. 25-114. Before this author's research was published, Casares Alonso (1973), pp. 367-377, carried out an estimate of the social savings on freight and passengers transported by Spanish railways. However, his attempt was based on insufficient or wrong information on output and transport costs and, therefore, cannot be compared with Gómez Mendoza's work.

343 Gómez Mendoza (1981), pp. 67-71. In further publications, those amounts were increased, due to a higher estimate of the carting rate and a correction of the 1878 railway output, to 535.8/536.2 and 2,425 million pesetas respectively, i.e. 11.9 per cent of national income in 1878 and 19.2 to 23.7 per cent in 1912; see Gómez Mendoza (1982), pp. 94-96, and Gómez Mendoza (1989a), pp. 195-196. The transport of freight at high speed (perishables, excess luggage, etc.) and livestock is excluded from those estimates.

344 The problem of the presence of idle resources for the estimation of social savings was stressed, in the case of the Mediterranean countries, by Toniolo (1983), and had previously been raised from a more general point of view by Fogel (1964), pp. 108-109, and Fishlow (1965), p. 30.

345 Gómez Mendoza (1981), p. 79.

346 Ibidem, p. 95.

considered to be the most likely, resource saving due to the introduction of railways came to 326 million pesetas or 7.5 per cent of Spain's national income in 1878.[347]

Gómez Mendoza warned that, especially in the case of the last two estimates, those figures should be increased by the indirect costs associated with holding higher stocks in the non-railway economy. He estimated those costs in the case of the coal transported by the two main railway companies (*Norte* and *MZA*) and, on the basis of that example, concluded that indirect costs would have been insignificant in the "interim" and "intermediate" cases and would have increased the "inventory" estimate only by 7.7 per cent.[348]

According to these results, if the "interim" or (in the case of 1878) the most likely "intermediate" solution are considered, Spain would rank among the countries with a highest ratio of railway social savings to GDP both in 1878 and in 1912. As may be observed in Table 6.1, only the percentages for Mexico in 1910 and Brazil in 1913 would be higher than the Spanish ones.[349] The high level of social savings in Spain was attributed to the prominence that roads would have had in a counterfactual Spanish transport system without railways, unlike the situation in other countries with a better endowment of navigable rivers or with better possibilities for canal construction and coastal trade.[350] And Gómez Mendoza himself used his social saving estimates to refute some historians' claims that the resources devoted to the construction of Spanish railways had been excessive.[351]

---

[347] Ibidem, pp. 89 and 95.
[348] Ibidem, p. 94.
[349] Figures in Table 6.1 are not totally comparable due to differences in the estimation methods. For instance, Fogel's estimate for the US in 1890 is the only one to allow for improvements in alternative transport infrastructure in the absence of railways, which brings his percentage downwards relative to the others. On the other hand, in the case of the least developed countries in the table, whereas the Spanish estimates are corrected for the presence of idle resources in the economy, the Mexican, Brazilian and Colombian ones are not, and may therefore contain serious upward biases for this reason. Finally, the French figure is just the result of a very preliminary calculation, and no information is available on the methods followed to elaborate the Belgian one.
[350] See Fogel (1964), p. 31, and O'Brien (1983b), pp. 12-13.
[351] See, for instance, Gómez Mendoza (1989a), p. 196.

Table 6.1
Estimates of social savings on freight transported by railways

	Date	SS expressed as a share of GNP (%)
Belgium	1846	1
US	1859	3.7
US	1890	4.7
England and Wales	1865	4.1
Russia	1907	4.5
France	1872	5.8
Colombia	1927	3.4/7.9
Spain	**1878**	**7.5**
Spain	**1912**	**18.5/23**
Brazil	1886	4.5
Brazil	1913	22
Mexico	1910	24.9/38.5

Sources: For England and Wales, Hawke (1970), p. 196; for the US in 1859, Fishlow (1965), pp. 37 and 52; for the US in 1890, Fogel (1964), p. 223; for Russia, Metzer (1977), p. 50; for France, Caron (1983), p. 44; for Spain, Gómez Mendoza (1981); for Belgium, Laffut (1983), p. 221; for Mexico, Coatsworth (1979), p. 952; for Brazil, Summerhill (1997), p. 104; and, for Colombia, Ramírez (2001), pp. 89-91.

Despite their reluctance to accept Gómez Mendoza's main conclusions, Spanish historians have not raised major criticisms on the technical details of the estimation so far.[352] However, since the outcomes of that research were published a great deal of additional information about the Spanish economy has become available, which enables the social saving figure to be revised. In this section, I suggest three possible adjustments to the original Gómez Mendoza's estimates, in terms of the railway and road transport rates that he used in his calculations and the GDP data with which his estimates were compared.

[352] The only exception is Barquín Gil (1999), who has suggested an alternative social saving figure for 1878 of 1.3 per cent of Spanish national income. The main difference between Barquín Gil's and Gómez Mendoza's estimations is that the former allows for the re-routing of transport flows in the counterfactual economy without railways, by assuming that traffic between two points would take the most economic combination of road and water transport, even if it meant a longer distance than the direct road connection. Although Barquín Gil's assumption reduces the comparability of his figure (because most available estimates do not make that allowance), it is acceptable from a conceptual point of view; see Fogel (1964), pp. 26-27. However, in order to find out which would have been the hypothetical re-routing of flows in the counterfactual economy, it is necessary to know the actual distribution of railway transport among different routes in the actual economy. As this information is not available, Barquín Gil assumes that the transport flow between each pair of Spanish provinces was proportional to their population. This leads him to assume for 1878 a much longer average haul for freight railway transport than the actual one, because he ignores the effect of distance on the level of interprovincial trade. In addition, he also assumes too intense trade relationships among coastal provinces, because the Spanish periphery was much more densely populated that the interior. Both assumptions increase the potential for the replacement of railways by coastal transport (instead of roads) and, therefore, bring downwards the social savings figure. However, both of them are equally unlikely, because interprovincial trade also depended on distance and the economic structure of each area.

1. Railway rates/marginal costs.

As Gómez Mendoza indicated in his estimation exercise, in Spain "*railway rates were determined through monopolistic considerations rather than pure competition*."[353] Monopolistic situations were predominant in the Spanish railway system due to the low density of the network, which excluded the possibility of overt competition on most routes. In addition, in those few cases where competition was possible, collusion between companies may be traced back to the 1870's.[354] Accordingly, Spanish railway market rates cannot be assumed to have coincided with transport marginal costs and, therefore, cannot be used to calculate the social saving.[355]

As a substitute, Gómez Mendoza resorted to the so-called "internal rate" of the two main railway companies (*Norte* and *MZA*), which they used to book in their accounts the conveyance of goods for their own use. The average values of the market and the "internal" rates per ton-km in those two companies were, respectively, 0.085 and 0.022 pesetas in 1878 and 0.071 and 0.015 pesetas in 1912.[356]

However, there is no guarantee that "internal" rates reflected the actual level of marginal costs, since nineteenth century railway companies' accounting practices excluded the possibility of properly estimating the marginal cost of their production.[357] In this context, an alternative way to approach the level of railway marginal costs is the estimation of cost functions,[358] whose basic form is:

$$C = C\ (Y, W, T),$$

[353] Gómez Mendoza (1981), p. 45.
[354] Collusion was only broken in some routes during short periods of time, e.g. in the link between Madrid and Bilbao in the years 1865-1875, or in the route Barcelona-Saragossa in 1895-1896. Both competitive situations came to an end thanks to formal agreements between *Norte* and *MZA* in 1875 and 1896. On this subject see Casares Alonso (1973), p. 123, Comín Comín et al (1998), Vol. 1, pp. 216-217, or Pascual Domènech (1999b), pp. 465-469.
[355] Actually, oligopolistic strategies were not the only reason for market rates to be different from marginal costs. In addition, public regulation and subsidies also led the final level of railway rates to behave independently of cost considerations.
[356] Gómez Mendoza (1981), p. 70.
[357] This problem is described in Thompson (1991), pp. 2-5, who indicates that nineteenth century companies' calculations of marginal costs tended to be far under-estimated; see also Hawke (1970), pp. 290-291.
[358] This alternative is suggested by Fogel (1979), p. 21.

where C is cost, Y is the vector of outputs, W is the vector of input prices and T is time, which is a proxy for the growth of efficiency due to technological and organisational change. In the case of railways, however, cost per unit of output depends not only on factor prices, the level of efficiency and the level of production, but also on certain characteristics of each company's network, such as the average haul or load. It is therefore usual to include in the function additional variables to represent the effect of those characteristics.[359]

The estimation of such a function allows the decomposition of changes in railway costs into its different sources: price variations (through the coefficients of W), growth of output (through the coefficients of Y) technical progress (through the coefficient of T) and changes in network characteristics. In addition, it also allows the calculation of marginal costs, since the estimates of the output coefficients can be considered as cost elasticities at the sample mean.[360] Finally, under that specification it is also possible to estimate the level of returns to density in the railway system. They measure the cost effect of an increase in output, holding all other factors (including network characteristics) constant, and are usually calculated as the inverse of the sum of all cost elasticities with respect to different outputs. Returns to density calculated in that way constitute an indicator of the opportunities to reduce cost through increased use of the network.[361]

Table 6.2 reports the results of the estimation of a generalised translog multiproduct cost function for an unbalanced panel of Spanish broad gauge railway companies during the period 1858-1935.[362] The sample, the sources of information and the complete set of estimates are offered in the Appendix. The endogenous variable is each company's yearly variable cost, and network length has been included among the explanatory variables to proxy the level of the quasi-fixed inputs.[363] Although network length does not coincide with the value of the companies' capital stock, it has often been used as a proxy variable for it, especially in those cases, such as

[359] Caves et al (1985), pp. 100-101.

[360] See Oum et al (1999), pp. 25-26, or Caves et al (1985), p. 106.

[361] The main reason for the presence of returns to density in railways lies in the economies in the use of train, labour and equipment that they provide; on this subject see Keaton (1990), p. 212.

[362] In the estimation of cost functions, a translog specification is usually preferred because it provides a much more general representation of the cost structure than the Cobb-Douglas framework; see Dogdson (1993), pp. 163-164.

[363] Although the use of variable costs is more adequate than the use of total costs in productivity analysis, the exclusion of capital costs must be accounted for by including among the explanatory variable a measure of the quasi-fixed inputs. Otherwise, coefficients might be biased, because output elasticities estimated from a cost function which excludes capital costs will only be the same as if capital costs had been included if the production function is homothetic; see Dogdson (1993), p. 160.

the current research, in which the necessary information on each company's assets is incomplete.[364]

The network characteristics of each company are represented by individual dummies.[365] However, in a sample such as the current one, with very small and very large companies, there may be a high level of collinearity between, on the one hand, the individual dummies and, on the other hand, the companies' level of output and/or network length. As a consequence, company dummies may be capturing part of the cost variation which would be explained by other variables.[366] To account for this problem, two different specifications of the model are estimated. The first one includes individual dummies and the second one excludes them. The "true" value of the coefficients would probably be somewhere in between the two estimates.

In summary, the estimated model is:

$$\ln C = \beta^{0} + \beta^{T}T + \Sigma\beta^{Y}\ln Y + \beta^{N}\ln N + \Sigma\beta^{W}\ln W + \tfrac{1}{2}\,\Sigma\Sigma\beta^{YY}\ln Y\ln Y + \tfrac{1}{2}\,\beta^{NN}\ln N\ln N + \tfrac{1}{2}\,\Sigma\Sigma\beta^{WW}\ln W\ln W + \Sigma\beta^{YN}\ln Y\ln N + \Sigma\Sigma\beta^{YW}\ln Y\ln W + \Sigma\beta^{NW}\ln N\ln W + (F),$$

where Y represents output, W factor prices, N network length and F is a set of individual dummies which are only included in the first specification. Estimates in the table are feasible generalised least squares robust to the presence of cross-section heteroskedasticity.

[364] See, for instance, Winston (1985), p. 63.
[365] See Caves et al (1985), pp. 100-101.
[366] Oum et al (1999), pp. 26-27.

Table 6.2
Generalised translog cost function of Spanish broad gauge railways (1858-1935)

	(1) Fixed effects	(2) No fixed effects
Nº Obs.	1,056	1,056
Adj. R^2	0.99	0.99
Time	0.009**	0.001
	(8.828)	(1.054)
Ton-km	0.905**	0.730**
	(4.935)	(3.915)
Passenger-km	0.079	0.164
	(0.486)	(1.056)
Network length	-0.815**	-0.521**
	(-5.930)	(-4.752)
Labour price	2.502**	1.230**
	(4.471)	(2.603)
Coal price	0.055	0.368
	(0.154)	(1.011)
Iron price	0.443	0.037
	(1.803)	(0.142)
RTD	1.016	1.114

* 5 per cent significance level.
** 1 per cent significance level.
t-ratios in brackets.

Some of the results in Table 6.2 are anomalous, but it is difficult to know if they reflect the true cost structure of the companies in the sample or result instead from the bad quality of the data and the shortcomings of the specification. Firstly, the time coefficient is positive (although non-significant in the second specification), which indicates a negative rate of technological change. Actually, this coefficient would be expected to be small but negative. Although technology in the railway sector did not suffer major changes between the 1870's and the general adoption of electric power,[367] there were some opportunities to increase efficiency through the companies' agreements to share infrastructure or rolling stock, the use of steel instead of iron rails, and increases in locomotive power or in car capacity.[368]

[367] See, for instance, Hawke (1970), p. 312, or Cordero and Menéndez (1978), pp. 282-283.
[368] See, for instance, Wellington (1898), pp. 113-114, Fishlow (1965), p. 56, and (1966), pp. 634-642, or O'Brien (1983b), p. 11. On the benefits of alliances among companies in the field of productivity, see also Pratt (1908), pp. 396-398, Cain (1972) or Irving (1978), p. 65.

All those three aspects experienced certain progress in the Spanish railway system during the period under study and, therefore, *ceteris paribus*, productivity should have been growing slightly as time went by.[369] In this context, a possible explanation for the positive coefficient of the time variable would be a very high rate of depreciation in the Spanish railway system, which might be associated with the fact, often regretted at the time, that the companies' financial problems prevented them from undertaking a sufficient rate of renewal investment.[370]

The factor price coefficients have the expected sign. However, only in the case of labour is the coefficient significantly different from zero, which would indicate that this variable captures all the effect of cost inflation. On the other hand, the network length coefficient, which is intended to approach the value of the quasi-fixed inputs of each company, is significant and has the expected sign.

Both output coefficients are positive as expected. However, in the case of passenger transport the coefficient is not significantly different from zero, which is an extreme expression of the usual greater importance of freight in the determination of railway costs.[371] Output coefficients also reflect the presence of returns to density in the railway system, which are in line with those obtained for other historical or present economies.[372] They show therefore some opportunities to reduce costs by increasing the density of traffic. Given the apparently low impact of technological change on the reduction of costs, the evolution of traffic density turns out to be a key variable in the growth of the Spanish railway productivity.

---

[369] Spanish companies tried to increase productivity by different means. Firstly, by the substitution of steel for iron rails, which was widespread in Spain in the 1870's and 1880's; see Gómez Mendoza (1982), pp. 126-129. Secondly, by increases in locomotive power, although these could not be taken advantage of completely due to deficiencies in carriages, wagons and track; see Cordero and Menéndez (1978), pp. 286-287, Comín Comín et al (1998), Vol. 1, pp. 102-106, and Boag (1923), p. 2. Finally, by companies' mergers and takeovers; see especially Tedde de Lorca (1996), pp. 277-279. However, the effects of this last aspect seem to have been very moderate in Spain. On the one hand, most technical characteristics, such as signalling or tunnel height, remained different among companies or even among the lines of a single company when part of them had been acquired from other firms. On the other hand, attempts to co-ordinate operation between the largest companies were numerous, but still in 1933 they were said to be insufficient. On these problems, see Cordero and Menéndez (1978), pp. 187-320.

[370] On this issue, see below (Section 7.3). A negative rate of technological change has also been found for the European railway systems in 1969-1993 by Andrikopoulos and Loizides (1998), pp. 1633-1635, who have partially attributed it to the advanced age of equipment.

[371] See, for instance, Foreman-Peck (1990), p. 79, Dogdson (1993), p. 167, or Caves et al (1985), p. 107.

[372] See Winston (1985), pp. 66-68, Oum and Zhang (1997), p. 313, or Foreman-Peck (1987), p. 113 (note that the concept of returns to density as is presented in the text is close, although not equivalent, to Foreman-Peck's concept of returns to scale).

As has been indicated before, output elasticities allow inference of the marginal costs of the Spanish railway system at the sample mean. The results of that calculation are presented in Table 6.3. Figures in the table, however, are only a proxy for the actual ones, for two reasons. Firstly, the cost function that has been estimated only refers to broad gauge railways, which might have introduced minor biases in the estimate for 1912, since in that year the narrow gauge network had already experienced a substantial development. Secondly, and more importantly, the output coefficients in the cost function are elasticities at the sample mean. Actually, elasticities may have varied throughout the period according to factors such as the level of output, input prices, time or even the regulatory regime. Therefore, figures in the table may contain certain biases of an unknown direction and magnitude.[373] This shortcoming might have been overcome, to some extent, by estimating the model for shorter periods, through which the conditions of operation of railways were more homogeneous. However, the worsening in the efficiency of the estimation when shorter samples are considered has prevented advances in that direction.

Table 6.3
Cost elasticity, average cost and marginal cost in Spanish railway freight transport

Year	Cost Elasticity	Average Cost (pesetas/ton-km)	Marginal Cost (pesetas/ton-km)	Market Rate (pesetas/ton-km)	"Internal" Rate (pesetas/ton-km)
1878	0.730/0.905	0.069	0.050/0.062	0.085	0.022
1912	0.730/0.905	0.053	0.039/0.048	0.071	0.015

Sources:

- Cost elasticity: my own figure (see Table 6.2).
- Average variable cost per unit of freight output: for output, Gómez Mendoza (1981), p. 70; for aggregate variable cost, *MAEOP*.
- Marginal cost = Cost elasticity x average cost.
- Market rate and "Internal" rate: Gómez Mendoza (1981), p. 70.

The resulting marginal cost estimates are, in both cases, higher than the "internal" rate, although still lower than the market rate, which is consistent with the lack of competition in the sector. Therefore, according to the estimation results, the use of "internal" rates to represent the level of railway marginal costs might be misleading and a higher rate would be more appropriate.

[373] On this problem, see Andrikopoulos and Loizides (1998), p. 1630, and Wilson (1997), p. 35.

2. Road transport prices.

As has often been pointed out, one of the main drawbacks of social saving calculations is the difficulty to find "*sufficient information on tariffs charged by road and water transport which could pass any of the standard tests applied to representative samples of data or to averages derived from such samples*".[374] In the case of Spain, that problem mainly affects road transport, since most railway output would have shifted to roads in the counterfactual economy.

Unlike railways, it is possible to use market prices of road transport as representative of marginal costs, since the sector had a competitive business structure at the time.[375] Unfortunately, information on Spanish road transport prices for the late nineteenth and early twentieth centuries is very scarce, and assumptions on the their level in the counterfactual economy must be based on incomplete data.[376] In the case of Gómez Mendoza's research, the main source of information was a nation-wide questionnaire carried out in 1884 on the prices of wine transport by road.[377] From that information, Gómez Mendoza estimated the level of road transport rates in the counterfactual economy as 0.79 pesetas per ton-km in 1878 and 0.84 in 1912. Although the 1884 report only contained information on transport of wine, Gómez Mendoza considered those rates applicable to all commodities, because rates for wine were in a central position within the rate spectrum of one of the main railway companies (*Norte*). From his point of view, since the composition of freight transported in the counterfactual economy had to be the same as in the real economy, wine rates could also be assumed to be in a mid position among the counterfactual road transport rates.[378]

Nevertheless, the assumption that the price of wine transport by road is representative for all commodities on the basis of its position in the ranking of railway rates is difficult to sustain. Actually, that ranking may have been very different for railways and roads, due to the technical

[374] O'Brien (1977), p. 113; see also Fogel (1979), pp. 14-29.
[375] See Gómez Mendoza (1989a), p. 194. The most important source of divergence between market prices and marginal costs is associated with the costs of road construction, which were paid by the public sector and only partially included in the carriers' cost function through taxes on traffic (*portazgos*) before 1869 and (although only over some highways) in 1877-1881; see Gómez Mendoza (1981), p. 72, and (1999a), p. 724. However, some authors consider that the capital costs of alternative transport means must not be included in the social saving calculation, because they would have been met anyway, even if the railway network had not been closed as the counterfactual economy assumes; see especially McClelland (1972), p. 475.
[376] The absolute lack of information on Spanish road transport during the second half of the nineteenth century has been stressed by Frax Rosales and Madrazo (2001), pp. 39-40.
[377] See Gómez Mendoza (1981), pp. 57-66 and 111-112.

differences between those two transport modes, and also because railway companies, unlike road carriers, did not establish their market rates according to marginal costs, but tried to favour certain transport flows. In fact, Gómez Mendoza himself recognised that the rates of wine transport by road could be higher than for other commodities at the time.[379] The use of those rates therefore constitutes a possible source of upward biases in the counterfactual exercise, and makes the estimation of alternative figures appropriate. However, this is not an easy task, due to the inadequacy of the available information, and all suggested corrections can only be rough and provisional.

The main commodities carried by Spanish railways in the years under study were wine, grain and coal.[380] For wine, the 1884 questionnaire that was used by Gómez Mendoza may be accepted as the highest-quality source among the available ones. Its main problem is that it reports carrying rates for hauls under 74 km in the case of pack animals and under 89 km in the case of carts.[381] These are much shorter distances than the average haul of railway transport in 1878 and 1912, which was, in the case of *Norte* and *MZA*, 247 and 157 km respectively.[382] As the unit cost of road transport decreased with distance,[383] it is not clear to what extent the figures in the questionnaire are relevant for the flows involved in the counterfactual exercise. In addition, the questionnaire information relates to secondary roads that fed railway stations, which may be assumed to have been lower quality than those highways that ran parallel to railway lines and that would have received the traffic shifted from railways to the road system in the counterfactual economy. Gómez Mendoza's rates may therefore be considered as an upper bound of the counterfactual wine rates, but the lack of alternative information prevents attempts to reduce the possible upward biases.

Regarding commodities other than wine, the largest available amount of information on road transport in the nineteenth century relates to grain. On the contrary, evidence available on coal transport prices is very scarce. In the case of grain, Santos Madrazo, using information on

---

[378] Ibidem, p. 61.
[379] Gómez Mendoza (1982), p. 90.
[380] See, for instance, Comín Comín et al (1998), Vol. 1, pp. 225-238.
[381] Gómez Mendoza (1981), p. 111.
[382] See sources for *Norte* and *MZA* hauls in the Appendix of this chapter. Actually, individual companies' hauls understate the actual average haul of the Spanish freight railway transport, because they do not allow for the transhipment of goods among companies; see Gómez Mendoza (1981), p. 36.
[383] Ibidem, p. 60.

four routes that ran between the coast and the interior of the country, estimated the average rate of long-distance road transport at 0.41 pesetas per ton-km by the mid-nineteenth century. This figure is consistent with those provided by other researchers,[384] and has therefore been used here as representative of the rates for grain transport in the counterfactual economy. Its main drawback is the fact that it comes from a period several decades before the years of the counterfactual exercise and, therefore, does not include the effect of changes in prices or in the quality of the road system after 1850.[385] However, it has been accepted here due to the lack of information on road transport prices during the railway age.

A weighted average of Gómez Mendoza's wine and Madrazo's grain rates has been calculated according to the shares of grain and wine in the freight transport of the two main railway companies in 1878 and 1912. The resulting road market rates are 0.54 and 0.60 pesetas per ton-km respectively, which have been incorporated to the social saving calculation.[386] However, it must be stressed that road rates constitute the weakest part of both Gómez Mendoza's and my own social saving estimation exercises, and that the new rates are only intended to reduce to some extent the size of the upward biases that may have affected that author's estimates.

3. GDP figures.

Gómez Mendoza based his calculation for 1878 in Mulhall's estimate of Spanish national income. For 1912, he used two alternative figures, which had been elaborated by the *Consejo de Economía Nacional* and Julio Alcaide.[387] However, since the early 1980's, the quantitative information available on the historical evolution of the Spanish economy has experienced a huge increase. On the basis of that information, Prados de la Escosura has recently estimated a new series of Spanish nominal GDP which, for 1912, has given support to Julio Alcaide's estimate

---

[384] See Madrazo (1984), p. 749, and similar road transport rates in Garrabou and Sanz Fernández (1985b), p. 48, and Barquín Gil (1997), p. 35.
[385] The lack of precise information on the dates of Madrazo's estimate prevents from correcting it for price inflation. However, the general level of Spanish prices in the 1840's would be very similar to that of 1878 or 1912, according to the series of Castilian prices by Reher and Ballesteros (1993).
[386] The shares of grain and wine within *Norte* and *MZA* freight transport have been obtained from the information on the composition of those two companies' traffic that is reproduced by Anes Álvarez (1978), pp. 497-505.
[387] See Gómez Mendoza (1981), p. 67, and Alcaide Inchausti (1976).

(the difference between the two figures being only 1.6 per cent), and which, for 1878, is instead twice as large as Mulhall's figure.[388]

Table 6.4 shows the effects of introducing each one of the three suggested adjustments in the original Gómez Mendoza's estimation of the social savings of Spanish railways in 1878 and 1912, as well as the alternative estimates that result from introducing all of them.

Table 6.4
Alternative estimates of social savings on freight transported by Spanish railways (1878 and 1912)

		1878	1912
A)Gómez Mendoza's estimates	*Railway economy:*		
	(a) Railway output (million ton-km)	876.1	3,780
	(b) Railway rate (pesetas per ton-km)	0.02165	0.015
	(c) Railway output (million pesetas) (a x b)	19.0	56.7
	Counterfactual economy:		
	(d) Canal output (million ton-km)	8	
	(e) Canal rate (pesetas per ton-km)	0.1403	
	(f) Canal output (million pesetas) (d x e)	1.1	
	(g) Coastal output (million ton-km)	81	475
	(h) Coastal rate (pesetas per ton-km)	0.04053	0.04245
	(i) Coastal output (million pesetas) (g x h)	3.3	20.2
	(j) Road output (million ton-km)	669	2,809
	(k) Carting rate (pesetas per ton-km)	0.7937	0.8447
	(l) Road output (million pesetas) (j x k)	531.0	2,372.8
	(m) Social saving (million pts) (f+i+l-c)	**516.4**	**2,336**
	(n) Original GDP (million pesetas)	4,375	10,210/12,638
	SS/Original GDP (m/n) (%)	**11.8**	**18.5/23.0**
B) Suggested adjustments.			
1. Railway rate	(o) Alternative rate (pesetas per ton-km)	0.050/0.062	0.039/0.048
	(p) Social saving (million pesetas)	481.1/491.6	2,211.3/2,245.3
	SS/Original GDP (p/n) (%)	11.0/11.2	17.5/22.0
2. Carting rate	(q) Alternative rate (pesetas per ton-km)	0.54	0.60
	(r) Social saving (million pesetas)	346.7	1,648.6
	SS/Original GDP (r/n) (%)	7.9	13.04/16.15
3. GDP	(s) Alternative GDP (million pesetas)	8,722.2	12,840.8
	Original SS/Alternative GDP (m/s) (%)	5.9	18.5
1+2+3	**(t) Alternative social saving (million pts)**	**311.3/321.9**	**1,524.12/1,558.1**
	(u) SS/GDP (t/s) (%)	**3.6/3.7**	**11.9/12.1**

Sources: Gómez Mendoza (1981), pp. 69-70, except for the alternative carting rate -my own estimate, on the basis of Gómez Mendoza (1981), Madrazo (1984) and Anes Álvarez (1978)-, alternative GDP, from Prados de la Escosura (forthcoming), and my own alternative railway rates (Table 6.3).
Note: Railway output does not coincide with the sum of output figures by alternative means, because these have been corrected in order to account for the circuitousness of the Spanish railway system; see Gómez Mendoza (1981), pp. 70-71.

[388] Prados de la Escosura (forthcoming).

Figures in Table 6.4 are by no means a final result. In fact, they are just an upper bound of the "true" resource savings brought about by Spanish railways in freight transport, and the size of the upward biases involved depends on several different factors. Firstly, the elasticity of transport demand is assumed to be zero in the estimation. As Robert Fogel points out, the bias associated with that assumption depends both on the true demand elasticity and on the ratio between counterfactual and railway transport marginal costs. In the Spanish case, even with quite a low elasticity of -0.4, that bias would be around 47 per cent of the "true" social saving in 1878, and 82 per cent in 1912.[389]

Secondly, the estimates in Table 6.4 do not allow for the re-routing of transport flows. However, this would have been very relevant in an economy such as the Spanish one, in which some railway routes might be replaced by a combination of road transport and coastal navigation with much longer distance but much cheaper than the direct road connection. For instance, before the railway age, the wheat produced in Northern Castile was shipped to Catalonia not directly by road but by boat from the Northern coast, circumventing the Peninsula, and it is likely that this indirect route would have been used again in a counterfactual economy without railways.[390] Unfortunately, the lack of precise information on the origin and destination of the actual railway flows prevents the estimation of the magnitude of this bias.

Finally, figures in Table 6.4 are based on the assumption of full employment of the national resources. However, a certain share of the transport shifted from railways to roads in the counterfactual economy would have been performed by idle peasants in the off-peak season of the agricultural working year, and would therefore have had a very low opportunity cost. As has been pointed out, Gómez Mendoza already considered this possibility and calculated alternative social saving estimates by applying a lower carting rate for the counterfactual transport system.

---

[389] According to Fogel, assuming a transport demand function such of the following form: $Q = DP^{-\varepsilon}$, the bias caused by setting the demand elasticity at zero, expressed as a percentage of the "true" social savings, is given by: $[(\phi^{1-\varepsilon}-1)/(1-\varepsilon)(\phi-1)-1]\text{x}100$, where ϕ is the ratio between counterfactual and railway transport marginal costs; see Fogel (1979), p. 10. For the value of ϕ in Spain see below (Table 6.6). It is not possible to estimate the elasticity of transport demand in Spain, because the railway output figures available for the period have been estimated by dividing the companies' revenues by the average market fares. Therefore, the estimation of a demand function with those data would suffer from serious endogeneity problems. The biases indicated in the text may be considered as lower bounds for the true ones, since –0.4 is among the lowest elasticity estimates available for nineteenth and early twentieth transport systems; see, for instance, Coatsworth (1979), p. 951, Summerhill (1998), p. 390, and Ramírez (2001), p. 100.

[390] See, for instance, Garrabou and Sanz Fernández (1985b), p. 49.

That rate only included the increase in the maintenance expenses of idle draught animals when they were incorporated to transport activities (since all other expenses would have been met anyway without the counterfactual transport shift), and was carefully estimated by Gómez Mendoza as 0.082 pesetas per ton-km.[391]

The application of that rate to all freight transported by road in Table 6.4 (the so-called "inventory solution") would bring down the new social saving estimate to around 0.15 per cent of Spanish GDP in 1878 and 0.65 per cent in 1912. If it were applied only to part of that freight ("intermediate solution") the resulting estimates would be 2.46 per cent of Spanish GDP in 1878 and 8.21 per cent in 1912.[392] These percentages should be increased by the indirect costs incurred by firms holding higher stocks in the absence of railways, although these were estimated to be quite low by Gómez Mendoza, especially in the "intermediate" solution.[393]

The viability of these solutions, however, mainly depends on the availability of draught animals in the Spanish agrarian sector during the period under study. Any statement on this issue, however, must remain mere conjecture. Apparently, the livestock available in Spain during the last few decades of the nineteenth century might have been able to cope with the 669 million ton-km that would have been shifted from railways to roads in the 1878 counterfactual economy. In that year, horses, mules and donkeys amounted in Spain to approximately 2,400,000 head, and cattle to 2,600,000 head.[394] The carrying capacity of that stock is impossible to know, because no information exists on the number of animals that were already involved in transport in the real economy (and therefore, on the idle capacity for transport in the off-peak season of agrarian work). A preliminary idea of this capacity, however, is provided by Gómez Mendoza, who indicates that, at the technological level of the second half of the nineteenth century, the (full-time) yearly transport capacity of an equivalent population of 130,619 horses would be around 216.5 million ton-km.[395] Under those conditions, it is likely that the livestock available in 1878 would have been able to accept the additional transport demand. Therefore, the "inventory" or the most

---

[391] See Gómez Mendoza (1981), p. 88. In further publications, that rate was increased to 0.144 pesetas per ton-km; see Gómez Mendoza (1989a), p. 198.
[392] These percentages are obtained by applying the average of the two alternative railway rates that are reported in Table 6.4.
[393] Gómez Mendoza (1981), p. 94.
[394] These figures result from a log-linear interpolation between the data for 1865 and 1891, that are available in Grupo de Estudios de Historia Rural (1985), p. 276.

likely "intermediate" estimate (2.46 per cent of GDP) might be closer to the "true" social saving than the "interim" solution that is presented in Table 6.4.[396]

Certainly, the situation would have been different in 1912, when the road transport sector would have had to carry 2,809 million additional ton-km, an amount four times as large as in 1878. In that year, the number of horses, mules, donkeys and oxen in the economy was virtually the same as in 1878, which indicates that the idle transport capacity in the off-peak season of the agricultural working year would not have grown much in the meantime.[397] As a consequence, the prospects to reduce the marginal cost of road transport through the use of idle resources would have been lower in 1912 than in 1878. In other words, the upward bias associated with the presence of idle resources would be much smaller in the 1912 estimate than in the 1878 figure, and the "intermediate" solution would no longer be an upper bound of the "true" resource saving. As a consequence, the "interim" solution reported in Table 6.4 (12 per cent of Spanish GDP) has been preferred here as such upper bound.[398]

---

[395] Gómez Mendoza (1983), pp. 150-151.

[396] On the other hand, Ramon Garrabou has recently warned of the tendency in the historiography to overestimate the situations of peasant underemployment in the Spanish economy. Actually, the complexity of the agrarian activity would have involved much higher labour demands than are usually assumed; see Garrabou (2000), p. 30. In the case of the social saving, this would imply lower prospects of resorting to idle peasants during the period under study and, therefore, a higher opportunity cost of road transport. In other words, the "true" social saving might be in between the "interim" and the "intermediate" solutions. However, all considerations around this issue must remain mere suggestions due to the lack of precise quantitative information. Therefore, for the sake of comparability I have kept in my research Gómez Mendoza's assumptions on the likelihood of each solution in 1878 and 1912 respectively.

[397] Grupo de Estudios de Historia Rural (1985), p. 276. Obviously, in a counterfactual economy without railways, the number of draught animals would have increased according to road transport demand. However, this growth would not have increased the idle transport capacity during the off-peak season of the agrarian year, since the additional animals would have been full-time involved in the transport sector.

[398] Apart from the three sources of upward biases that have been mentioned, there is a potential downward bias associated with the possibility of congestion of the alternative transport means in the counterfactual economy; on this subject, see Fishlow (1965), p. 29, or O'Brien (1977), p. 46. In case of congestion, marginal costs might have been much higher than the rates indicated in Table 6.4. Gómez Mendoza raises the issue of congestion only for 1878. For that year, he shows some evidence of excess capacity in the Canal of Castile, as well as in the Spanish ships engaged in coastal navigation. However, it is not clear that domestic ship capacity constitute an adequate indicator of congestion, since transport services could be hired from foreign agents. In fact, the only really unavoidable congestion costs would arise from the capacity of the existing infrastructure, both in the case of road and water transport. Regarding this matter, however, it is not possible to draw definite conclusion, although the possibility of infrastructure congestion does not seem very likely. Firstly, as Gómez Mendoza indicates, the actual quality of roads was probably "*good enough to bear the higher volume of road traffic due to a railway closure*"; see Gómez Mendoza (1981), p. 27. Secondly, in the counterfactual economy, capital that was not invested in railways would have gone to alternative destinations, and might have been used to improve water and road transport infrastructure, as in Fogel's social saving estimation for the US, where an additional 5,000 miles of canals that never existed were allowed for in the absence of railways; see Fogel (1964). Although that allowance is not made in most estimations for other countries, which are based on the *ceteris paribus* hypothesis, it lies within the possible specifications of

6.3 An interpretation of the social saving of Spanish railways

Although the ratio of the new Spanish social saving estimate to GDP in 1912 (12 per cent) is still high in comparative terms, in the case of 1878 the 2.5 percentage is much closer to ratios for other European countries than the original Gómez Mendoza's figures. Apparently, the new 1878 ratio would be inconsistent with the generally accepted idea that railways were more vital in countries with less opportunities for water transport.[399] However, this apparent contradiction may be clarified just by looking at the way in which that ratio is usually calculated, i.e.:

$$SS = (P_{ALT}-P_{FC}) \text{ x } Q_{FC} / GDP,$$

where P_{FC} and P_{ALT} are, respectively, the marginal cost of railway and counterfactual transport, and Q_{FC} is the railway transport output in the real economy.

Broadly speaking, the level of the term $(P_{ALT}-P_{FC})$ depends on the share of railway output that would be shifted from railways to roads in the counterfactual situation. Given the minor importance of waterways in nineteenth century Spain, this share was very high in that country compared with other European economies. However, the social savings are also determined by the term (Q_{FC}/GDP), i.e. the ratio between railway output and GDP.[400] And, in this respect, Spain ranked much lower than those countries with which it has been compared. Table 6.5 shows the level of the term (Q_{FC}/GDP) in several European economies. The table reports the ratio between the total ton-km and passenger-km transported by each railway system and the level of GDP in 1990 Geary-Khamis dollars. Obviously, those figures are not strictly comparable among countries, due to the different value and composition of transport services in each economy. However, the table offers a preliminary picture of the huge differences in what might be called the "railroadization" of the European economies during the period under study.[401]

the social saving calculations. Actually, it constitutes a step further from a pure partial equilibrium approach to the isolation of the unique attributes of the railways, which is the final interest of the social saving exercise; see O'Brien (1977), pp. 33-34, Fogel (1979), pp. 6-7, and Crafts (2000), p.4. In the Spanish case, there was little scope for the extension of waterways, but it is likely that congestion in roads and ports might have been avoided.

399 See, for instance, Fogel (1979), p. 31, O'Brien (1983b), pp. 12-13, and Gómez Mendoza (1989a), p. 201.

400 The importance of this factor has been stressed by Coatsworth (1979), p. 939, and McCloskey (1987), p. 67, among others.

401 The term "railroadization" comes from Schumpeter (1939), Vol. 1, p. 325.

Table 6.5
Railway output/GDP in some European economies (1870-1910)
A) Freight transport (ton-km per thousand 1990 G-K $ of GDP)

	1870	1880	1890	1900	1910
Russia				282	316[g]
Germany	75	144	180	211	248
France	74	132	131	144	185
Belgium	50	111	125	149	165
Sweden	26[a]	50[b]	69[c]	111	162
England and Wales	86[a]	106	106	102	115[h]
Finland	4	21	33	79	84
Switzerland				69	82
Italy			38[c]	49[e]	79
Spain	**26[a]**	**43[b]**	**43[c]**	**54[f]**	**68**
Netherlands		33[b]	51[c]	58	65
Norway	9	14	28	28	60
Denmark			25[d]	38	48

B) Passenger transport (passenger-km per thousand 1990 G-K $ of GDP)

	1870	1880	1890	1900	1910
Germany	57	69	90	115	157
Belgium	46	76	84	125	155
Switzerland				106	152
France	62	75	88	126	145
Russia				94	121[g]
England and Wales	58[a]		88	109	118[i]
Finland	1	29	40	78	101
Sweden	24[a]	33[b]	44[c]	63	96
Denmark			59[d]	77	94
Norway	8	18	36	44	69
Netherlands		38[b]	44[c]	46	63
Italy			42[c]	48[e]	57
Spain	**28[a]**	**29[b]**	**32[c]**	**38[f]**	**48**

Sources: GDP figures are the product of income per capita and population of each country, obtained respectively from Maddison (1995b) and Mitchell (1988) and (1998). Railway output comes from Mitchell (1998), except for the following: for Belgium, it comes from Laffut (1983), p. 215; for England and Wales, from Cain (1988); for Sweden in 1870-1890, it has been taken from the *Statistisk Årsbok för Sverige*; for Switzerland in 1900, it comes from the *Statistisches Jahrbuch der Schweiz*. Finally, in the Spanish case, output figures for 1900-1910 have been taken from *MAEOP*, and for 1870-1890 have been estimated by dividing the freight and passenger revenues of the whole railway system, which is also available in *MAEOP*, by the average fare of the two main firms (*Norte* and *MZA*). These companies' rates are calculated by dividing their freight and passenger revenues by their total ton-km and passenger-km of output, which are available in Anes Álvarez (1978), pp. 487-491, and Gómez Mendoza (1989b) pp. 291-294.
Notes: (a) 1871; (b) 1881; (c) 1891; (d) 1893; (e) 1899; (f) 1901; (g) 1913; (h) 1911; (i) 1912.

The reasons for the differences among countries in Table 6.5 are diverse. For instance, in the case of Denmark and the Netherlands, geography and a highly developed water transport network would have reduced the need for railway transport, which helps to explain the low level of the ratio in those two countries. But, undoubtedly, the factor that seems to have the greatest influence on figures in Table 6.5 is the level of economic development.[402] Railway transport was less used in those countries, such as Spain, whose regional economies were less specialised, and where industry accounted for a lower share of total GDP. The demand for railway transport in each country only increased with the growth and the geographical concentration of industrial production and with the regional specialisation of economic activity.[403]

Table 6.6 reports the value of the two variables that determine the ratio of social savings to GDP (i.e. P_{ALT}/P_{FC} and Q_{FC} / GDP) for several European economies for which they are readily available. The table clearly shows that, in the case of Spain, the huge cost difference between railways and the alternative transport means was largely overcome by the minor role played by railway transport in the Spanish economy during the period.

[402] The increasing share of the railway sector in GDP as the process of economic development advances may be observed from a single country perspective in Krantz (2000).

[403] The most striking feature of Table 6.5 is the high position of Russia in freight transport. This would contradict Metzer's statement that the social saving of Russian railways was low in 1907 due to the minor importance of railway transport and trade in the Russian economy. According to data in the table, the low level of the Russian social saving might only be attributed to the large share of transport that would have been shifted to waterways in the counterfactual economy; see Metzer (1976), p. 109, and also below (Table 6.6). One possible explanation for the high degree of "railroadization" in Russia would be the very long haul of railway transport, which has been noted, for instance, by White (1976).

Table 6.6
Differences in unit costs between railway and counterfactual freight transport, ratio of railway freight output to GDP, and social savings in European economies

	England and Wales (1865)	France (1872)	Russia (1907)	**Spain (1878)**	**Spain (1912)**
P_{ALT}/P_{FC} in freight transport	2.6	3.1	2.6	**5.0**	**10.4**
Freight railway output / GDP (ton-km per 1,000 1990 G-K $)	67.31	103.8	268.0	**28.8**	**70.9**
Railway social saving in freight transport/GDP	**3.8**	**5.8**	**4.5**	**2.5**	**12.0**

Sources:
a) P_{ALT}/P_{FC}: for Russia, Metzer (1977), pp. 42 and 49; for England and Wales, Hawke (1970), pp. 88, 156 and 188; for France, Caron (1983), p. 44; and for Spain, Section 6.2.
b) Q_{FC} / GDP: for Russia and France, Mitchell (1998) and Maddison (1995b); for England and Wales, Q_{FC} from Hawke (1970), p. 88, and GDP from Maddison (1995b) and Deane (1968); English and Welsh GDP is assumed to be 81 per cent of the UK GDP, as in Hawke (1970), p. 196. For Spain, Q_{FC} comes from Table 6.4, and GDP from Prados de la Escosura (forthcoming) and Maddison (1995b).
c) Social saving/GDP: for Russia, Metzer (1977), p. 50; for England and Wales, Hawke (1970), after correcting GDP by a factor of 0.81; for France, Caron (1983), p. 44; and for Spain, Section 6.2.
Notes: Figures for England and Wales exclude livestock. Spanish figures relate to the “intermediate” solution in 1878 and to the “interim” solution in 1912 (see above). The ratio P_{ALT}/P_{FC} always takes into account the change in distance between the counterfactual and the railway transport routes, as well as the increase in indirect costs, when available. Obviously, the last line is not exactly proportional to the product of the first and second lines, because the original ratios given for England and Wales, France and Russia by Hawke, Caron and Metzer were calculated on the basis of different GDP figures to Maddison’s ones.

The low level of the ratio of railway output to GDP in Spain helps to explain that the Spanish social saving on freight transported by railways was not higher in relative terms than the English and Welsh, the French or the Belgian ones by 1878, despite the prominence of roads in the Spanish counterfactual economy. That situation would gradually have changed as the possibilities to use idle resources in the counterfactual road transport decreased and, as a consequence, the difference between transport costs in the real and counterfactual economy increased. By 1912, the low level of “railroadization” of the Spanish economy seems to have finally been overcome by the large difference between P_{ALT} and P_{FC}, and the ratio of social saving to GDP would probably be among the highest in Europe at that date.[404] However, it remained much lower than the equivalent figure for large non-European countries such as Mexico and Brazil.

[404] Unfortunately, no social saving estimates comparable to the Spanish one are available for the European countries during the first years of the twentieth century, except for Russia. Foreman-Peck has estimated the social saving of British railways to be 31.6 per cent of British GDP in 1890. However, this figure has been obtained with very different procedures to the estimates reported in Table 6.6, and under the assumption of too large differences between counterfactual and railway transport fares; see Foreman-Peck (1990), p. 77.

These conclusions have been confirmed, to some extent, by the analysis of Spanish passenger railway transport. Gómez Mendoza's social saving estimates did not include passenger transport, on the basis that it "*must be considered as a completely new commodity (…) which, for the most part, would never have taken place without the advent of railways*".[405] However, subsequent research has shown that road passenger transport was highly developed at the beginning of the railway age, being the object of the main technological improvement that had taken place in the road transport sector before 1850.[406] Although the statistical records of the Spanish stagecoach companies are much worse than those of railway firms, Madrazo's estimate of their custom for 1850 amounts to 825,000 passengers.[407] This is of course a much lower number than the 7.5 million passengers that were transported by railways already in 1861.[408] However, if the zero demand elasticity assumption is removed, an estimate of the social saving provided by passenger railway transport may be meaningful in the Spanish context.

There are several possible ways to remove the zero elasticity assumption. For instance, in the case of the US and Russia, Boyd and Walton and Metzer assumed a demand elasticity of –1 for passenger transport, on the basis of information on present times demand functions.[409] For Brazil and Mexico, it has instead been assumed that demand was completely inelastic in the case of first class passenger transport, and completely elastic in the case of the second class. In other words, in the counterfactual economy all first class travellers would have used coach transport to make the same journeys as in the railway economy, whereas all second class travellers would have walked instead.[410] In the Spanish case, the second of these two options on the demand elasticity of passenger transport is consistent with information available on stagecoach transport in Spain before the railway era, since the number of railway passengers in the two upper classes in the early 1860's was higher but not very far away from the previous number of coach travellers.

An estimation of the social saving of passenger transport should take into account not only the savings of resources in the transport activity itself but also the time saved by individuals thanks

[405] Gómez Mendoza (1981), p. 26.
[406] Gómez Mendoza (1997), p. 477; see also Frax Rosales and Madrazo (2001), p. 36.
[407] Madrazo (1984), p. 534. This author estimated the distance travelled by stagecoaches at 8.4 million km. Obviously, the actual Spanish passenger traffic would have been much higher than the reported figures, since it also included non-regular road services and canal and coastal water transport.
[408] This information comes from *MAEOP*.
[409] Boyd and Walton (1972), pp. 247-250, and Metzer (1977), p. 73.
[410] Coatsworth (1979), pp. 943-944; Summerhill (1997), pp. 109-110.

to the replacement of traditional transport means by railways. However, an adequate assessment of time savings would demand information on the reason for each journey. Since the value of leisure is not included in historical estimates of national income, only journeys for work reasons should be considered in the time saving calculation. Unfortunately, no information exists on the reasons for individual journeys, and assumptions in this respect have been very different among researchers. In some cases, such as Hawke's estimation for England and Wales, the value of time has been completely excluded from the estimation, under the assumption that most traffic was for pleasure.[411] On the contrary, in the case of the US in 1890, Boyd and Walton have treated all travel time as working time and have valued it accordingly.[412] Finally, for Mexico, Brazil and Russia, it has been considered that only about half of the time savings should be included in the estimation of the social savings for passenger transport.[413]

Regarding this aspect, information about Spain is as scarce as for other countries. A prudent assumption, however, would be including in the calculation about 50 per cent of the time savings, as in the Mexican, Russian and Brazilian cases. Although pleasure journeys would be rather rare in a country such as Spain, with relatively low income per capita, there are some reasons to consider that certain share of travel time for work reasons should not be valued at its market price. As Metzer indicates for Russia, a large amount of passenger traffic took place during the off-peak season of the agricultural working year, and the time invested in those movements would have a very low opportunity cost. In addition, "*[o]ne should consider (…) the travelling housewives, the time of whom had virtually no market value, and all the other passengers whose income was not a function of hours of work, and those who could do some work whilst being on the way*".[414]

Time savings must be valued differently depending on the railway passenger classes. I have assumed first and second class travellers to be among the highest-income social groups and have valued their travel time at twice the hourly wage of skilled industrial workers. The resulting figure is similar to the hourly earnings of the medium ranks of the managerial staff of railway

---

[411] See Hawke (1970), p. 52. The value of time is also excluded from the US estimate for 1859 by Fishlow (1965).
[412] See Boyd and Walton (1972), pp. 239-240.
[413] The percentages are 58 per cent in the case of Brazil, 50 per cent in the case of Russia and 40 per cent in the case of Mexico; see Summerhill (1998), p. 398, Metzer (1977), p. 62, and Coatsworth (1979), p. 945.
[414] Metzer (1977), p. 60.

companies.[415] In the case of third class passengers, I have valued travel time at the hourly wage of skilled industrial workers, under the assumption that the lowest-income social groups did not use railway transport.[416] This assumption may introduce a slight upward bias in the time saving figures, especially in the case of 1912, but it is necessary to avoid downward biases and to guarantee the upper bound character of the social saving estimates.[417] The resulting unit values of travel time can be seen in Table 6.7.

Table 6.7
Assumptions on the value of travel time in Spanish railways (pesetas per hour)

	1878	1912
First and second class	0.76	0.94
Third class	0.38	0.47

Source: Camps (1995), pp. 204 and 214-215.

Under these assumptions, the estimation of the social saving of Spanish passenger railway transport also requires information on railway passenger output in 1878 and 1912, and on marginal costs and speed in railway and stagecoach transport.[418] The output of Spanish railways has been estimated as 719.2 million passenger-km in 1878 and 2,904.6 million passenger-km in

[415] Hourly wages have been taken from Camps' research on Catalan industry (see Camps (1995), pp. 194-215), which, for 1912, is consistent with national data from the reports of the *Instituto de Reformas Sociales*. I thank Margarita Vilar for providing me detailed information on these reports. For managerial wages in the railway companies, see Juez Gonzalo (1992), pp. 185-217.
[416] This would be consistent with Gómez Mendoza's conclusion that population immigrating to Madrid between 1878 and 1901 did not use the railways in their journey, but cheaper transportation methods; see Gómez Mendoza (1989a), p. 169.
[417] In the Brazilian case, Summerhill also values time savings of first-class passengers at twice the wage for a skilled worker, and time savings of second-class passenger at the hourly wage of skilled manufacturing workers; see Summerhill (1998), pp. 392-394. Other authors use, for lower-class passengers, the wage for "railway workers" or "manufacturing workers", without specifying professional rank; see Coatsworth (1979). p. 945, and Boyd and Walton (1972), p. 245.
[418] Due to the absence of information on coastal navigation rates and speed, I do not allow any share of passenger transport to be shifted to that sector in the counter-factual economy. However, water passenger transport was well developed at the advent of railways in some routes parallel to future railway lines, such as the Mediterranean coastline; see Valdaliso Gago (1997), p. 25. The scarce Spanish navigation waterways were also used to some extent for passenger transport. Uriol Salcedo (1979), p. 872, for instance, indicates that the rate per passenger-km in the *Canal Imperial* in 1808 was 0.08 pesetas, i.e. around half the average stagecoach rate in the middle of the nineteenth century. The size of the bias that is introduced in the estimation by the failure to account for coastal navigation may be approached by the first and second class-passenger revenues of the railway companies involved in transport along the Mediterranean coast (*AVT* and *TBF*), which was 6.8 per cent of the total passenger revenues of the Spanish railway companies in 1878. Not all that transport, however, would have been captured by coastal navigation in the counterfactual economy, since traffic north of Barcelona and south of Valencia ran far away from the coast and some share of the remaining passengers would have used instead the much faster coach transport.

1912.[419] These amounts have been distributed among classes according to the number of passengers in each class, i.e. by assuming the same haul in all classes.

The marginal cost of passenger railway transport may be approached, as in the case of freight, by multiplying the estimated cost elasticity (as offered in Table 6.3) by the average cost per passenger-km.[420] The result of that calculation would be around 0.01 pesetas per passenger-km both in 1878 and 1912. However, the lack of significance of the passenger-km coefficients in Table 6.2 raises some doubts about the accuracy of this figure. Unfortunately, the only available alternative is the market rate of passenger transport in the two main railway companies, since the so-called "internal" rates were only produced for freight transport. Both alternative figures are used here, the former producing much higher social saving estimates than the latter. Finally, the average speed of express trains was approximately 34.4 km per hour in 1870 and 45 km per hour in 1910, and these figures have been applied to 1878 and 1912 respectively.[421]

Regarding road transport, passenger rates have been estimated by Madrazo, in the case of the regular coach companies in the mid-nineteenth century, at 0.15 pesetas per passenger-km, and the speed of stagecoaches was around 7 km per hour by that date.[422] The speed of travel by foot is assumed to be 3 km per hour. Table 6.8 presents the social saving estimates that result from these data.

---

[419] These numbers have been estimated by dividing the total passenger revenue of Spanish railways (available in *MAEOP*) by the average passenger rate of the main companies (*Norte* and *MZA*), which has been obtained from information on those companies in Anes Álvarez (1978), pp. 487-491, and Gómez Mendoza (1989b), pp. 291-294.

[420] Total variable costs are available in *MAEOP*.

[421] Cordero and Menéndez (1978), pp. 307 and 335.

[422] Madrazo (1984), pp. 552-560. Lack of information on the date of the reported price prevents deflation, but Spanish prices in the 1840's might be similar to 1878 or 1912; see Reher and Ballesteros (1993).

Table 6.8
Social saving on passengers transported by Spanish railways (1878 and 1912)

	1878	1912
1) First and second class		
(a) Passenger-km (million)	203.96	564.71
(b) Rail rate (pesetas/passenger-km)	0.010/0.100	0.008/0.075
(c) Rail cost (a x b) (million pesetas)	2.040/20.478	4.518/42.353
(d) Stagecoach rate (pesetas/passenger-km)	0.15	0.15
(e) Stagecoach cost (a x d x 0.85)[a] (million pesetas)	26.005	72.001
(f) Unit value of working travel time (pesetas/hour)	0.76	0.94
(g) Working travel time by rail (50 per cent of a at 34.4/45 km per hour) (million hours)	2.965	6.275
(h) Value of the working travel time by train (f x g) (million pesetas)	2.186	5.899
(i) Working travel time by stagecoach (50 per cent of a x 0.85 at 7 km per hour) (million hours)	12.383	34.286
(j) Value of the working travel time by stagecoach (f x i) (million pesetas)	9.411	32.229
(k) Saving on transport costs (e-c) (million pesetas)	5.527/23.965	1.977/29.648
(l) Saving on travel time (j-h) (million pesetas)	7.225	26.330
(m) Total savings (k+l) (million pesetas)	*12.752/31.190*	*28.307/55.978*
2) Third class		
(a) Passenger-km (million)	515.24	2,339.89
(b) Rail rate (pesetas/passenger-km)	0.010/0.045	0.008/0.027
(c) Rail cost (a x b) (million pesetas)	5.152/23.289	18.719/63.177
(d) Unit value of working travel time (pesetas/hour)	0.38	0.47
(e) Working travel time by rail (50 per cent of a at 34.4/45 km per hour) (million hours)	7.478	25.999
(f) Value of the working travel time by train (d x e) (million pesetas)	2.842	12.220
(g) Working travel time by foot (50 per cent of a x 0.85 at 3 km per hour) (million hours)	72.992	331.484
(h) Value of the working travel time by foot (d x g) (million pesetas)	27.737	155.797
(i) Saving on travel time (h-f) (million pesetas)	24.895	143.577
(m) Total savings (i-c) (million pesetas)	*1.606/19.743*	*80.400/124.858*
3) Total social saving of the railway system (first, second and third classes) (million pesetas)	**14.358/50.933**	**108.707/180.836**
GDP	8,722.2	12,840.8
Passenger social saving/GDP (%)	**0.16/0.58**	**0.85/1.41**

Sources: see text.
Notes: (a) The 0.85 coefficient is intended to correct road output for the road network being less circuitous than the railways (see Table 6.4).

Comparison of passenger social saving estimates in Table 6.8 with those of other countries is even more troublesome than in the case of freight, due to the diversity of assumptions that underlie each estimation process. The most comparable figures to those presented here are the Mexican, Brazilian and, to a lesser extent, Russian ones. In the case of Mexico, passenger social savings amounted to 1.38 per cent of GDP in 1910. In Brazil, they were 2.2 per cent of GDP in 1887 and 4.03 in 1913.[423] Both were countries highly dependent on roads in the counterfactual situation and, as in the case of freight, they obtained similar or larger benefits from passenger railway transport than Spain. Metzer's estimate for Russia in 1907 (which is slightly different to the Mexican and Brazilian ones because he assumes a -1 elasticity for transport demand without distinguishing among classes of passengers)[424] amounts to 1 per cent of GDP.[425] This ratio is not very far away from the Spanish one for 1912, in spite of the prominence of water transport in the counterfactual Russian economy. The different importance of railway transport within the Russian and Spanish economies, as is reflected in Table 6.5, explains this unexpected result.[426]

To sum up, the ratio of Spanish passenger social savings to GDP would also reflect, as in the case of freight, the low degree of "railroadization" of the Spanish economy. In spite of the prominence of roads in the counterfactual system, the underdevelopment of the country would have prevented that ratio from being significantly higher than in other economies with more possibilities for water transport.

[423] For Mexico, see Coatsworth (1979), pp. 943-947; for Brazil, see Summerhill (1997), pp. 109-110, and (1998), pp. 391-395.

[424] However, the effect of this difference in the assumption on demand elasticity is probably not very large, since the social savings of Spanish passenger railway transport have also been estimated under the same assumptions as Metzer's and rather similar results to those of Table 6.8 have been obtained.

[425] Metzer (1977), p. 74.

[426] Other estimates are less comparable to the Spanish one. Boyd and Walton (1972) also apply a -1 elasticity to passenger transport demand, but consider all travel time as working time, obtaining a ratio of 2.6 per cent of GDP in the US in 1890. Fishlow's estimate for the US in 1859, Hawke's calculation for England and Wales in 1865 (without considering changes in comfort) and Caron's figure for France in 1872, which are in all cases around 1.6/1.7 per cent of GDP, assume a zero elasticity for transport demand and do not consider any time savings; see Fishlow (1965), Hawke and Higgins (1983), pp. 189-190, and Caron (1983), p. 44. *Ceteris paribus*, in these four cases, one of the assumptions makes the social saving higher than the Spanish one, whereas the other one makes it lower, and therefore it is not clear which would be the effect on these estimates of using similar assumptions to those applied to the Spanish case.

6.4 Social savings and beyond: the impact of railways on Spanish economic growth

According to the results of the previous sections, the social savings of the Spanish railways would have amounted at most to 3.1 per cent of GDP in 1878 (applying the most likely "intermediate" solution to freight transport) and to 13.4 per cent in 1912 (applying the "interim" solution). As has been indicated, these are upper bounds of the "true" resource saving, since a zero demand elasticity has been assumed for freight.[427] Comparison of these ratios with estimates for other countries indicates that the resource saving brought about by railways in Spain in 1878 was not high in relative terms. Later on, as the "railroadization" of the country increased, and the cost of road transport in the counterfactual economy became higher due to the decreasing opportunity to use idle resources, the ratio of the social saving to GDP would gradually have reached higher levels in Spain than in other European economies. However, it never attained the size that it had in some large non-European countries, such as Mexico and Brazil.

In other words, the social benefits of Spanish railways seem to have been in line with their level in other European countries during the second half of the nineteenth century. However, this does not confirm some historians' hypothesis that Spanish railways constituted an economic failure. That hypothesis may only be accepted if resources invested in the railways are proved excessive for the social benefits they provided. Answering that question, however, requires the estimation of the average social rate of return of the Spanish railway system, which is beyond the possibilities of this research. Nevertheless, the new social saving estimates allow an approximation to that rate in 1878 and 1912, which may offer some insights on its level and evolution.

The social rate of return *r* of certain investment in a single year *t* is given by:

$$r = \frac{SS + GR - OE - D - S + Y}{GI} \qquad (1)$$

where *SS* is the social saving, *GR* and *OE* the gross receipts and operating expenses of the railway companies, *D* is depreciation, *S* is the yearly public subsidy, *Y* is the sum of all

[427] On the other hand, these estimates contain a downward bias due to the exclusion of the transport of freight at high speed (perishables, excess luggage, etc.) and livestock, which amounted to 7.3 per cent of the Spanish railway companies' revenues in 1878.

externalities created by railways and not included in the social saving measure, and GI is the value of the total resources invested in the sector.[428]

Unfortunately, due to the lack of information, an estimation of the social rates or return of the Spanish railways must exclude the externalities of the railway system (Y), which ranged from the so-called "backward effects" of the construction and operation of railways to external economies associated with the integration of domestic markets. Spanish historiography, however, has provided some clues about their importance. Indeed, the most studied aspect has been the "backward effects" of the construction and operation of the network, which seem to have been rather small, since most of the Spanish demand for rails and rolling stock was met by foreigners at least until the 1890's, due to the tariff policy applied by Spanish governments.[429] Only recently have some researchers stressed the importance of certain positive "backward effects" of railways, such as their impact on the development of Spanish financial institutions, and on the diffusion of managerial skills and human capital.[430]

Regarding the externalities associated with the so-called "forward linkages" of railways, it must be remembered that the social saving measure already encompasses most of the growth impact of the integration of domestic markets, as it adopts an end-point perspective. Only in those cases in which market integration increased the stock of production factors in the economy, or generated positive external and scale effects, should those indirect benefits be added to the social saving indicator.[431] In the Spanish case, railway transport seems to have allowed, on the one hand, the exploitation of a large amount of resources that had remained idle until then,

[428] See, for instance, McClelland (1972), pp. 471-474, and O'Brien (1977), p. 41.

[429] According to Nadal Oller (1975), pp. 158-165, the railway tariff exemption was one of the biggest mistakes that have ever been made by the Spanish governments, and delayed the development of the iron and steel industries for thirty years. However, other historians have considered that Spanish industry was probably not ready to meet the demand coming from the railway network. See especially Gómez Mendoza (1982), pp. 142-154, and also Casares Alonso (1973), pp. 336-338, Tortella Casares (1981a), p. 194, Cubel Montesinos and Palafox Gamir (1999), pp. 30-31, or Broder (2000), pp. 78 and 268-269, and, from a more general perspective, O'Brien (1983b), pp. 17-18. These authors have pointed out that, without the tariff exemption, construction costs of Spanish railways would have been much higher. Recent research by Pascual Domènech (1998) has introduced some qualifications on this issue. He has indicated that the exemption was adequate in the case of most rolling stock or the companies' telegraph equipment, but if railways had been built with Spanish rails, construction costs would only have increased by 3 to 5 per cent.

[430] The impact of railways on the development of Spanish financial institutions has been stressed, among others, by Hernández (1999), p. 425, and Comín Comín (1999), p. 256. Their importance for the modernisation of managerial techniques, in the wake of the analyses by Chandler (1965), has been studied by Vidal Olivares (1996b). The diffusion of human capital as a by-product of railway construction and operation has been described, among others, by Pascual Domènech (1999a), p. 409, and Hernández (1999), p. 425.

[431] See Metzer (1984), pp. 66-69.

provoking as a consequence an increase in the national production of certain commodities.[432] This was especially relevant for some export-oriented products, such as wine, oil and mining in Andalusia,[433] wine in Castile-La Mancha,[434] or oranges and other agrarian products in the Valencian Community.[435] But it was also crucial for some primary production mainly oriented to the domestic markets, such as agriculture in Aragon or Extremadura, or livestock in Galicia.[436] On the other hand, the process of geographical reorganisation of Spanish economic activity that railways made possible may be assumed to have provoked substantial productivity improvements through the exploitation of scale, specialisation and agglomeration economies.[437] However, since no quantitative evidence is available on those phenomena, their actual relevance is impossible to ascertain. Therefore, as happens with similar studies for other countries, the externalities associated with the construction of Spanish railways cannot be incorporated to the social rates of returns reported before, which should be considered therefore as lower bounds of the actual ones.

Table 6.9 presents the results of the estimation of the social rate of return of Spanish railways for 1878 and 1912. It shows the ratio between each term of the numerator of expression (1) and the value of gross capital stock in the sector for each year, as well as their sum. As the social saving estimates are upward biased due to the zero elasticity assumption, the table also indicates the effect that a different assumption (ε=–0.4) would have on the final rates.

[432] See Gómez Mendoza (1981), pp. 220-221 and 261, and (1998), p. 10, and Comín Comín et al (1998), Vol. 1, pp. 137-140.
[433] Morilla Critz (1999), p. 505, and Cuéllar Villar and Sánchez Picón (1999), p. 631.
[434] Gallego Palomares (2001).
[435] Vidal Olivares (1992), pp. 278-279 and (1996a), pp. 281-288.
[436] On Aragon, see Germán Zubero (1999), p. 517; on Extremadura, see Cendal Búrdalo (1999), p. 581; on Galicia, Comín Comín et al (1998), Vol. 1, p. 138.
[437] See, for instance, Tedde de Lorca (1978), p. 181. Pascual Domènech (1999a) and (1999b), pp. 496-497, describes some agglomeration economies in the industrial area of Barcelona (related to labour markets, the supply of intermediate goods, and information and service availability), whose exploitation was largely allowed by the railways.

Table 6.9
Social rate of return of Spanish railways in 1878 and 1912 (%)

	1878	1912
(a) SS/GI	19.5	57.9
(b) SS/GI (assuming ε = -0.4 in freigth transport)	14.4	34.5
(c) (GR-OE)/GI	3.9	6.7
(d) S/GI	1.7	1.7
(e) D/GI	1.7	1.7
(f) Y/GI	na	na
(g) r (a+c-d-e)	*20.0*	*61.2*
(h) r (assuming e = -0.4 in freight transport) (b+c-d-e)	*14.9*	*37.8*

Sources and notes:

- na: not available.
- SS/GI: SS comes from Sections 6.2 and 6.3. It has been expressed in 1990 pesetas by applying the GDP deflator available in Prados de la Escosura (forthcoming). GI comes from the Appendix of Chapter 2, after increasing the railway infrastructure stock by the value of land and rolling stock. In the case of 1912, the use of "First Establishment" accounting figures (coming from *MAEOP*) as GI, and the new social saving in nominal terms as SS, yields virtually the same rate. Aggregate "First Establishment" figures, however, are not available for 1878 and, as a consequence, I have preferred my own estimates of railway capital stock.
- (GR-OE)/GI: for 1912, *MAEOP*; for 1878, the ratio for *MZA*, *Norte* and *TBF*, coming from Tedde de Lorca (1978), Pascual Domènech (1999a) and *MZA*'s annual reports has been applied a coefficient of 0.85, coming from later periods.
- S/GI is assumed to amount to 28 per cent of the total stock, according to information in Artola (1978b), pp. 352-353, and has been applied a yearly 6 per cent, which was the opportunity cost of capital in Spain during most of the period under study (see below; Section 7.2).
- D/GI results from the assumptions on the useful lifetimes of the assets that were made in Chapter 2.

Of course, estimates in Table 6.9, which are very preliminary, do not include externalities and only refer to two single years, do not provide conclusive evidence about the average level of the social rate or return of Spanish railways. However, some inference may be made from those figures on the role of railways in Spanish economic growth. Firstly, they would allow the rejection of the economic failure hypothesis, since the social returns from railways were high and positive already in 1878, largely exceeding the private rates of return of the railway companies and the market interest rates. Secondly, comparison of these results with the available estimates for other economies (which lie in the range of 15-20 per cent)[438] would confirm the previous idea that the social benefits of Spanish railways were similar to other European countries by 1878, but had become much larger in 1912.

To sum up, the available quantitative information, although still incomplete, would indicate that the gains afforded to the Spanish economy by railway transport were similar to other

[438] For England and Wales in 1830-1870, see Hawke (1970), pp. 405-407; for the US in 1859, see Fishlow (1965), and in 1890, see David (1969), p. 522. See also O'Brien (1977), pp. 51-53.

European countries in 1878, and increased gradually to a substantially higher level between that year and 1912. According to this conclusion, the realisation of the full economic benefits of the Spanish railway system appears to have been rather slow. This hypothesis would be consistent with information about the integration of Spanish domestic markets and about the geographical reorganisation of activity that took place as a result. Both of them were relatively slow processes and only reached their full development in the early twentieth century.

On the one hand, regarding market integration, convergence in price levels among the Spanish regions was clearly noticeable once the main railway connections had been finished,[439] and was parallel to the increase in the commercialisation of agrarian products[440] and to the gradual disappearance of subsistence crises in the country.[441] However, researchers have indicated that the integration process was not complete until the first years of the twentieth century. Although geographical differences in price levels were quickly eroded, cyclical fluctuations were not perfectly simultaneous among regions during the second half of the nineteenth century. In fact, regional price fluctuations even diverged to some extent during the 1870's and 1880's since, in those two decades, the free trade policies of the government and the decrease in international transport fares led foreign price movements to have a greater influence on the Spanish coastal regions than prices in the interior of the country.[442]

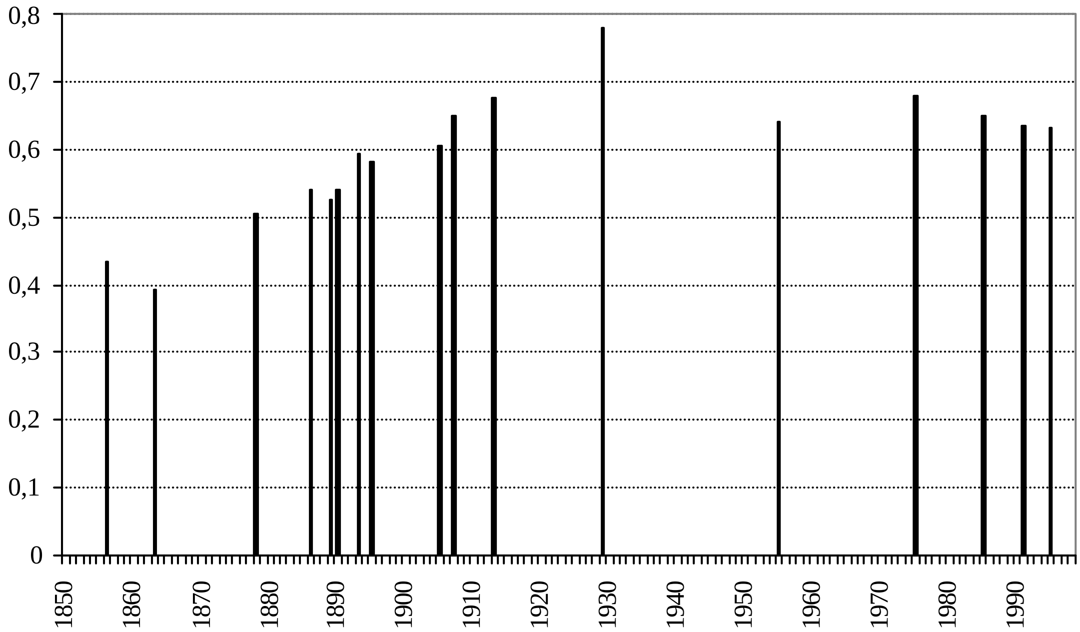
On the other hand, transport cost reduction completely altered the structure of location incentives in the Spanish economy and made possible the agglomeration of population and activity in urban and industrial centres from the middle of the nineteenth century onwards. The importance of railways for the development of Spanish industrial districts has been stressed in many cases, such as Catalonia, Madrid,[443] the Basque industrial centres[444] and other industrial agglomerations,

[439] Garrabou and Sanz Fernández (1985b), pp. 64-65. Nevertheless, the integration of Spanish commodity market was a very long-run process that started well before the construction of railways, as has been stressed by some historians; see, for instance, Barquín Gil (1997), Martínez Vara (1999), Llopis Agelán and Jerez Méndez (2001) or Reher (2001).
[440] Ibidem, pp. 56-58, and Tedde de Lorca (1978), p. 143.
[441] See, for instance, Garrabou and Sanz Fernández (1985b), pp. 64-65, Simpson (1989), p. 371, or Cubel Montesinos and Palafox Gamir (1999), p. 22.
[442] Regional price fluctuations can be seen in Peña Sánchez de Rivera and Sánchez-Albornoz (1983), p. 117, and in Barquín Gil (1997), p. 45. On the impact of free-trade policy and the decrease in international transport prices on the process of Spanish market integration see, for instance, Gómez Mendoza (1981), p. 187, Hernández Marco (1999), p. 611, or Morilla Critz (1999), pp. 507-511.
[443] See Comín Comín et al (1998), Vol. 1, pp. 139-140.
[444] See González Portilla et al (1995), pp. 313-346, and Macías (1999), pp. 461-474.

such as Alcoy in the Valencian Community.[445] The reorganisation of the Spanish port hierarchy, which led to the concentration of port activity in a small number of centres, has also been associated with railways.[446]

However, the process of geographical reorganisation was also rather slow, as may be observed in Graph 6.1, which shows the evolution of the spatial concentration of Spanish industrial activity throughout the last hundred and fifty years.[447]

Graph 6.1
Provincial concentration of Spanish industry (Gini Index)



Sources : EACI (1856-1909), Betrán Pérez (1997) and Banco de Bilbao, La Renta Nacional de España y su distribución provincial (1955-1995).

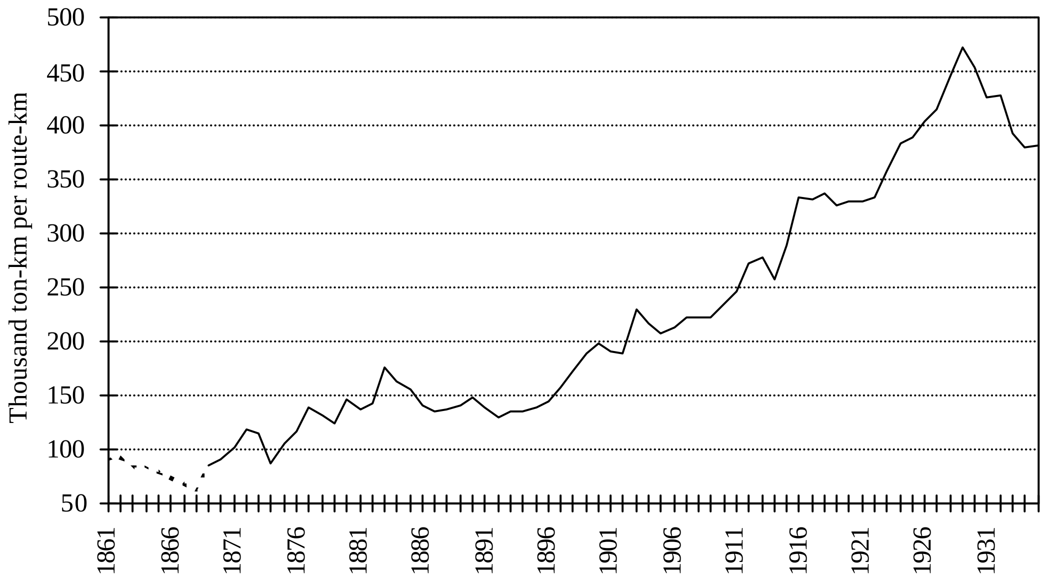
Although the three different sources on which the graph is based are not totally comparable, the data clearly indicate that the location of Spanish industry experienced a process of gradual concentration up to the Civil War of 1936, which was followed by a process of

[445] See, for instance, Hernández (1999), p. 424.
[446] See Guimerá Ravina (1996), pp. 132-133, and Frax Rosales (1981), p. 58.
[447] The graph is based, for 1856-1909, on the provincial returns of the main industrial tax, which have been taken from *EACI*; for 1913 and 1929, on Betrán Pérez (1997); and, from 1955 onwards, on *La Renta Nacional de España y su distribución provincial*, which has been published by the Bank of Bilbao since that year. For the characteristics and shortcomings of the first two sources, see above, Section 3.3. As was indicated there, *EACI* data, which have been used for the first decades of the period, do not include the Basque Country and Navarre.

dispersion thereafter. This inverted U shape is typical of the time evolution of activity location, and has also been found for other countries.[448]

However, the graph also shows that the spatial concentration of activity was, as market integration, a very slow process that took 50-60 years to reach its maximum. This slowness is consistent with the timing of the evolution of the social saving and social rate of return of Spanish railways, as has been described before. Actually, market integration and the geographical reorganisation of activity were directly associated with the increase in the railway social saving and social rate of return, since they involved a higher use of transport services and, therefore, a higher level of these two measures. The increasing use of the railway network may be seen in Graph 6.2, which depicts the evolution of the density of freight transport on Spanish broad-gauge railways between 1861 and 1935.

Graph 6.2
Density of freight transport on the Spanish broad gauge railway network (1861-1935)



Sources : network length from Cordero and Menéndez (1978), pp. 324-325. Output from Gómez Mendoza (1989b), pp. 288-289, except for 1861-1869, for which it has been calculated as is indicated in Table 6.5.

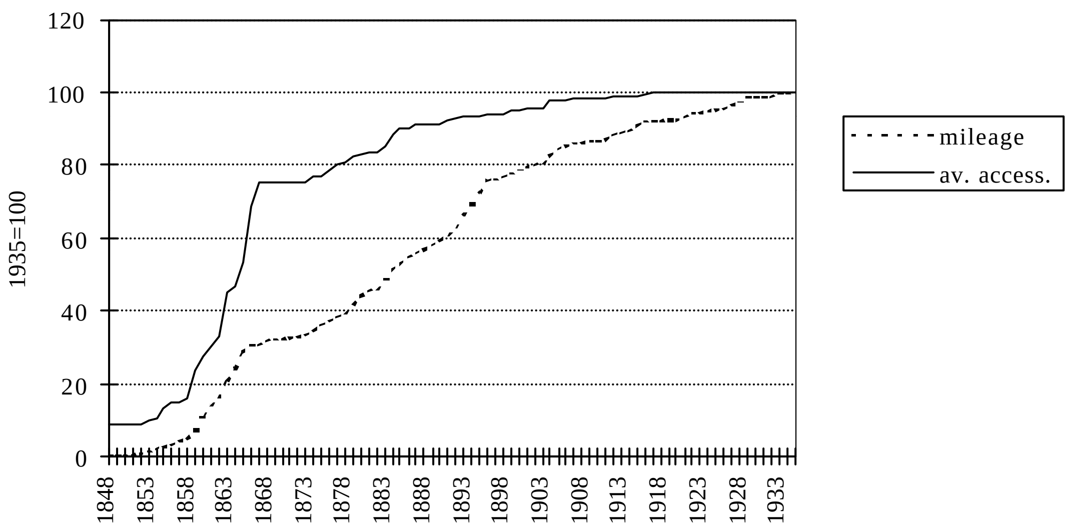
[448] See, for instance, Ottaviano and Puga (1997), pp. 26 and 29-30, or, for the US, Kim (1995). Actually, according to information in Betrán Pérez (1997), p. 76, the process of dispersion of Spanish economic activity already started, in the case of the most advanced industries, between 1913 and 1929. Data in Sudrià Triay (1997b) indicate that the process of dispersion spread to the whole of industry from the 1950's. An increase in the dispersion of internal migrants' destinations has also been observed for the second half of the twentieth century by Silvestre Rodríguez (2001a) and (2001b); see also Gómez Díaz and Céspedes Lorente (1996), p. 70.

Actually, the fulfilment of the whole potential impact of railways was even slower than it appears to be in Graphs 6.1 and 6.2, because most gains in the market potential of Spanish urban centres were actually achieved very early on, during the first wave of railway construction, in which the most profitable and heavily used lines were constructed. This can be observed in Graph 6.3, which shows, together with the evolution of the network mileage, the average accessibility index of the four main cities of the country (Madrid, Barcelona, Valencia and Seville) through the railway network during the period 1850-1935. Accessibility of centre i has been calculated as:

$$acc_i = \sum_{j=1}^{n-1} \frac{pop_j}{d_{ij}};$$

where j are the heads of provinces and the cities with a population larger than 20,000 during the whole or part of the period 1860-1930, and d_{ij}, is the distance between i and j through the railways network.[449]

Graph 6.3
Railway network mileage and average accessibility of the main Spanish urban centres (1848-1935)



Sources : network mileage from Cordero and Menéndez (1978); average accessibility has been estimated from information in Wais San Martín (1987), pp. 255-263 and Luna Rodrigo (1988).

The exasperating sluggishness of response that is reflected in Graphs 6.1 to 6.3 helps to explain, for instance, the frustration felt by Catalan businessmen during the last three decades of

[449] In order to make up for the effect of demographic changes, population figures have been set fixed at their 1900 level. On the measurement of accessibility, see, for instance, Frost and Spence (1995), pp. 1833-1834.

the nineteenth century. As has been described by Pere Pascual, the Catalan bourgeoisie had developed great expectations around the construction of the railway network in the 1850's, but had to face very low social and private returns to their investment for a long time.[450] The slowness of the response also helps to explain the failure to observe a positive growth impact of infrastructure in the econometric analysis that was carried out in the previous chapter. According to the graphs, a time lag of 50/60 years passed before the first Spanish railway investments reached their full potential impact and their maximum social return. Obviously, time series models have great difficulties in capturing causal relationships among variables with such long lags.[451]

New Economic Geography provides some clues as to why the lag was so long. As was indicated in Chapter 1, that theoretical framework points out that the relationship between infrastructure investment and the reorganisation of the economy is far from direct or immediate. On the contrary, there are many intermediate factors that influence the pace at which the potential created by infrastructure investment is fulfilled. The main ones are the characteristics of technology, the size of the available markets and the mobility of factors among sectors and across regions. As the Spanish workforce appears to have been quite mobile from the middle of the nineteenth century,[452] the slowness of the process should probably be related to the insufficient capacity of the Spanish industrial centres to attract workers, due to demand and/or supply constraints to their growth (such as the reduced capacity of consumption of industrial products or the high price of some inputs), as Spanish historians have often pointed out.

But there is yet another reason that might have also prevented a faster growth of the social saving and social rate of return of Spanish railways. As can be seen in Graphs 6.2 and 6.3, the first wave of railway construction, which took place before 1866, gave rise to what might be called the "core" of the network, i.e. the lines with the largest potential economic impact. This first wave was followed by a long period of more gradual construction that caused the enlargement of

[450] Pascual Domènech (1999b), pp. 479-483.

[451] Rietveld (1995), p. 117. However, it must also be reminded that the exercise carried out in Chapter 5 refers to the total infrastructure stock, and not only to railways.

[452] The Spanish rural population started migrating by 1860, due to demographic pressures and the decrease in rural workers' opportunities of being involved in occupations complementary to agriculture as industrialisation advanced. The appearance of foreign competitors in the markets of Spanish agrarian products accelerated this process at the end of the nineteenth century. However, the poor absorption capacity of Spanish cities meant that most peasant migration was only seasonal or very long distance (mainly to American countries). Only from the 1920's did the main Spanish cities start attracting population from

the network by lines with much lower potential impact. This can be observed in Graph 6.3, in the very small increase in the market potential of the main urban centres after 1866, and also in Graph 6.2, in the reduction of the average density of use of the system during the 1880's and 1890's, which was associated with the construction of little used lines. Actually, between 1881 and 1895, although freight transported by the railway system increased by 47 per cent, density of use remained stagnant due to the incorporation of lines with very low traffic.[453] As a consequence, the Spanish railway network turned out to be a very heterogeneous system, where a number of heavily used lines coexisted with a series of underutilised railways.

The difference between the lines built in the first wave of railway construction and the rest of the network is clearly noticeable in Table 6.10, which compares, for the beginning of the twentieth century, the density of use of the share of the network that had been constructed before 1873 with the density of the lines that were opened after that date.[454]

Table 6.10
Density of use of the Spanish railway network, distinguishing between periods of construction (1904/1905)

	Route-km	Thousand ton-km per route-km	Thousand passenger-km per route-km
Lines opened before 1873	7,482	247	166
Lines opened after 1873	5,672	103	89
Whole network	**13,224**	**185**	**132**

Source: *MAEOP*.

According to the table, railway construction after 1873 would have prevented for some decades the increase in the social returns of the network, due to the low level of utilisation of the new lines. Apparently, the railway lines in the second row of Table 6.10 would have been the result of a process of overinvestment in the Spanish railway network, which would be in line with some historians' suggestions. However, this hypothesis is still difficult to sustain, for two reasons. Firstly, it is unlikely that the use of the "core" railways would have been so high as it actually was

outside their hinterland in a significant way. On this subject see, for instance, Silvestre Rodríguez (forthcoming) and also, on external migration, Sánchez Alonso (2000a) and (2000b).

[453] That process has been highlighted by Pascual Domènech (1999b), pp. 463 and 484.

[454] Figures are not exact, because the *MAEOP* does not distinguish within the different lines of the networks of *MZA*, *Andaluces*, *MZOV* and *Asturias, Galicia y León*, which were only partially in operation in 1873. The networks of the first two companies have been included among the lines constructed before 1873, as most of

in the absence of the secondary lines, since these transported a large amount of traffic towards the most utilised railways.

But, secondly, it has to be remembered that railways in the nineteenth century were not only an instrument of economic growth, but performed very different roles. As has been pointed out, they were essential to guarantee food supply in certain areas in years of bad harvests, and they helped to improve communications among the Spanish regions, which was important on social and political grounds. This plurality of functions explains the consideration of railways as a public service by the State, as well as the interest of governments to extend them to the whole country, even through those areas where not enough traffic could be expected to make lines profitable.[455] Actually, equity and efficiency were in conflict precisely in those countries, such as Spain, with very sparsely-populated areas, in which railway lines could not be justified from a purely market perspective.[456] In this context, it is still difficult to speak of overinvestment, waste of resources or railway failure, because inefficient lines might be performing functions that were crucial from an equity point of view and for the economic development of the peripheral areas of the country.

6.5. Conclusions

This chapter has analysed evidence on the impact of railways on Spanish economic growth before the Civil War of 1936. The treatment of this subject in the historiography has been dominated since the 1980's by Gómez Mendoza's social saving estimates for 1878 and 1912, which were very high from a comparative point of view. In this chapter, a revision of those estimates has been carried out which has offered some interesting results. To start with, the use of

---

their mileage was already in operation at that date, whereas *MZOV* and *Asturias, Galicia y León* have been included in the other group for the opposite reason.

[455] The State's willingness to expand the network to the whole Spanish territory was patent from the 1860's. Whereas the initial 1855 Railway Act gave preference to the construction of the trunk routes from Madrid to the main ports and the frontiers, the 1870 and 1877 Acts reflected the wish to connect all Spanish provinces to the network, and also to reduce inequality among provincial railway endowments, according to the "theory of the dispossesed provinces" as Alzola y Minondo (1979), p. 420, called it. On this subject, see Mateo del Peral (1978), pp. 90-131, and Cordero and Menéndez (1978), pp. 169 and 193-194. Obviously, that policy reflected equity objectives at least as much as vote catching aims, as in the so-called "parliamentary" lines that were built in several countries; see Pratt (1908), p. 121. Similar policies were followed in other countries; see, for France, Leclerq (1990), pp. 53-54; for Italy, Giuntini (1999), p. 89; for Germany, Girard (1966), p. 238; and for the Nordic countries, Andersson-Skog (2000), p. 37.

[456] Evans (1991), p. 226.

alternative unit cost figures for railway and road transport, as well as the most recently available figures for Spanish GDP, has reduced the estimates of the social savings of freight transport from 7.5 to 2.5 per cent of Spanish GDP in 1878, and from around 20 per cent to around 12 per cent of GDP in 1912. These new percentages have been supplemented by preliminary estimates of the social savings of railway passenger transport, whose maximum level amounts to 0.6 per cent of GDP in 1878 and 1.4 in 1912.

The resulting total upper bound resource saving provided by the Spanish railways would be 3.1 per cent of Spanish GDP in 1878 and 13.4 per cent in 1912. Although the percentage for 1912 is not as high as in Gómez Mendoza's research, it would still be higher than in other European countries. On the contrary, social savings for 1878 are not far away from other available estimates. This would be inconsistent with the widely-accepted idea that social savings were higher in those countries, such as Spain, with few opportunities for water transport. This inconsistency, however, is only apparent, because the influence of the prominence of roads on the estimates for 1878 would have been overcome by the little importance of railway transport output within the whole economy.

Social saving figures have allowed an approximation to the social rate of return to Spanish railway investment, which may help to test some historians' hypotheses on the overinvestment and the resulting economic failure of the Spanish railway system. Actually, the preliminary estimates for the social rates of return of the Spanish railways in 1878 and 1912 do not confirm those hypotheses. Social gains from railways seem to have been high and positive even in 1878, largely exceeding both the private rate of return of the railway companies and the market interest rates. On the other hand, comparison of the social rates of return of Spanish railways with the available estimates for other economies provides a similar picture to the social saving analysis. Apparently, the Spanish railway social rates of return were similar to their level in other European countries in 1878, but they had become much higher by 1912.

These positive results seem to be in conflict with the negative outcomes of the growth analysis that was carried out in the previous chapter. However, evidence on market integration and the geographical reorganisation of the activity indicates that the problem lies in the extremely long time (up to 50 or 60 years) that the achievement of the full potential impact of railway investment would have taken. This is a lag that the available time series models are not able to grapple with. Therefore, the slowness of the response of the economy to the new opportunities helps to explain those negative results.

Finally, disaggregated information on the Spanish railway network has shown that the lines with the highest potential economic impact were built in the first wave of railway construction. Afterwards, the incorporation of new lines with very low levels of utilisation and rather small economic effects might have hindered the growth of the social rate of return of Spanish railways during the last decades of the nineteenth century. However, the extension of the network does not necessarily give the measure of the overinvestment in the Spanish railway system, given the diversity of functions that were performed by railways in nineteenth century societies. They were essential not only from a purely efficiency point of view, but also on equity grounds, if welfare was to be extended to the maximum amount of people. However, the low population density of many areas of the country led these two objectives to be in overt conflict in Spain and, once the first wave of railway construction had finished by 1866, railways started spreading to areas in which they could not be profitable by any means.

In this context, the measures adopted by the State to guarantee the financial viability of the railway lines became crucial. However, it is generally believed that Spanish railways were a failure from a purely private point of view. The next chapter is intended to analyse evidence regarding that failure in financial terms, as well as the State's role in the process.

APPENDIX

SPANISH RAILWAY COST FUNCTION

A.6.1 List of firms in the sample

Firm	Time period
Alar del Rey-Santander (ARS)	1867-1877
Alcantarilla-Lorca (AL)	1885-1935
Almansa a Valencia y Tarragona (AVT)	1869-1885; 1887-1890
Andaluces (A)	1878-1935
Argamasilla-Tomelloso (AT)	1914-1930; 1932-1934
Ávila-Salamanca (AS)	1904-1905; 1909-1922
Bobadilla-Algeciras (BA)	1892-1912
Baza-Guadix (BG)	1919-1935
Betanzos-Ferrol (BF)	1913-1923; 1925-1927
Bilbao-Portugalete (BP)	1888-1902; 1904-1927; 1929-1930; 1932-1934
Central de Aragón (CA)	1903-1935
Granollers-San Juan de las Abadesas (GSJ)	1881-1889
Lérida-Balaguer (LB)	1925-1930; 1933-1934
Lorca-Baza y Águilas (LBA)	1895-1901; 1903-1930; 1932-1934
Madrid a Cáceres y Portugal (y del Oeste) (MCPO)	1882-1927
Madrid a Zaragoza y Alicante (MZA)	1858-1935
Medina del Campo-Salamanca (MS)	1875-1928
Medina del Campo-Zamora y Orense-Vigo (MZOV)	1867-1928
Mollet-Caldas (MC)	1899-1927; 1929-1930
Norte (N)	1865-1935
Oeste (O)	1929-1935
Puebla de Híjar-Alcañiz (PA)	1904-1930; 1933-1934
Puerto de Santa María-Sanlúcar (PS)	1901-1916
Salamanca-Portugal (SP)	1888-1890; 1892-1928
Santander-Mediterráneo (SM)	1930-1935
Santiago-Carril y Pontevedra (SC)	1874-1926
Sur (S)	1899-1928
Sevilla a Jerez y Cádiz (SJC)	1867-1875
Soria-Navarra (SN)	1918; 1920-1930; 1932-1934
Tudela-Bilbao (TB)	1867-1877
Torralba-Soria (TS)	1892; 1895-1902; 1904-1922
Villaluenga-Villaseca (VV)	1927-1935
Valencia y Aragón (VA)	1890-1891; 1893-1930; 1932-1934
Zafra-Huelva (ZH)	1889-1935
Zaragoza a Pamplona y Barcelona (ZPB)	1867-1876

A.6.2 Sources of information

1) Cost

MZA, *Norte* and *Andaluces*' cost figures come from Anes Álvarez (1978), pp. 508-109, except for *MZA* in 1932 and *Andaluces* in 1876-1879, which have been taken from *AFT* and *MAEOP*, respectively.

For other firms, data come from *MAEOP* for 1857-1922, and from Ministerio de Obras Públicas (1940), vol. 4, pp. 12-65, for 1923-1935. Gaps have been filled, when possible, with information in *AFT* and Cambó Batlle (1918-1922), vol. 2, pp. 94-98.

2) Output

For *MZA*, ton-km and passenger-km figures come from the company's annual reports for 1858-1867, from Gómez Mendoza (1989b), pp. 293-294, for 1868-1912, and from Ministerio de Obras Públicas (1940), vol. 4, pp. 16-17, for 1913-1935.

For *Norte*, data come from Gómez Mendoza (1989b), pp. 293-294.

For the remaining companies, output figures are only available for 1897-1922 in *MAEOP* and for 1923-1935 in Ministerio de Obras Públicas (1940). For the period before 1897 (and also to fill in gaps in further periods), the procedure has been the following. Each company's total tons of freight and passengers transported (taken from *MAEOP*) have been multiplied by its average freight and passenger hauls of later periods. When this information was not available (because the firm had been absorbed by another one before 1897), assumptions about average hauls in Gómez Mendoza (1981), pp. 99-101, have been accepted. To avoid large biases resulting from this indirect procedure, freight and passenger revenues, also coming from *MAEOP* and Ministerio de Obras Públicas (1940), have been divided by the estimated output, in order to get average fares. When the result of that division was not consistent with the information on actual market fares in each period, output data have been dismissed. In addition, those companies with significant changes in their network length during the period before 1897 have also been excluded, since the average haul of their freight and passenger traffic cannot be assumed to have remained constant.

3) Network length

Figures of each company's yearly average network length in operation are available in *MAEOP*, *AFT*, Cambó Batlle (1918-1922) and Ministerio de Obras Públicas (1940).

4) Factor prices

Wages are taken from Reher and Ballesteros (1993) until 1905, and from Compañía de los Caminos de Hierro del Norte de España (1940) for the period after 1905, for which they have been calculated by dividing total labour expenses by the number of workers. Reher and Ballesteros' wage series is consistent with the few data available on railway wages in Juez Gonzalo (1992). Coal prices come from Carreras (1989b), pp. 216-218, for 1857-1879 and 1933-1935; from Coll Martín and Sudrià Triay (1987), for 1880-1911; and from the companies' own accounts, which are available in Anes Álvarez (1978), p. 450, for 1912-1932. The three series have been linked in a continuous price index. Iron prices come from Carreras (1989b), pp. 225-226.

A.6.3 Regression coefficients (complete set)

	(1) Fixed effects	(2) No fixed effects
Nº Obs	1,056	1,056
Adj. R^2	0.99	0.99
Constant	-19.919** (-7.409)	-1.562 (-0.901)
Time	0.009** (8.828)	0.001 (1.054)
Ton-km	0.905** (4.935)	0.730** (3.915)
Passenger-km	0.079 (0.486)	0.164 (1.056)
Network length	-0.815** (-5.930)	-0.521** (-4.752)
Labour price	2.502** (5.471)	1.230** (2.603)
Coal price	0.055 (0.154)	0.368 (1.011)
Iron price	0.443 (1.803)	0.037 (0.142)

Interaction terms		
Ton-km x Ton-km	0.083** (5.837)	0.106** (11.312)
Passenger-km x Passenger-km	0.037** (4.207)	0.053** (14.587)
Ton-km x Passenger-km	-0.058** (-3.229)	-0.110** (-10.183)
Network length x Network length	0.132** (10.408)	0.116** (20.882)
Ton-km x Network length	-0.170** (-8.956)	-0.162** (-12.041)
Passenger-km x Network length	-0.010 (-0.514)	0.023 (1.948)
Labour price x Labour price	-0.135** (-2.994)	-0.004 (-0.089)
Coal price x Coal price	0.076* (2.384)	0.069* (2.048)
Iron price x Iron price	0.171** (6.093)	0.248** (9.179)
Labour price x Coal price	0.119 (1.462)	0.181* (2.084)
Labour price x Iron price	-0.265** (-6.593)	-0.288** (-6.460)
Coal price x Iron price	-0.197** (-4.811)	-0.296** (-7.278)
Ton-km x Labour price	-0.096** (-3.805)	-0.060* (-2.241)
Ton-km x Coal price	-0.071* (-2.385)	-0.080* (-2.506)
Ton-km x Iron price	0.117** (4.325)	0.141** (4.876)
Passenger-km x Labour price	0.011 (0.510)	-0.001 (-0.041)
Passenger-km x Coal price	0.131** (4.482)	0.137** (5.272)
Passenger-km x Iron price	-0.059* (-2.401)	-0.082** (-3.491)
Network length x Labour price	0.166** (7.648)	0.118** (6.458)
Network length x Coal price	-0.010 (-0.499)	-0.017 (-0.843)
Network length x Iron price	-0.093** (-5.705)	-0.093** (-5.705)

Firm effects	
N	0.736
ARS	0.658
MZA	0.594
ZPB	0.590
AVT	0.467
S	0.424
SJC	0.397
A	0.357
O	0.240
BA	0.205
MCP	0.182
VV	0.146
ZH	0.135
BF	0.108
TB	0.084
LBA	0.060
MZOV	0.030
GSJ	-0.016
PA	-0.042
BP	-0.115
AT	-0.144
MS	-0.154
SC	-0.159
SP	-0.178
CA	-0.206
AL	-0.251
VA	-0.286
SM	-0.380
BG	-0.407
LB	-0.428
MC	-0.441
AS	-0.494
PS	-0.497
SN	-0.602
TS	-0.610

* 5% significance level.
** 1% significance level.

CHAPTER SEVEN

DID SPANISH RAILWAYS FAIL? SOME CONJECTURES ON THE SO-CALLED "PARADOX OF SPANISH RAILWAYS"

7.1 Introduction

As has been noted in the previous chapter, a number of Spanish historians have been reluctant to accept Gómez Mendoza's optimistic views on the economic impact of railways, because of the serious problems that the Spanish railway companies had to face during most of their lives. According to Gabriel Tortella, among others, the State's mistakes in the regulation of the railway construction process prevented the growth impact of railways from reaching its full potential and condemned the railway companies to a precarious situation during their whole existence. More specifically, this author indicates that the highly permissive character of the 1855 Railway Act provoked the excessively fast construction of most of the network and, as a consequence, serious deficiencies in design, the business structure of the sector, the companies' debt structure and the quality of infrastructure. As a result of those mistakes, demand was insufficient, traffic scarce and the financial results very poor once the lines had been built.[458]

Actually, this perspective inherently assumes that it is possible to imagine a counterfactual scenario in which, had the State's behaviour been more efficient, the network would have been utilised more heavily and the railway companies would have been more successful. In this context, this chapter has two main objectives. On the one hand, it is aimed at testing the hypothesis that financial results and the level of utilisation were lower in the Spanish railway system than could have been expected. To that aim, Spanish and European evidence regarding these two aspects is examined. On the other

[458] See, especially, Tortella Casares (1999), p. 250.

hand, the State's intervention in the railway system is analysed, also from a comparative point of view, in order to find out which anomalous aspects of the Spanish experience may have contributed to the allegedly bad financial situation of the companies. Together with the results of Chapter 6, this chapter is intended to shed some light on the so-called "paradox of Spanish railways".

The chapter is organised as follows. Firstly, Section 7.2 analyses the level of utilisation and the financial results of the Spanish railway system from a comparative point of view. Secondly, Section 7.3. suggests an interpretation of the State's role in the alleged failure of the Spanish railways. The main conclusions are summarised in Section 7.4.

7.2 Density of use and financial results in the Spanish railway system

As has been indicated, a number of Spanish historians have insisted that the level of utilisation and the financial results of Spanish railways were lower than they could have been, given the high potential benefits of the railway system in Spain. Gabriel Tortella, for instance, has contrasted the poor returns of the Spanish companies with the situation in countries such as France, Germany or the UK, in which railways were (in his own words) "magnificent" business.[459] Comín Comín and his co-writers have indicated that the State's mistakes were the main reason for the companies' critical financial situation, because expectations "*were very brilliant when the process started*."[460] And Keefer has expressed his surprise at the companies' inability to capture a larger share of the very high social saving of Spanish railways.[461] However, no systematic comparison with the situation in other European countries has been carried out to confirm the idea that the traffic or the companies' results were much worse than could have been expected. This section is intended to advance in that direction.

To start with, the density of use of the Spanish network has been said to be too low. According to the historiography, the reasons for the underutilisation of the network would have been diverse. Firstly, some authors have indicated that the radial design of the network was inadequate for the country's needs and made the link between production and

[459] Tortella Casares (1994a), p. 112.
[460] Comín Comín et al (1998), Vol. 1, p. 144 (my translation).
[461] Keefer (1996), pp. 174-175.

consumption centres difficult.[462] However, this conclusion has not been accepted by other historians, who consider that the radial framework adapted quite well to the previously existing road transport flows, and was the cheapest way to connect the whole country by rail.[463] Secondly, the establishment of a gauge different from most European railway networks has been considered to have put an additional burden on international transport flows, discouraging the use of international railway links.[464]

Thirdly, the density of use of Spanish railways would also have been reduced by the insufficient development of the network of secondary roads, which should have acted as conveyors of freight for the railways.[465] Fourthly, railway rates have been said to remain at too high levels as to stimulate traffic.[466] And, finally, the multiplicity of companies prevented the management of the whole railway network as an integrated system and imposed as a consequence an unfavourable cost structure, for both companies and users, which would have also discouraged the use of the network.[467]

However, in spite of all those problems, on the basis of the available evidence it is difficult to see that the density of use of the Spanish railways was much lower than it could have been given the level of development of the Spanish economy. Table 7.1 reports data on density of use for a sample of European railway networks, and Graphs 7.1 and 7.2

---

[462] See Nadal Oller (1975), pp. 48-50, Casañas Vallés (1977), p. 52, Hernández (1999), p. 419, or Broder (2000), pp. 77-78.

[463] Artola (1978a), p. 24, showed that the design of the main railway lines tended to reproduce the direction of the previous road traffic, on the basis of data on tolls (*portazgos*). Equipo Urbano (1972) found a high level of coincidence between the actual railway network and the theoretical optimal network which results from population and distances among urban centres. From the point of view of Cordero and Menéndez (1978), p. 173, the radial design was the cheapest way to connect the whole country with the railway network. These considerations have been accepted by Tortella Casares (1994a), p. 114, Gómez Mendoza (1997), p. 492, and Comín Comín et al (1998), Vol. 1, p. 11.

[464] See Cordero and Menéndez (1978), p. 188, Comín Comín et al (1998), Vol. 1, p. 59, and also Puffert (1995), p. 303, and Siddall (1969), p. 48. Moreno Fernández (1999) indicates the reasons that led to the initial adoption of the 1.67 m gauge instead of the much more usual 1.44 m "European" one, which ranged from the Spanish engineers' insufficient skills to the inefficiency of the Spanish political decision-making process. From the late 1860's, when the core of the network had already been constructed, the benefits of gauge reduction were always lower than the cost of the investment, due to the relatively low level of Spain's international trade; see Puffert (1995), p. 308, and (2000), pp. 942 and 956. In a curious text, Page y Saavedra (1854) supported the 1.67 m gauge by saying that: "*The passengers' lack of comfort due to the need to get off the train at the border will often be suffered by them within Spain and France if they change to a different company or for other reasons, because it is (and will be) impossible for a person to travel for 24 hours within a carriage in an uninterrupted journey from Paris to Madrid*." (p. 137, my translation).

[465] See, for instance, Cordero and Menéndez (1978), p. 179, or Pascual Domènech (1991), p. 264. These authors indicate that most existing roads ran parallel to the railway lines in the mid-nineteenth century and, as a consequence, they were not complementary but competed for the same traffic.

[466] On this subject, see below (Section 7.3).

[467] Comín Comín et al (1998), Vol. 1, p. 144. An extreme example of that situation was the journey from Murcia to Granada, which was divided at the beginning of the twentieth century in five parts that were served by five different companies; see Cuellar Villar (2001), p. 3.

compare those data with each country's level of income per capita.[468] According to that evidence, the degree of utilisation of Spanish railways (which is highlighted in the graphs) compared quite well with European standards. Apparently, the effects of the radial design, the difference in gauge with respect to Europe, the high rates, the lack of co-ordination among companies or the absence of secondary roads were not strong enough to bring down the density of use of the Spanish railways much below the European average.

Table 7.1
Railway density of use in some European economies
A) Freight transport (thousand ton-km per km of line)

	1871/1875	1881/1885	1891/1895	1901/1905
Belgium	321[a]	455[c]	597[f]	902[j]
Russia				742
Germany	371	448	550	721
England and Wales	384[b]	472[d]	552[g]	638[k]
Netherlands		233	303	425
France	420	392	352	417
Italy			133	250[l]
Switzerland		136	176	212
Spain	**124**	**169**	**139**	**186**
Sweden	102[b]	69[e]	85[h]	145
Finland	54	60	66	119
Denmark			64[i]	100
Norway	56	43	57	77
Bulgaria				61

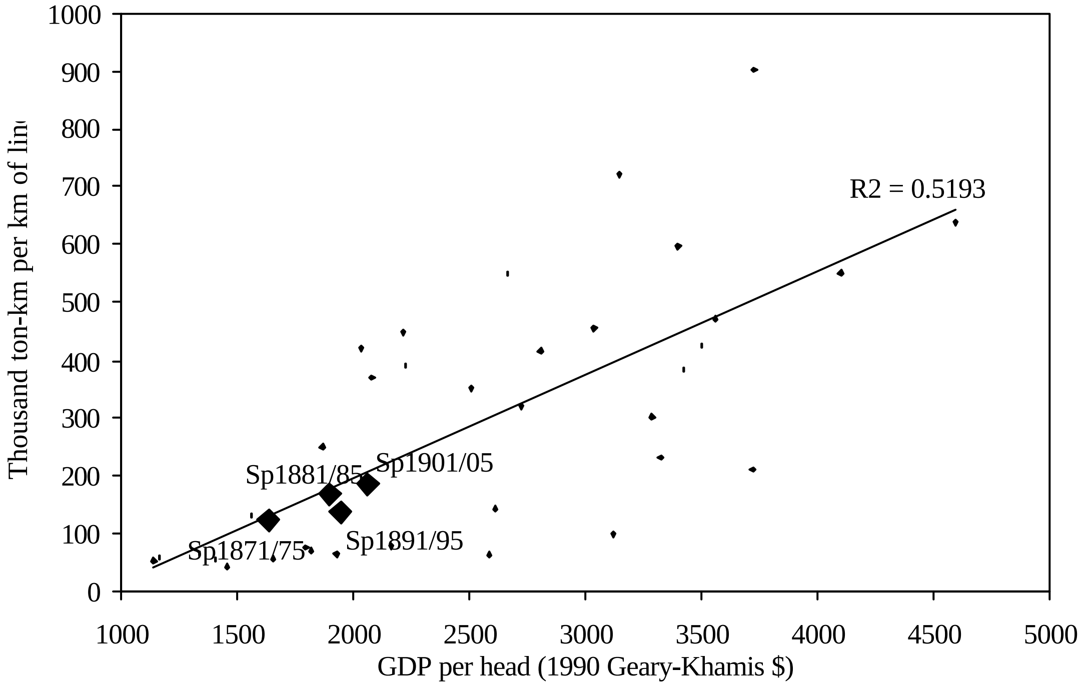
B) Passenger transport (thousand passenger-km per km of line)

	1871/1875	1881/1885	1891/1895	1901/1905
Belgium	254[a]	323[c]	421[f]	744[j]
England and Wales	256[m]		460[g]	678[k]
Germany	227	208	283	417
Netherlands		242	259	362
France	251	252	275	343
Switzerland		186	233	342
Russia				271
Denmark			148[i]	198
Italy			149	192[n]
Finland	87	67	64	130
Spain	**103**	**112**	**109**	**127**
Norway	72	56	82	105
Sweden	94[b]	46[e]	54[h]	80
Bulgaria				50

Sources: Mitchell (1998), except for Belgium, from Laffut (1983); England and Wales, from Cain (1988), pp. 124-125, and *Statistical Abstract for the United Kingdom*; Switzerland, from *Statistisches Jahrbuch der Schweiz*; Sweden in 1871/75-1891/95, from *Statistisk Årsbok för Sverige*; and Spain, for which output figures have been estimated as is indicated in Table 6.5.
Notes: (a) 1870 and 1875; (b) 1871; (c) 1880 and 1885; (d) 1880; (e) 1881; (f) 1890 and 1895; (g) 1890; (h) 1891; (i) 1893/1895; (j) 1900 and 1905; (k) 1900; (l) 1899 and 1905/1906; (m) 1870; (n) 1901/1903 and 1905.

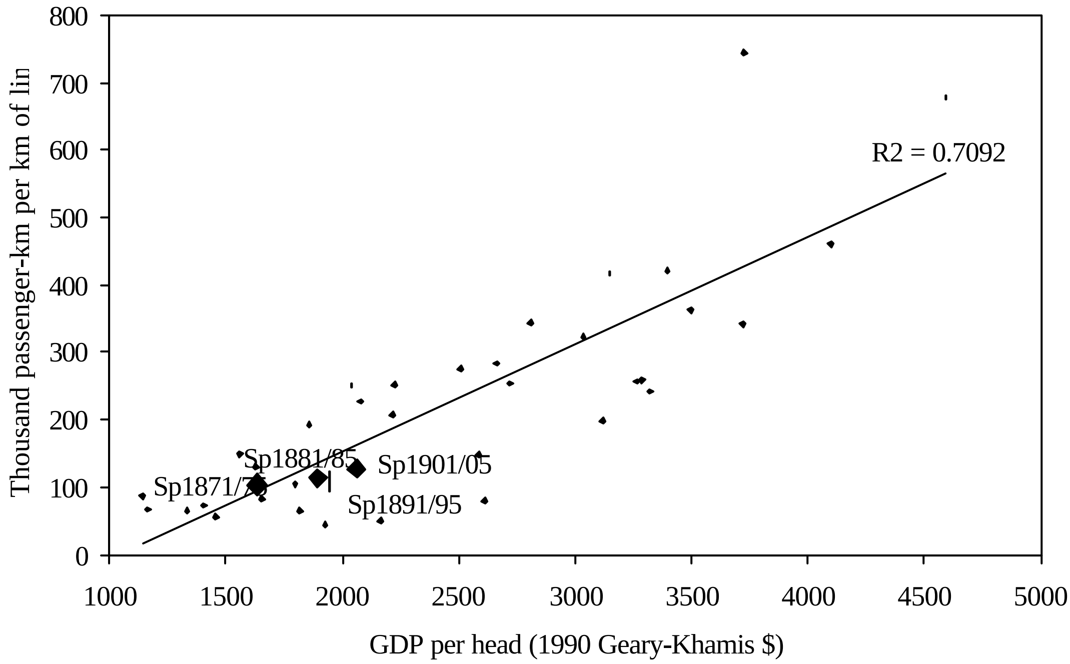
[468] Russia is not included in the graphs, because the characteristics of its traffic are not comparable with other European countries.

Graph 7.1
Freight railway traffic and income per capita in the European countries (1871/75-1901/05)



Sources: Table 7.1 and Maddison (1995b).

Graph 7.2
Passenger railway traffic and income per capita in the European countries (1871/75-1901/05)



Sources : Table 7.1 and Maddison (1995b).

Regarding the second major reason for Spanish historians' "railway pessimism", i.e. the low levels of the companies' returns, Table 7.2 reports two comparable indicators for a sample of European countries: the ratio between operation expenses and revenues, and the ratio between net revenues (receipts less operation expenses) and total capital cost of the networks.

Table 7.2
Private returns in European railways (1871/1875-1911/1913)
A) Operating ratio (working expenses/traffic receipts) (%)

	1871/1875	1881/1885	1891/1895	1901/1905	1911/1913
Austria	66[a]	57	56[b]	70[c]	75
Belgium[d]	64	61	58	63	70
Denmark				92[e]	81[f]
Finland[d]	80	67	66	85	73[f]
France	56	61	62	60	68
Germany[g]	59	57	61	64	68
Hungary			52[h]	56	65
Italy	60[i]	71	70	75[j]	84
Netherlands[k]			86	84	80
Norway	69[a]	72	76	80	75[f]
Portugal			43[l]	45[m]	
Romania	72[n]	62	70	59	
Russia		79[o]		65	
Spain	**46**	**44**	**45**	**49**	**48[f]**
Spain II[p]	**38**	**42**	**43**	**46**	**47**
Sweden	56	57	62	68	73
Switzerland	57[q]	53[r]	60	64	66
United Kingdom	52	52	56	62	63

B) Ratio of net receipts to capital costs (%)

	1871/1875	1881/1885	1891/1895	1901/1905	1911/1913
Austria	3.59[a]	3.26	3.83[b]	3.10[c]	3.25[s]
Belgium[d]		3.96[t]	4.66[u]	3.88[v]	1.24
France	4.76	4.33	3.60	4.06	3.68[f]
Germany[g]	5.49	4.52	4.90	5.64	5.98
Hungary				3.72[d]	
Italy		1.98[w]	1.66	1.52[j]	1.34[x]
Netherlands[d]			0.64	1.03[y]	-0.68
Norway	2.60[a]	1.63	1.70	1.59	2.17[f]
Spain				**4.36[z]**	**5.93[f]**
Spain II[a]	**4.19**	**5.04**	**4.53**	**5.52**	**6.53[f]**
Sweden	4.57	3.62	3.52	3.80	3.82
Switzerland	3.45[q]	3.26[r]	3.59	3.87	4.41
United Kingdom[β]	4.57	4.22	3.80	3.39	3.61[f]

Sources: Cambó Batlle (1918-1922); Mitchell (1988); Mulhall (1909); Pascual Domènech (1999a); Renkin (1904); Tedde de Lorca (1978); Toutain (1967); Webb, A. D. (1911); *AFT*; *MAEOP*; *MZA*'s annual reports (1871-1912); *Schweizerische Eisenbahn-Statistik* (1918); and Statistical Yearbooks of each country.

Notes: (a) 1870 and 1875; mixed Austro-Hungarian lines are included; (b) 1890 and 1895; (c) 1900 and 1905; (d) only State railways; (e) 1901-1902; (f) 1911-1912; (g) only broad gauge railways; (h) 1891-1894; (i) 1872-1875; (j) 1901-1903; (k) only the four largest companies; (l) 1891; (m) 1901 and 1905; (n) 1873-1875; (o) 1880; (p) only *Norte*, *MZA*, *Andaluces* and *TBF* (when available); (q) 1875; (r) 1883-1885; (s) 1913; (t) 1884-1885; (u) 1893-1895; (v) 1902; (w) 1881-1884; (x) 1911 and 1913; (y) 1905; (z) 1904-1905; (α) only *Norte*, *MZA* and *TBF* (when available); (β) on paid-up share and loan capital.

Although figures in Table 7.2 may not be entirely comparable, due to differences in the accounting procedures and in the quality of data among countries, they seem to indicate that the operating coefficients of Spanish railway companies were rather favourable in comparative terms, and produced net revenues which, relative to the invested capital, were quite high by European standards.[469]

This result, however, is not an indicator of financial success, because percentages in the second part of Table 7.2 must be compared with the opportunity cost of capital in each country. Since net operating revenues had to cover both the amortisation and the interest of the capital invested in railways, rates of 4 or 5 per cent could have been sufficient in countries rich in capital, but not in Spain, where the level of risk, the scarcity of resources, the underdevelopment of financial institutions and the continuous pressure of government debt issues kept the market interest rate at relatively high levels during most of the period under study.[470] Percentages in the table, for instance, compare badly with the railway companies' returns to bond capital, usually around 6 per cent,[471] or with the interest on mortgage loans or the State's debt (also at similar levels),[472] and they are much lower than the average financial returns of the Spanish corporate firms, which was around 8.9 per cent during the period 1880-1935.[473]

However, it must be stressed that financial weakness was not exclusive to Spain. On the contrary, in other European peripheral economies, such as Italy and the Nordic countries, or even in a very rich country like the Netherlands, railway companies were probably worse off than in Spain during the late nineteenth and early twentieth centuries.[474]

[469] It must be kept in mind, however, that data under the heading "Spain II" in Table 7.2 are an upper bound of the returns in the whole system, since they refer to some of the most profitable companies, as may be seen by comparing the figures for the whole network and for those companies in 1901/1905 and 1911/1913.
[470] On the influence of the State's lack of financial discipline on the level of Spanish interest rates during the period, see Martín Aceña (1994), pp. 144-145.
[471] Bond railway returns ranged from 6.1 to 7.2 per cent during the railway mania of the early 1860's and reached levels up to 9.5 per cent during the subsequent crisis. After the crisis, they remained at levels of 6 per cent or slightly lower; see Pascual Domènech (1999b), pp. 243-269 and 348.
[472] Ibidem, pp. 125 and 343. Yields on Spanish government long-term bonds were on average 5.16 per cent between 1883 and 1914, a substantially higher rate than in Britain, France or Italy during those years; see Martín Aceña (1994), pp. 163-164.
[473] Tafunell (2000). This author includes railways among the Spanish sectors of "very low returns"; see especially pp. 92-93, and return data for Spanish firms in pp. 106-107.
[474] For instance, for Finland, Jutikkala (1970), pp. 67-68, stresses the complete financial failure of Finnish railways since their origin and, for Sweden, Hildebrand (1978), p. 606, indicates that the situation of the Swedish railways was "*often precarious*" between the crisis of the 1870's and the end of the nineteenth century.

On the other hand, the private return figures in Table 7.2 are the average of very heterogeneous situations within each railway system. In the Spanish case, as was indicated in the previous chapter, the first long wave of railway construction, in which the "core" of the network was established, was followed by a longer period in which a large number of lines with relatively low utilisation levels were built. Obviously, the lower density of use of the later lines also corresponded to relatively poorer profitability prospects, as may be observed in Table 7.3.

Table 7.3
Private returns of Spanish railways (1904-1905)

	Km	Density of passenger traffic (thousand passenger-km per km)	Density of freight traffic (thousand ton-km per km)	Gross revenue per km of line (pesetas)	Net revenue per km of line (pesetas)	Working expenses/ Gross Revenue (%)	Net revenue/ capital cost (%)
Lines open before 1873	7,482	166	247	29,125	15,720	46	5.63
Lines open after 1873	5,672	89	103	13,422	4,667	65	2.20
Whole network	**13,224**	**132**	**185**	**22,313**	**10,926**	**51**	**4.36**

Source: *MAEOP*.

Figures in the table indicate that, at the beginning of the twentieth century, the "core" of the Spanish railway network benefited from relatively high returns by European standards. Actually, some of the "core" railway lines were profitable from a pure market perspective. The companies included in that group were the largest ones (*Norte*, *MZA* and *Andaluces*), whose lines linked the main Spanish urban centres (such as Madrid, Barcelona, Valencia, Bilbao or Seville) and ran through the wealthiest areas of Spain (such as Catalonia, the Basque and Valencian Countries and, to some extent, Western Andalusia). In contrast, the lines that were built after 1873 yielded on average extremely poor returns. That group mainly included lines that ran through rural and very sparsely-populated areas (such as Extremadura, Western Castile or the South-East of Spain) and did not link any important urban centres.[475]

[475] Similar situations may be observed in other countries. According to Aldcroft (1974), p. 34, and Leclerq (1990), pp. 53-54, a large share of the worsening of the returns of the British and French railway systems (which is noticeable in Table 7.2) may be attributed to the construction of secondary unprofitable lines.

Apparently, a counterfactual scenario with more heavily utilised railways and higher private returns, as suggested by the historiography, would only have been possible if a smaller network had been built, which excluded most of the lines that were constructed after the 1860's (i.e., around one third of the actual network). That alternative investment strategy might have resulted in a more profitable system from the point of view of the companies' returns. However, as has been indicated before, the presence of lines with low density of use and poor returns is to be expected in a country like Spain, where the existence of some very sparsely-populated areas necessarily gives rise to conflicts between efficiency and the public desire to extend cheap transport to the whole country.

In fact, the notion that railways were a public service that should be made available to the entire territory of each country was widespread during the second half of the nineteenth century. In many cases, such as the Spanish one, the public interest justification of some railway links resulted in the construction of unprofitable lines. Obviously, those situations were only possible due to the State's involvement. As railways were considered a matter of public interest in most countries, a wide variety of public measures were developed, from regulation to direct transfers of resources, which were addressed at guaranteeing their construction, the quality of the service they provided, a moderate level of fares and a sufficient rate of return on the private capital invested in the system, in those cases in which the market was not able to do so.

However, the European states did not achieve the same success in those aims. And the Spanish railways constitute one of the clearest examples of State failure. In Spain, public intervention was not able to guarantee either the return on share capital or the quality of the railway service. And, in fact, it is in the failure of the State that the main reason for the widespread contemporary and historiographical "railway pessimism" can be found. To sum up, unlike Tortella and others' views, it does not seem possible to accept that, in the case of Spanish railways, traffic and returns were lower than could have been expected. Actually, they were as low as they "should" be, and what seems to have been lacking in Spain is an efficient public sector to underwrite the welfare of the companies' shareholders and the users of the railway system. The next section examines the failure of the Spanish State.

7.3 Did Spanish railways fail? A public service in an underdeveloped State

In most European countries, the State's intervention in the railway system, which took place through regulation and transfer of resources, was designed to guarantee construction, the quality of service, a moderate level of users' fares, and sufficient returns to private capital. Apparently, in the Spanish case, only the first objective was attained. Railways were constructed but, once in operation, service was precarious and fares too high, and returns on the companies' shares remained much lower than the Spanish market interest rate.[476]

The most likely origin of the inefficiency of public regulation was the poor financial situation of the Spanish State. As has been pointed out by research on the Spanish public sector, during the nineteenth century the social and political structure of the country prevented the establishment of a tax system that was sufficient for the needs of the economy.[477] Apparently, in the case of the railway system, the lack of public resources was compensated in two main ways: i) by allowing share capital to receive returns lower than the market level; ii) by minimising public control over the railway companies, letting them decrease the quality of service and apply relatively high fares. In other words, the missing public resources were obtained from the "indirect taxation" of two social groups: the original shareholders and the users of the service.[478] The remainder of this section offers some evidence on those two processes.

Unlike what happened in most European countries, the Spanish State left the railways entirely in the hands of private companies until the 1920's.[479] A concession regime was the basis of the system from the first public regulation of the new transport means (the 1844 *Real Orden*), which never contemplate seriously the possibility of public ownership.

[476] Obviously, all those problems were not exclusive of Spain. See, for instance, for Italy, Fenoaltea (1983).
[477] See, for instance, Comín Comín (1996), pp. 121-124.
[478] This idea is in line with Artola's conclusion that the objective of Spanish governments was "*to give the country a railway network at the lowest possible cost to the taxpayer although not to the investor*"; see Artola (1978b), p. 366 (my translation). A similar situation, in which the "indirect taxation" to users replaced an adequate tax system, has been described for Prussia between the 1880's and 1914 by Fremdling (1980), although under very different circumstances, since in that country the surpluses of the rather well-off state-owned railways constituted a direct revenue for the Prussian public budget.
[479] According to Cambó Batlle (1918-1922), Vol. 5, pp. 463-464, the shares of the railway network that were state-owned in the European countries by 1910 were the following: Germany, 91 per cent; Bulgaria, 89 per cent; Romania, 88 per cent; Italy, 84 per cent; Norway, 81 per cent; Austria-Hungary, 80 per cent; Serbia, 72 per cent; Switzerland, 58 per cent; Denmark, 56 per cent; Netherlands, 54 per cent; Belgium, 51 per cent; Portugal 37 per cent; Sweden, 31 per cent; France, 20 per cent; and United Kingdom, Spain and Greece, 0 per cent.

On the other hand, in that earliest regulation, the lack of clarity on the matter of public subsidies gave birth to a highly discretionary policy, which opened up great possibilities for speculation, as the State's involvement in each project depended on the political influence of promoters.[480] Later on, a number of decrees in the early 1850's clarified the issue to some extent by guaranteeing a fixed 6 per cent interest rate on the companies' capital during the period of construction of the line, and the difference between 6 per cent and the companies' rate of return thereafter, as well as an annual 1 per cent as amortisation.[481] However, the absence of a General Railway Act before 1855 preserved the discretionary character of the State's involvement during those years, and asymmetric information and the close links existing between politicians and promoters made it very easy for the latter to expropriate the State in the process.[482] In addition, the guarantee of interest seems to have given rise to intense Averch-Johnson-type overinvestment processes in that initial stage of railway construction.[483]

In that context, the 1855 Railway Act was an attempt to stimulate construction and, at the same time, eliminate discretionary subsidies and speculation. The system established in 1855 was maintained in the subsequent 1870 and 1877 Acts and constituted, therefore, the basic framework within which most of the Spanish railway system operated until the first decades of the twentieth century.

The 1855 Act consolidated a regime of concessions according to which railways were ultimately publicly owned but would be built and operated by private companies during a period of 99 years; at the end of that time, they would revert to the State. The

480 Actually that problem was worsened because, in the 1844 *Real Orden*, preference in concessions was granted to "well known and established individuals".

481 On the Spanish railway regulation before 1855, see Mateo del Peral (1978), pp. 31-87 and 133-143, Artola (1978b), pp. 341-436, or Comín Comín et al (1998), Vol. 1, pp. 37-54.

482 Examples of that situation are the high profits that were obtained by José de Salamanca (who was Minister of the Spanish government several times during those years), or the Duke of Riánsares (second husband of the Spanish Queen Mother) in the promotion of railway lines. In fact, speculation transformed the railway policy into one of the reasons for the 1854 Spanish revolution. On José de Salamanca's involvement in railway investment see, for instance, López-Morell (2001).

483 As Averch, Johnson and Wellisz, among others, have pointed out, the use of a "fair rate of return" criterion in the regulation of firms that provide services subject to public control, may induce them to adopt an excessively capital-intensive technology and to take on additional business, if necessary, at unremunerative rates. That expansion of investment and output may produce inefficient results from the society's point of view, since the social benefits of new investment may fall short of its social costs. This type of process was described in detail by Averch and Johnson (1962) and Wellisz (1963); a survey on this issue may be seen in Khan (1988), Vol. 2, pp. 49-59. In the case of Spanish railways, Hernández (1983), pp. 79-80 and 131-176, gives some examples of overinvestment in the main line of *AVT*, which was one of the few railways that benefited from the guarantee of interest; see also Artola (1978b), pp. 346-348.

matter of public subsidies to the railway companies was left open in the text,[484] and from 1855 onwards the most usual aid was a lump-sum subsidy for construction, which was to be paid in negotiable State bonds.[485] Its level was established through an auction system, in which the concession of each line was granted to the applicant that asked for the lowest subsidy.[486] In the context of the financial problems of the Spanish public sector, that system was intended to keep the State contribution at just a sufficient level as to guarantee the construction of the network by the private sector, but avoiding any waste of public resources.[487]

However, immediately after the system was established, auctions for concessions became overcrowded. That situation was not surprising once the institutional framework had been clarified since, all over Europe, railway construction was an activity which yielded substantial profits to promoters. As a consequence, the final level of subsidies was too low to guarantee returns on share capital at the market level. Actually, in some of the lines with better profitability prospects as, for instance, the Seville-Cadiz line and most Catalan railways, the final result of the auctions was the total absence of subsidies in the concession contract.[488]

As a result of the auction system, direct public subsidies until 1863 amounted to 28 per cent of the *ex-ante* construction cost estimates.[489] However, the actual direct State contribution to railway construction was substantially lower than that percentage, for two reasons. Firstly, a large share of those subsidies was paid in public debt, which was usually

[484] According to the 1855 Act, the State's subsidies could consist of the direct construction of some works, lump-sum subsidies or guarantee of interest; see Casares Alonso (1973), p. 91.
[485] The matter of subsidies was not substantially altered in the 1870 and 1877 Railway Acts; see Mateo del Peral (1978), pp. 155-157. Lump-sum subsidies were accompanied from the beginning by some indirect subsidies, such as tariff and tax exemptions, which, according to some research, had greater effects on the companies' results than the direct subsidy itself; see ibidem, p. 159, and Artola (1978b), pp. 366-379.
[486] On the other hand, applicants used to be different from the final companies which would carry out the line construction and operation. These were only constituted, and financial resources collected from the capital market, once concessions had been obtained and the lump-sum subsidy level had been established. In other words, the determination of the level of subsidies was previous and independent of the companies' share and bond issues; see Tedde de Lorca (1978), pp. 13-14.
[487] The advantages for the State of a system of lump-sum subsidies that were paid in public debt, compared with the guarantee of interest are illustrated in Artola (1978b), pp. 358-360; see also Hernández (1983), pp. 92-93, and Comín Comín et al (1998), Vol. 1, p. 57.
[488] See Broder (2000), p. 295, and Pascual Domènech (1999b), p. 161.
[489] Comín Comín et al (1998), Vol. 1, p. 98.

quoted under its nominal value.[490] And, secondly, *ex-ante* estimates were greatly exceeded by the actual costs of construction of the lines.

According to Cordero and Menéndez's analysis of a sample of lines, the actual costs of railway construction were 54 per cent higher than *ex-ante* estimates.[491] Although engineering mistakes could have been the origin of some mismatch between estimated and actual costs,[492] such a huge miscalculation is rather unlikely. In fact, there seems to be clear evidence that the final construction cost figures were artificially increased by promoters during the process of railway building, as a direct way to extract rents at the expense of future profits.[493] Keefer's recent research has shown that the cost of grading, bridges, tunnels and ballasting of the lines of *Norte* and *MZA* was 8 to 39 per cent higher than would have been expected according to contemporary technical information.[494] This result has confirmed suspicions (widespread in the historiography and among contemporaries) that a high level of fraud was present in the process of construction of the Spanish railways.[495] Actually, this was possible due to the State's lack of control over the construction process,[496] as well as its generous attitude towards the companies' capacity to issue bonds.[497] These were the first signs of the State's generalised permissiveness, which acted as a substitute for public investment.

As could be expected, high construction costs, low direct subsidies and the parallel increase in the companies' leverage ratio, resulted in negative returns for the companies'

[490] Artola (1978b), pp. 356-366. In addition, as this author indicates, in 1882 the government unilaterally consolidated the debt bonds as perpetual assets at a lower interest rate than the original ones.
[491] Cordero and Menéndez (1978), p. 264; see some contemporary complaints about that mismatch in *Revista de Obras Públicas*, 14, 7, (1866), pp. 79-80, or in Page (1871), p. 132.
[492] Actually, some mismatch could not be avoided, because estimates were based on official valuations of commodities (coming from the Spanish tariff regulation), rather than actual market prices. I thank Pere Pascual Domènech for this information.
[493] In fact, artificially increased construction costs characterised the process of railway building in most countries; see Debande (1997), pp. 207-211, and also, for the British case, Kenwood (1965), p. 314; for the US, Fishlow (1965), p. 179, and Fogel (1960), p. 54; and for Portugal, Pinheiro (1979), p. 284.
[494] Keefer (1996), pp. 187-188.
[495] See, for instance, Tortella Casares (1973), p. 78, Nadal Oller (1975), p. 46, Tedde de Lorca (1978), pp. 118-120 and 235 and (1980), pp. 34-35, Hernández (1983), pp. 52-53 and 382-398, Veiga Alonso (1999), pp. 593-594, López-Morell (1999), pp. 682-683, Pascual Domènech (1999b), pp. 259, 315-316 and 352-353, Comín Comín et al (1998), Vol. 1, p. 142, or Hernández (1999), pp. 418-421, as well as some contemporaries' considerations in Mateo del Peral (1978), p. 153, *Revista de Obras Públicas*, 14, 5 (1866), pp. 49-55 and 79-80, or Sánchez de Toca (1911), pp. 152-153.
[496] See, for instance, Comín Comín et al (1998), Vol. 1, p. 144, and Veiga Alonso (1999), p. 594.
[497] The legal limit to issue bonds was, at the start, 50 per cent of the sum of paid-up share capital and subsidies. It was soon extended until 200 per cent of that amount, allowing at the same time the inclusion of tariff exemptions within subsidies for the calculation. Finally, in 1868, due to the deep French and Spanish financial crises, the legal limit was replaced by a discretionary policy in which each company's applications for bond issues were dealt with individually; see Broder (2000), p. 76, Casares Alonso (1973), pp. 98 and 267, or Nadal Oller (1975), pp. 42-43.

share capital. During the period 1859-1913 the average return distributed to shareholders was 2.09 per cent in the case of *Norte*, 2.16 per cent in the case of *MZA* and 2.11 per cent in the case of *Andaluces*.[498] For the Catalan lines, Pere Pascual has recently calculated the average returns on share capital when the changes in the nominal value of the assets that took place with the successive companies' mergers are considered. His results indicate that the share capital of the three companies that would constitute *TBF* (later to be absorbed by *MZA*) received an average dividend of 2.30, 3.20 and 4.11 per cent, respectively, during the period 1849-1935. And in the *Compañía del Ferrocarril de Barcelona a Zaragoza* (which was later integrated in *Norte*) the average dividend amounted to 1.46 per cent of the share capital during the same years.[499] These examples give an upper bound for the returns that railway shareholders obtained from their assets, since *Norte*, *MZA*, *Andaluces* and the Catalan lines were among the most profitable railway undertakings in the country, all of them being included in the first row of Table 7.3.[500]

The reported percentages were clearly below the 6 per cent interest rate that private capital could expect from the Spanish financial market. However, in spite of the poor profitability prospects of the Spanish railway companies, share issues found enough subscribers, at least during the first wave of railway construction. Several circumstances may explain that surprising behaviour. The first reason was obviously the fact that a substantial proportion of share capital was bought by the promoters themselves, who expected to get their returns by means other than dividends. Apart from the fact that the promoters' subscription to shares was under privileged conditions,[501] they were interested in management control as a way to pursuit personal (non-profit maximising) objectives and treat themselves preferentially at the expense of small investors.[502] This helps to explain

[498] *El problema…* (1933), p. 133, and Tedde de Lorca (1980). The figure for *Andaluces* corresponds to the period 1878-1913, since that company was established in 1877.
[499] Pascual Domènech (2000), pp. 17-21.
[500] An example of the situation in other companies is the case of *Sur*, which was the eighth Spanish company in route-miles, and in which no dividend was distributed ever in the whole life of the company; see Cuéllar Villar and Sánchez Picón (1999), p. 626.
[501] See, for instance, Hernández (1983), pp. 231-232.
[502] See Schleifer and Vishny (1997). Personal objectives might be achieved, for instance, "*by paying themselves special dividends or by exploiting other business relationships with the companies they control*" (p. 758-759); according to Comín Comín et al (1998), Vol. 1, p. 324, such situations would have been frequent in the Spanish railway companies. For instance, Rodrigo y Alharilla (1999), p. 701, has stressed the importance of the demands from *Norte* for other business of the Marquis of Comillas, which was one of the main shareholders of the company during the 1880's. And in the case of foreign promoters, some authors have insisted on the profits they could obtain from the supply of materials or the negotiation of shares and bonds in the French and Belgian markets; see Nadal Oller (1975), pp. 42 and 46, Pascual Domènech (1999b), pp. 24-25 and 259, or López-Morell (1999), pp. 687-690, who offers a detailed description of the benefits that the Rothschild obtained from the promotion of *MZA*.

the fact that the Rothschild and the Péreire families kept their majority position in *MZA* and *Norte* at least until the First World War, in spite of the low profitability prospects of those two companies.[503] And, in fact, situations of overt conflict between the interests of large and small shareholders were not unknown in those firms.[504]

On the other hand, the presence of large European financial institutions in the companies could also have stimulated the acquisition of railway shares by individuals, acting as guarantee for small investors with incomplete information on the new companies' prospects.[505] In the Spanish case, for instance, the intervention of Rothschild and Péreire was crucial for the placing of the first railway share issues on the French markets.[506] Similarly, the Spanish State's support was also fundamental in the process, for two reasons. Firstly, although no interest rate was guaranteed to share capital, the State's intervention was taken by investors as an indication of lower risk.[507] And, secondly, the State's approval of the promoters' projects, including the acceptance of their over-optimistic estimates of future transport demand, was misleading for private capital.[508]

Initially, subscriptions to shares were also relatively easy because promoters guaranteed yearly dividends to the first issues during the period of construction of the lines.[509] Obviously, that procedure attracted investors but, at the same time, further jeopardised the companies' future by increasing construction costs. Finally, in addition to all those factors, there is no doubt that the first wave of Spanish railway construction benefited from an atmosphere of exaggerated optimism and a speculation bubble, which

---

[503] In 1901, the Rothschild owned 41 per cent of the share capital of *MZA* and the Péreire 29 per cent of the share capital of *Norte*; see Comín Comín et al (1998), Vol. 1, pp. 317-320.

[504] The most clear situation of overt conflict took place in *MZA* when *TBF* was taken over in 1897 because, once in their new company, *TBF* old shareholders started claiming for higher dividends than those usually distributed by *MZA*; see Comín Comín et al (1998), Vol. 1, p. 326.

[505] In infrastructure projects, "*the participation of banks has an effect of signalling, which makes it easier to finance the project by issuing shares*"; Debande (1997), p. 205.

[506] See Hernández (1983), p. 53, or López-Morell (1999), p. 681. The proportion of share and bond capital of the Spanish railway companies that was sold in foreign markets has been estimated at 60 per cent of the total. Obviously, not all this percentage was bought by foreign investors, but part of it was acquired by Spanish agents abroad; see Tedde de Lorca (1980), pp. 32-33, Gómez Mendoza (1989a), pp. 73-78, or Comín Comín et al (1998), Vol. 1, p. 143. See also Platt (1984), p. 131, who estimates the proportion of capital that was actually subscribed by foreigners as 40 per cent of the total.

[507] Cubel Montesinos and Palafox Gamir (1999), p. 26. Sampité (1888), p. 488, indicates, on the French secondary railways, that State intervention might have reduced the bond interest rate from 6 to 7.5 per cent until 5 to 5.25 per cent.

[508] Actually, mistakes in traffic forecasts were not only the result of over-optimism but also reflected the engineers' difficulties to know the actual economic potential of the areas which would be crossed by future lines, due to the unavailability of information. In this regard, Cordero and Menéndez (1978), pp. 201-202, indicate that engineers often replaced sound economic analysis by rough considerations on the "enormous wealth" of the area crossed by the future railway.

[509] That procedure was usual in most European countries; see Pascual Domènech (1999b), p. 205.

was not exclusive to the Spanish case and caused the short-term overvaluation of the Spanish railway projects.[510]

Nevertheless, the situation was soon corrected by the market. On the one hand, after the crisis of 1866, the Spanish railway companies' shares were quoted under their nominal value during most of their life. For instance, in the case of the Catalan railways, which were among the most profitable in the country, the average market price of the different companies' shares during the period 1849-1935 amounted to a percentage between 38 and 92 per cent of their nominal value (depending on the firm). As a consequence, as has been pointed out by Pere Pascual, resources invested in the acquisition of railway shares on the Barcelona stock exchange after 1866, yielded profits close to the market interest rate.[511] In other words, whereas most of the investors that bought their shares at market prices after construction did not suffer any significant erosion in the value of their investment, the original subscribers of share capital had part of their resources expropriated due to the shortcomings of the State's intervention.

However, the highly frustrating experience for shareholders in the 1860's, as well as the fact that the new lines under construction had still lower profitability prospects, made potential investors highly reluctant to accept new share issues.[512] As a consequence, after the first wave of railway construction, the importance of share capital gradually decreased, and bond capital, which had already been important before 1866, became the essential source of funds. The result was an increasing ratio between bond and share capital in the railway system, from 1.1 in 1864 to 1.9 in 1891.[513]

---

[510] See Schleifer and Vishny (1997), p. 750. According to Wellington (1898), p. 30, in the context of nineteenth century railway construction, bubbles were "*all but unavoidable*". On the Spanish case see, for instance, López-Morell (1999), p. 670. After the first wave of railway construction, a second short episode of over-optimism took place in the Barcelona capital market in the period 1879-1882, in which, despite the companies' previous financial failure, demand for railway shares was much higher than supply; see Pascual Domènech (1999b), pp. 346 and 426.

[511] Pascual Domènech (2000), pp. 24-30.

[512] For instance, Pascual Domènech (1999b), p. 347, indicates that after the 1866 railway crisis it was no longer possible to issue shares at their nominal value in the Barcelona stock exchange, except for the years 1879-1881.

[513] Nadal Oller (1975), p. 43. Those ratios, however, are not too high according to the historical experience of infrastructure construction in less developed countries, which usually involves a high level of risk. Eichengreen (1994), pp. 21-22, indicates that, in a context of imperfect information, a high leverage is necessary to attract capital, although it increases the problems of adverse selection and moral hazard; see also Wellington (1898), pp. 29-30, and Baskin (1988), pp. 215-219, and for the French case, Caron (1983), p. 29, who estimates, for the French railways, a leverage ratio of 4 in 1880. On the other hand, Tedde de Lorca (1978), p. 35, among others, indicates that the increase in the leverage ratio was also related with the promoters' desire to keep control of the companies' management; see also Baskin (1988), p. 220.

Apart from the original shareholders, the lack of public resources also put unexpected burdens on the railway users. Once operation had started, the lack of State control over the companies had two main features. On the one hand, companies seem to have benefited from a virtual freedom in the establishment of fares at least until the First World War. On the other hand, their renewal and improvement investments were clearly insufficient, specially after the last few years of the nineteenth century. The next paragraphs offer some evidence on these two problems.

There is unanimity among historians and contemporaries on the fact that the legal maximum rates were kept, at least until 1914, at such a high level that, in fact, the companies had no restrictions on their fare policy.[514] The original concession terms provided that maximum rates would only be reduced if the companies' returns were higher than 12 or 15 per cent of the value of their capital. Obviously, such returns were not attained during the whole period under study.[515]

In fact, the preservation of the excessively high original regulatory rates is consistent with the gradual increase in the maximum legal leverage ratio of the Spanish railway companies. The establishment of a virtual freedom to set rates helped to avoid the financial distress that the regulated companies could have suffered with the increase in bond capital, while minimising State contribution.[516] In that context, according to some researchers, the strategy of the main companies consisted of establishing rates at the maximum possible level, especially on the most densely-utilised lines, under the assumption that the elasticity of transport demand was very low.[517] Obviously, the only exceptions arose when competition from other transport means was possible, as in those short-distance routes where roads could compete with railways. In those situations, a system of special rates was adopted, in order to attract traffic.[518] Only when some

[514] See, for instance, Sánchez de Toca (1917), p. 60, Casares Alonso (1973), p. 391, and Artola (1978b), p. 391. This author indicates that the first "provisional" maximum market rates seem to have resulted from the direct conversion of the French rates to Spanish currency, with no reference to the Spanish purchasing power level. An excessively high level of the maximum legal rates has also been pointed out for the Italian railways in Fenoaltea (1983), pp. 86-87.
[515] According to Artola (1978b), p. 394, attempts to avoid that level of returns led some companies to increase artificially the level of their capital accounts.
[516] This idea was already advanced by Anes Álvarez (1978), pp. 393-395, and Gómez Mendoza (1981), p. 202. See also Dasgupta and Nanda (1993), or Spiegel (1994).
[517] See, for instance, Alzola y Minondo (1884-1885), 33, p. 6, and also Tortella Casares (1973), pp. 190-191, Comín Comín et al (1998), Vol. 1, p. 218, or Hernández (1999), p. 420.
[518] For instance, in the case of grain transport between Castile and Barcelona, *Norte* applied a special rate system to bring traffic away from the route through the Canal of Castile, the Santander railway and along the Peninsula coastline; see Pascual Domènech (1999b), pp. 455-456, 469 and 480, Barquín Gil (1997), pp. 43-44, and Moreno Lázaro (2000), pp. 17-20.

indications of a higher demand elasticity emerged, in the first years of the twentieth century, did the companies start applying substantial reductions in the market rates.[519]

The Spanish State also seems to have replaced financial contribution with a lower control over the system with regard to the quality of the companies' transport services. During the whole second half of the nineteenth century, the State railway inspection service was criticised for its inefficiency, and public inspectors were even blamed for behaving as companies' employees.[520] As a result of the companies' virtual freedom, the quality standards of Spanish railway transport were rather low. Complaints about the bad quality of the service can be traced back to 1865, and the measures taken by the government to sort out problems were in general ineffective.[521] Some reports of the 1870's and 1880's point out that commodities had to wait at the railway station for several days until they could be delivered, even in the case of livestock,[522] and in some extreme cases, delays of two months were reported.[523] Those problems gradually worsened from the 1890's, when the growing need to renew assets that were reaching the end of their useful life coincided with a significant rise in transport demand and with the increase in the companies' financial costs due to currency depreciation, as a large share of bond returns had to be paid in francs.[524]

In that context, the response of the companies was a clearly inadequate investment policy. As a consequence, from the last few years of the nineteenth century, the shortcomings of the companies' equipment and infrastructure became more and more evident. Firstly, double track was absent from the main trunk routes, which jeopardised the development of traffic by preventing an increase in the daily number of trains. In fact, the need for double track was already evident in the 1880's in the most heavily-utilised line of the system (the route Madrid-Irún towards Paris), and Pablo de Alzola directly attributed its absence in that line to the government's lack of control over the companies.[525] Secondly, the rolling stock of the main railway companies was also considered by the

[519] Pascual Domènech (1999b), pp. 494-496. As is described below, the situation was completely altered by the inflation process of the First World War, after which the legal maximum rates turned out to be too low for the companies to survive.
[520] Casares Alonso (1973), pp. 396-400.
[521] Cordero and Menéndez (1978), pp. 319-320.
[522] See Artola (1978b), p. 401, and Anes Álvarez (1978), p. 475.
[523] Gómez Mendoza (1999a), p. 724.
[524] See, for instance, Sánchez de Toca (1895), pp. 38-42, Casares Alonso (1973), p. 159, and, especially, Tedde de Lorca (1978).
[525] Alzola y Minondo (1884-1885), 33, p. 234; see also Vega Armentero (1884), pp. 32-34.

1890's to be totally insufficient to meet the country's transport needs.[526] Later on, in 1912, in spite of some attempts to improve the situation, the actual traffic demand seemed to have exceeded the capacity of the railway system by far,[527] and the quality of service was so low that the Local Council of the city of Almería, for instance, went so far as to head a one-day general strike against the local railway company.[528]

Representatives of the railway companies insisted that those shortcomings were the unavoidable result of the low density of use of the network.[529] However, other contemporary opinions pointed out that the situation was the result of the companies' bad financial situation, which could be partly attributed to State policy mistakes.[530] Actually, a different investment strategy would have been unlikely in the Spanish context. As has been pointed out, the State railway policy, which had been oriented to minimising the public contribution to the system, had constrained the companies' returns to very narrow limits. On many occasions, the payment of the interest on the bond capital excluded any investment in asset renewal or improvement. When the companies' situation was better, it was necessary to choose between offering some returns to shareholders or improving the companies' equipment. Large capital expenditures were discouraged because they would have had to be financed to a large extent by additional bond issues. As the end of the concession period became closer, issuing new bonds would have required the application of growing amortisation rates on the bond capital, which would have gradually reduced the companies' yields and, in the medium term, would probably have prevented interest payments to bonds.[531] In that context, the inefficiency of the State control over the companies' activity increased the probability that the companies would apply an inadequate investment policy.

---

[526] See Cordero and Menéndez (1978), p. 300.
[527] Rodríguez Saiz (1979), p. 447. The insufficiency of rolling stock renewal during the period 1906-1922 is pointed out by Cordero and Menéndez (1978), pp. 293-299. For instance, according to these authors, 30 per cent of *Norte* locomotives were more than 50 years old in 1924, and 50 per cent were more than 30 years old.
[528] Cuéllar Villar and Sánchez Picón (1999), p. 636.
[529] See, for instance, Maristany y Gibert (1889), p. 3, or Peralta (1891), pp. 366-369. That opinion was accepted by Boag, who indicated in 1923 that: "*None of the main trunk lines have ever had a traffic sufficiently productive to warrant heavy expenditure on improved location and the consequence is a general low average of speed*"; Boag (1923), p. 2.
[530] See, for instance, Sánchez de Toca (1895), pp. 37-38 and 124-125, who indicates that the application of a strict State control over the companies' operation would have led them to bankruptcy.
[531] See Olariaga (1921), p. 147, *El problema…* (1933), pp. 16-17, Artola (1978b), pp. 416-417 and 423, Casares Alonso (1973), p. 277, Iglesias (1981), p. 157, Tortella Casares (1994a), p. 113, Comín Comín et al (1998), Vol. 1, p. 282, or Broder (2000), p. 269. Reduction of the quality of the service as the end of the concession term gets closer is a typical feature of transport companies when public control is not efficient; see, for instance, De Rus (1999), p. 9. This author indicates that strict public control increases the risk

In fact, the companies' choice was equivalent to supporting the level of the returns on share and bond capital in the short term, at the expense of the long term viability of the firm. Actually, that behaviour only made sense if the companies regarded the theoretical public ownership of the lines as an ultimate guarantee for the survival of the system. In other words, the railway companies' behaviour corresponded to a large extent to a "looting" strategy, according to which the lax regulation of the railway system gave the agents that controlled the companies "*an incentive to pay themselves more than their firms [we]re worth and then default on their debt obligation*". In other words, they "*acted as if future losses were somebody else's problem*".[532]

The companies' expectations were confirmed when the increasingly interventionist Spanish State became gradually more involved in their problems after the First World War. At that date, the costs of the previous strategy became evident. The rise in sea transport rates associated with the war provoked a huge increase in the demand for railway services, whereas some constraints arose in the supply of some materials, such as coal or rails. The Spanish railway system was then close to collapse, especially in the case of the most heavily-utilised lines. And the sudden inflation process that took place simultaneously, which could not be transferred to the railway fares due to the preservation of the maximum legal rates at their pre-war level, substantially reduced the returns of the railway companies and further prevented them from reacting to the increasing traffic.[533]

Although the war bottlenecks were transient, the railway chaos of those years indicated that the concession regime's days were counted. After the war, the companies' proposals were always aimed at reducing the public control over their operation even more and at obtaining increases in the maximum legal fares. Under that policy, they would have been able to maintain a "looting" strategy until the end of the concession period. However, the companies' demands had to face widespread opposition. As early as in 1918, in the so-called "National Railway Assembly", representatives of numerous sectors of the Spanish

assumed by private investment in the transport sector and, therefore, should be associated with a high public financial contribution. This, however, was excluded from the Spanish regulation model.

[532] Akerlof and Romer (1993), pp. 2 and 4. See also Eichengreen (1994), p. 28. A similar process has been pointed out for the Italian railways before their nationalisation in 1905 by Fenoaltea (1983), pp. 53-54. In fact, the companies' reliance on the ultimate public ownership of the lines can be traced back to the first stages of the railway era; see Nadal Oller (1975), p. 46; Hernández (1983), pp. 53 and 189, or López-Morell (1999), p. 684.

[533] See, for instance, Cambó Batlle (1918-1922), Vol. 6, pp. 337-338, Anes Álvarez (1978), pp. 366-368, or Muñoz Rubio and Vidal Olivares (2001), p. 92. Inflation was made worse by the improvement in the workers' conditions that resulted from the intense labour conflicts of the period; see, for instance, Martínez Vara (2001).

economy supported the nationalisation of the railway system and, during the years 1918-1923, governments made several legislative proposals in the same direction.[534]

Nevertheless, the insufficiency of public resources and, overall, the political instability of those years, prevented the success of the nationalisation projects. And, in 1923, the parliamentary regime was replaced by a military dictatorship much more sensitive to the desires of the railway companies and the heavy industry sectors, which were financially linked to them since the Great War.[535] Nationalisation aims were therefore abandoned and the government established instead a close institutional agreement between the State and the majority of the Spanish railway companies (the *Estatuto Ferroviario)* which contemplated, on the one hand, the possibility of increasing the maximum legal rates and, on the other hand, the investment of public resources in the railway system, with the aim of increasing its quality and capacity through rolling stock renewal, extension of double track and electrification.[536]

As could have been expected, the new regime was highly beneficial for the railway companies, which could consolidate their short-term oriented strategy, based on the payment of high returns to share capital, without meeting investment requirements.[537] At the same time, the flow of State's resources towards the railways guaranteed the continuity of the system and, in addition, benefited a number of heavy industries which, as has been indicated, had developed close links both with the political regime and with the railway companies.

In fact, the *Estatuto Ferroviario* might be considered as a way to advance towards nationalisation without affecting the companies' strategy. Actually, under that regime, a substantial part of the railway system became publicly owned. On the one hand, the resources invested by the State in the railways were immediately considered as public ownership. And, on the other hand, the establishment of the *Estatuto Ferroviario* was

[534] Comín Comín et al (1998), Vol. 1, pp. 285-291.
[535] The replacement of foreign by domestic agents in the share capital of the Spanish railway companies has been stressed, for instance, in Vidal Olivares (1999b), pp. 634-641, and Muñoz Rubio and Vidal Olivares (2001), p. 92.
[536] See Comín Comín et al (1998), Vol. 1, p. 297, Cordero and Menéndez (1978), pp. 301 and 318, Artola (1978b), pp. 429-430, and Ortúñez Goicolea (1999). Actually, from the establishment of the *Estatuto Ferroviario* in 1924, the State assumed, at least in theory, the responsibility for most railway investment; see Tedde de Lorca (1978), p. 211.
[537] See Iglesias (1981), pp. 158-159, Comín Comín et al (1998), Vol. 1, p. 298, Muñoz Rubio (1999), pp. 307-308, or Muñoz Rubio and Vidal Olivares (2001), p. 94. Apart from paying high dividends, the companies endowed large accounting reserves which ended up benefiting shareholders after the Civil War; see Benito (1935), pp. 74-85, Casares Alonso (1973), p. 233, and Tedde de Lorca (1978), pp. 203 and 222.

complemented by the State's expropriation of some companies that were in a very critical situation.[538] As a consequence, 41 per cent of the assets of the railway system were already in the State's hands in 1930.[539]

In the early 1930's, the end of the dictatorship and the establishment of a democratic regime reduced governments' sensitivity to the companies' interests. As a consequence, the resources invested by the State in the railway system substantially decreased, and nationalisation proposals returned to the parliamentary debates. However, political instability seems to have been again an obstacle to the advance of those projects during the years of Spain's Second Republic (1931-1936) and, in fact, that failure led governments of the period to authorise the increase in the maximum legal rates that had been demanded by the companies for so long.[540] The nationalisation of the Spanish railway system only arrived later on, in 1941, in the context of Francoist dictatorship's extreme economic nationalism. In the meantime, however, the short-term orientation of the companies' strategy, the increasing competition of the motor car and, overall, the serious damages caused by the Civil War had made the companies' survival totally impossible.[541]

7.4 Conclusions

Chapter 6 and 7 of the thesis have been aimed at reviewing the hypothesis of the failure of the Spanish railways. According to some historians, both the density of use and the financial returns of the Spanish railways during the second half of the nineteenth century were much lower that would have been expected, due to State policy mistakes. This has often been considered as evidence of the low impact of railways on Spanish economic growth.

Those hypotheses, however, have not been confirmed by this research. Firstly, as was indicated in Chapter 6, the companies' poor returns were not necessarily a sign of lack of economic impact. In fact, the social benefits of the Spanish railway system seem to have been positive and high from the beginning of the railway age. Secondly, the comparative

[538] The most important nationalisation episode before 1941 was the establishment of the public company *Oeste* in 1927 by merging several companies that operated in Western Spain and were in a very precarious financial situation. Those companies were joined by *Andaluces* in 1933; see Casares Alonso (1973), p. 167, and Artola (1978b), pp. 431-432.
[539] Iglesias (1981), p. 159.
[540] See Comín Comín et al (1998), Vol. 1, pp. 308-316.
[541] Iglesias (1981), pp. 158-159; Muñoz Rubio and Vidal Olivares (2001), p. 95.

analysis that has been carried out in Section 7.2 of this chapter, has not provided evidence that the density of use of the lines or the companies' financial returns were lower in Spain than could have been expected. On the contrary, the degree of utilisation of the Spanish railways seems to have been similar to that of other European countries when differences in the level of development are allowed for. Similarly, the Spanish companies' financial results do not appear either to have been low in the European context.

Nevertheless, there is no doubt that the financial returns of the Spanish railway companies, in spite of their respectable level in comparative terms, did not reach the opportunity cost of the capital invested in the lines. Actually, such a situation could be observed in many European economies at the time. To some extent, it was related to the public interest justification of some railway links, which resulted in the construction of unprofitable lines. This, however, required the State's involvement in the process, in order to guarantee not only construction, but also the quality of the service provided, a moderate level of fares and a sufficient rate of return on the private capital invested in the system.

Actually, it is here where the clearest evidence of failure may be found in the case of the Spanish railway system. Public regulation succeeded in encouraging the construction of an extensive network, but it was totally ineffective at guaranteeing service quality, a low level of fares and returns on share capital. As some historians have already pointed out, the main reason for that situation seems to have been the financial poverty of the Spanish State. Trying to minimise subsidies to the railway system, the public sector instead gave companies great freedom in most aspects of railway construction and operation. As a consequence, shareholders were expropriated of part of their capital by the companies' promoters and users could not benefit from an adequate transport service. In other words, the shortcomings of the Spanish public sector were made up for by the "indirect taxation" of railway shareholders and users.

However, it is difficult to imagine an alternative scenario, given the weakness of the Spanish tax system. Actually, in spite of their relatively low level, railway subsidies were one of the reasons for the collapse of the Spanish Treasury in the late 1860's and the early 1870's. And, on the other hand, it does not make much sense to reproach the government for not having been wiser since, as Fogel said, "*the broader issues involved in premature and mixed enterprises were still basically unexplored in the mid-1860's*."[542] In

[542] Fogel (1960), p. 24.

fact, the failure of the system was probably a reflection of the low level of development of the country and the presence of social and economic constraints, and it is unlikely that a sounder regulation process could have overcome these structural problems.

CONCLUSIONS

As has long been recognised by economists and economic historians, infrastructure performs an essential role in the process of economic growth. It provokes profound changes in the cost structure of firms, both through direct reductions in the price of some production factors and through the overall decrease in transport and distribution costs, bringing about, as a result, substantial productivity increases in the economy. However, even more important than those impacts is the subsequent alteration in the structure of location incentives that they produce. Infrastructure substantially enhances the range of firms' location possibilities and, as a result, allows the spatial concentration of the activity, and opens up the way towards the exploitation of scale, specialisation and agglomeration economies. The removal of location constraints is particularly important during the first stages of industrialisation, in which the growth of technologically advanced sectors and the development of increasing returns to scale take place to a large extent through the agglomeration of the activity in urban and industrial centres.

The key role of infrastructure in growth has led economic historians to pay it considerable attention in the accounts of nineteenth and early twentieth century industrialisation. Whereas the first analyses on the subject were highly concentrated on the study of railways and focused particularly on their direct cost-saving effects, the scope of research has gradually been enlarged to encompass other kinds of infrastructure, and increasing effort has been devoted to the study of the indirect long-term effects of infrastructure on growth.

The evolution of the treatment of infrastructure in analyses of Spanish industrialisation has been similar. Within infrastructure, railways have been the main object of attention since the earliest research, and the debate on their role has been dominated for a long time by Gómez Mendoza's direct cost-saving measurement efforts. Actually, the conflict between the strong direct growth impact that he attributed to the Spanish railways and the bad financial situation of the railway companies that had been previously described by other historians gave rise to a historiographical paradox which has remained unresolved. On the other hand, research on the growth impact of Spanish railways has been accompanied in the last few years by some studies on other sectors of infrastructure, and by a number of analyses that describe the effects of infrastructure increases on the economic evolution of some regions. However, generally speaking, those investigations have not gone beyond the purely sectoral or regional perspective.

This dissertation has provided an approach to the long-term impact of infrastructure on Spanish economic growth from an aggregate perspective, which has been absent from the historiography so far. In addition, it has contributed to a better understanding of the impact of railways on economic growth by offering a solution to the aforementioned "paradox of Spanish railways", i.e. the apparent contradiction between the widespread pessimism on the growth impact of Spanish railways and the intense direct resource-saving effect claimed by Gómez Mendoza.

Chapter 2 of the thesis presents a complete series of the net stock and gross investment of Spanish infrastructure during the first long period of the country's industrialisation, from the 1840's until the Civil War of 1936-1939. According to that data, during the nine decades before 1936, the country endowed itself with a complex stock of infrastructure assets, whose value was, at that date, 36 times as large as in 1845. On average, gross infrastructure investment amounted to 1.14 per cent of Spanish GDP, and absorbed 14 per cent of the total resources invested in capital formation in the country during that period.

Two distinct periods in the evolution of infrastructure investment can be distinguished. Firstly, the second half of the nineteenth century was characterised by the intense growth of the Spanish infrastructure endowment per unit of output, which may be attributed to the construction of the railway network, since railways accounted, in that period, for remarkably high shares of total infrastructure investment. The network economies of the railway system and the lack of feasible alternatives for long-distance transport in Spain led to very intense building activity during the 1860's, 1880's and 1890's, which was suddenly interrupted once the main railway network had been built. At that point, the low population density of the country prevented an extensive development of secondary short-distance railway lines.

In contrast, between the late 1890's and 1936, the stock of infrastructure per unit of output stagnated. During that period railway investment was rather low, and infrastructure increase was mainly associated with other elements, such as roads, electricity distribution networks and hydraulic works. Those assets had much lower network economies than railways and, as a consequence, their construction took place in a much more gradual fashion. This explains the stability of the endowment of infrastructure per unit of output and the parallel reduction in the share of infrastructure in Spanish capital stock. The situation only started to change in the fifteen years before the Civil War, when network economies emerged again in the highway system, electricity distribution or telecommunications. However, the war and post-war years thwarted the achievement of those network economies until the second half of the twentieth century.

The geographical distribution pattern of Spanish infrastructure was rather constant during the whole period under consideration. Broadly speaking, the best-endowed provinces were always situated on the Northern and Eastern coastlines of the country and in the strip of land between Cantabria and Madrid. Among those areas, the Basque Country clearly stood out during the whole period. In a context in which the Spanish endowment of infrastructure was very low from a comparative point of view, the Basque provinces were always close to the European average. On the contrary, at the other end of the scale, a number of inner provinces in regions such as Aragon, Extremadura and Castile-La Mancha, as well as the Canary Islands, had extremely low levels of endowment by any standards.

To a large extent, that geographical distribution reflected the structural characteristics of each region. Obviously, population density was the main determinant of regional infrastructure endowments. But this research has also shown that, when levels of population density are accounted for, railways turn out to have been much better adapted to the level of development of each area than roads. In addition, within the railway system, broad gauge lines were more oriented to serve urban markets and showed a higher sensitivity to the level of construction costs in each province, whereas narrow gauge railways could spread throughout rural markets and areas with difficult terrain, thanks to their lower capital costs. Unlike railways, the road network was much more oriented by political than by economic criteria, and tended to spread so as to serve the largest possible population. Only in the case of local and provincial roads did each province’s endowment also reflect to some extent the level of development of the area.

By comparing its level of infrastructure endowment with other European countries, this research has shown that Spain might have suffered from a situation of mild relative infrastructure shortage during the whole period under study. To start with, in the case of railways the Spanish economy seems to have been well endowed for a short period, just after the first long wave of railway construction of 1855-1866. However, that advantage seems to have been gradually lost, and Spain ended up suffering from a smaller endowment than other European peripheral countries with similar economic density. That situation may also be observed in the development of the secondary road network and, to some extent, in the case of the telegraph system, where relatively adequate network density levels were overcome by a very short number of points of access to the system.

That situation of relative shortage would be consistent with the existence of bottlenecks in the economy and, therefore, infrastructure increases would be expected to have had a positive impact on economic growth. In that context, a time-series analysis has been carried out to identify the relationships between infrastructure and the main variables of the economy during the period 1850-1935. As a result, it has been possible to observe that infrastructure investment followed, with some lag, the behaviour of the Spanish output variables. This indicates the presence of Wagner-Law dynamics in the Spanish economy. On the contrary, no impact of infrastructure on production has been found. This result would be in conflict with the expectation associated with the apparent Spanish infrastructure shortage, and its most likely interpretation is that the impact of infrastructure on the Spanish economy was too low and slow to be captured by standard time-series analysis.

The reasons for the low level and slowness of the response of the economy could have been diverse, ranging from the inadequate design, regulation or management of infrastructure to the underdevelopment of the economy, which would have involved the presence of several growth constraints and, as a consequence, a low capacity to adapt to new situations. However, adequate understanding of the actual reasons for the slow reaction of the Spanish economy is only possible if a more disaggregated approach is adopted in the research. In this thesis, the very variety of assets that made up the Spanish infrastructure has constrained the analysis to the main part of the stock, i.e. the railway network. In addition, that closer look at the Spanish railway system has shed some light on the so-called “paradox of Spanish railways” that had been described by some historians.

The thesis has provided alternative estimates of the social saving of freight transported by the Spanish railways, which are much lower than the previous Gómez Mendoza figures. Under the most likely assumptions, social saving estimates are reduced from 7.5 to 2.5 per cent of GDP in 1878 and from around 20 to around 12 per cent of GDP in 1912. By adding in a rough estimate of the social saving of passenger transport, those figures grow to a maximum of 3.1 per cent in 1878 and 13.4 per cent in 1912. For the latter year, these results would still be higher than the available figures for other European economies. However, in the case of 1878 they are comparable to other countries' estimates. This would seem to be in conflict with the prominence of roads as opposed to water transport in a Spanish counterfactual economy without railways, but may be understood by taking into account the low importance of railway transport relative to Spanish GDP in 1878, in comparison with other economies for which social saving estimates are available.

A lower level of the social saving estimates does not imply that the economic impact of railways was unimportant. In fact, according to the new figures, the social rate of return of the Spanish railway system was already positive and substantial in 1878. By 1912 it would have reached a level much higher than in other European economies. However, attaining that maximum potential impact took an extremely long time, which is consistent with the results obtained in the econometric analysis of the growth impact of the whole infrastructure. Actually, apart from the low response capacity of the Spanish economy to changes, the increase in the social rate of return of the railway system would also have been prevented, between 1870 and 1900, by the incorporation to the system of lines with very low potential impact but that were important from an equity point of view.

In spite of the evidence on the growth effects of Spanish railways, there are still some reasons for pessimism, which are associated with the enormous financial problems that the Spanish railway companies suffered during their whole lifetime. The thesis has shown, however, that the private returns of the Spanish railway companies were not particularly low by European standards. They were, of course, lower than the opportunity cost of the capital invested. But that situation must be understood in the context of the State's involvement in the system. The importance of railways for the country, not only on economic but also on social and political grounds, led the Spanish State to encourage their construction up to a level at which they could by no means be profitable. This happened especially in the case of those peripheral lines that were opened after the first wave of railway construction, which carried much less traffic than the "core" lines that were constructed before 1870.

Nevertheless, that situation was not exclusive to Spain. On the contrary, most countries developed measures to stimulate the extension of railways to their whole territory. These were usually accompanied by the regulation of the system in order to guarantee both the standards of the service and returns on private capital. The Spanish State, however, appears to have been particularly unable to develop such regulation. Apparently because of its low fiscal capacity, the State ended up obtaining the necessary resources for the construction and operation of the railway system from the “indirect taxation” of railways users and shareholders.

In summary, the analysis of the relationships between infrastructure and economic growth in Spain has shown the difficulties of a peripheral country in taking full advantage of infrastructure investment and in achieving adequate regulation of both infrastructure construction and operation. Although infrastructure capital formation was an essential component of the country’s industrialisation process before the Civil War, Spain suffered greater difficulties than the core European countries in adapting to new situations, due to the presence of different constraints in its economy and institutions.

BIBLIOGRAPHY

Statistical sources

Annuaire Statistique de la Belgique et du Congo Belgue (1897-1937).

Annuaire Statistique de la France (1878-1937).

Annuaire Statistique de la République Tchécoslovaque (1920-1936).

Annuaire Statistique Hongrois (1895-1938).

Annuario Statistico Italiano (1886-1936).

Anuario de Ferrocarriles de D. Enrique de la Torre (1893-1935).

Anuario Estadístico de España (1860-1942).

Anuário Estatístico de Portugal (1921-1937).

Anuarul Statistic al Romaniei (1909-1936).

Banco de Bilbao, *La Renta Nacional de España y su distribución provincial* (1955-1995).

Censo de la Población de España (1857-1930).

Compañía de los Caminos de Hierro del Sur de España, *Memorias* (1889-1928).

Compañía de los Ferrocarriles Andaluces, *Memorias* (1877-1935).

Compañía de los Ferrocarriles de Madrid a Cáceres y Portugal (y del Oeste de España), *Memorias* (1882-1928).

Compañía de los Ferrocarriles de Madrid a Zaragoza y a Alicante, *Memorias* (1858-1935).

Compañía Telefónica Nacional de España, *Memorias* (1924-1935).

Concise Statistical Year-Book of Poland (1937).

Danmarks Statistisk Aarbog (1890-1935).

Eidgenössischen Statistischen Amt / Statistisches Jahrbuch der Schweiz (1891-1936).

Estadística Administrativa de la Contribución Industrial y de Comercio (1856-1909).

Estadística Telegráfica de España (1864-1934).

Jaarcifers Voor Nederland (1880-1935).

Memoria(s), *Anuario(s)* and *Estadística(s) de Obras Públicas* (1856-1924).

Österreichisches Statistisches Handbuch / Statistisches Handbuch für die Republik Österreich / Statistisches Handbuch für den Bundesstaat Österreich (1870-1935).

Red Provincial de Guipúzcoa, *Memorias* (1928-1934).

Revista de Obras Públicas (1855-1899).

Schweizerische Eisenbahn-Statistik (1918).

Statistical Abstract [for the Republic of Ireland] (1931-1936).

Statistical Abstract for the United Kingdom (1885-1935).

Statistisches Jahrbuch für das Deutsche Reich (1891-1936).

Statistisk Årbok for Norge (1891-1936).

Statistist Årsbok för Sverige (1914-1936).

Suomen Tilastollinen Vuosikirja (1914-1936).

Other publications

Abramovitz, Moses (1993), "The Search for the Sources of Growth: Areas of Ignorance, Old and New", *Journal of Economic History*, 53, 2, pp. 217-243.

AENA (1996), *Los aeropuertos españoles. Su historia, 1911-1996*, Madrid, AENA.

Akerlof, George A. and Romer, Paul M. (1993), "Looting: The Economic Underworld of Bankruptcy for Profit", *Brookings Papers on Economic Activity*, 2, pp. 1-73.

Albert, William (1972), *The Turnpike Road System in England 1663-1840*, Cambridge, Cambridge University Press.

Alcaide Inchausti, Julio (1976), "Una revisión urgente de la serie de renta nacional española en el siglo XX", en Instituto de Estudios Fiscales (ed.), *Datos básicos para la historia financiera de España (1850-1975)*, Madrid, Instituto de Estudios Fiscales, Vol. 1, pp. 1125-1150.

Aldcroft, Derek H. (1974), *Studies in British Transport History 1870-1970*, London, David and Charles.

Alemany Llovera, Joan (1991), *Los puertos españoles en el siglo XIX*, Madrid, Centro de Estudios Históricos de Obras Públicas y Urbanismo.

Al-Mudayna (1991), *Historia de los regadíos en España (… a.C.-1931)*, Madrid, Ministerio de Agricultura, Pesca y Alimentación.

Álvarez Llano, Roberto (1986), "Evolución de la estructura económica regional de España en la historia: una aproximación", *Situación*, 1, pp. 5-61.

Alvargonzález Rodríguez, Ramón (1996), "Los puertos españoles desde una perspectiva geográfica. Modelos portuarios de los siglos XIX y XX", in Guimerá Ravina, Agustín and Romero Muñoz, Dolores (eds.), pp. 167-184.

Alzola y Minondo, Pablo (1884-1885), "Ferro-carriles de vía ancha y de vía estrecha", *Revista de Obras Públicas*, nº 32, pp. 183-188, 197-204, 229-236, 249-256, 264-269, 277-284, 295-304, 309-316, 327-331, 337-345, and 353-362, and nº 33, pp. 3-12, 17-24, 33-39, 49-54, 65-69, 81-86, 113-117, 145-151, 161-168, 209-217, 225-237, 241-249, 257-265, 273-277, 289-299, and 305-314.

Alzola y Minondo, Pablo (1898), *Monografía de los caminos de Vizcaya*, Bilbao, Imprenta Provincial.

Alzola y Minondo, Pablo (1979) [1899], *Las obras públicas en España. Estudio histórico*, Madrid, Colegio de Ingenieros de Caminos, Canales y Puertos.

Andersson, Åke E. and Strömquist, Ulf (1989), "The Emerging C-Society", in Batten, David F. and Thord, Roland (eds.), pp. 29-39.

Andersson-Skog, Lena (2000), "National Patterns in the Regulation of Railways and Telephony in the Nordic Countries to 1950", *Scandinavian Economic History Review*, 48, 2, pp. 30-46.

Andrikopoulos, Andreas A. and Loizides, John (1998), "Cost Structure and Productivity Growth in European Railway Systems", *Applied Economics*, 30, pp. 1625-1639.

Anes Álvarez, Rafael (1978), "Relaciones entre el ferrocarril y la economía española (1865-1935)", in Artola, Miguel (ed.), Vol. 2, pp. 355-512.

Anes Álvarez, Gonzalo (ed.) (1999), *Historia económica de España. Siglos XIX y XX*, Barcelona, Galaxia Gutenberg/Círculo de Lectores.

Anselin, Luc (1988), *Spatial Econometrics: Methods and Models,* Boston, Kluwer Academic Publishers.

Argimón, Isabel; González-Páramo, José Manuel and Roldán, José María (1994), "Productividad e infraestructuras en la economía española", *Moneda y Crédito,* 198, pp. 207-241.

Armstrong, John (1987), "The Role of Coastal Shipping in the UK Transport. An Estimate of Comparative Transport Movements in 1910", *Journal of Transport History*, 8, 2, pp. 164-178.

Armstrong, John (1995), "Inland Navigation and the Local Economy", in Kunz, Andreas and Armstrong, John (eds.), pp. 307-311.

Armstrong, John (1998), "Transport History, 1945-95. The Rise of a Topic to Maturity", *Journal of Transport History*, 19, 2, pp. 103-121.

Arrillaga, Manuel María (1930), *Los iniciadores y promotores de los Caminos de Hierro de España (1830-1855)*, Madrid, Sucesores de Rivadeneyra.

Artola, Miguel (1978a), "Introducción" in Artola, Miguel (ed.), Vol. 1, pp. 11-27.

Artola, Miguel (1978b), "La acción del Estado", in Artola, Miguel (ed.), Vol. 1, pp. 339-453.

Artola, Miguel (ed.) (1978c), *Los ferrocarriles en España, 1844-1943*, Madrid, Banco de España.

Artola, Miguel (1986), *La Hacienda del siglo XIX. Progresistas y moderados*, Madrid, Alianza.

Aschauer, David A. (1989), "Is Public Expenditure Productive?", *Journal of Monetary Economics*, 23, pp. 177-200.

Avakian, Léon (1936), "Le rythme de développement des voies ferrées en Belgique de 1835 à 1935", *Bulletin de l'Institut des Sciences Économiques*, 7, 4, pp. 449-482.

Averch, Harvey and Johnson, Leland L. (1962), "Behavior of the Firm Under Regulatory Constraint", *American Economic Review*, 52, 5, pp. 1052-1069.

Azariadis, Costas and Drazen, Allan (1990), "Threshold Externalities in Economic Development", *Quarterly Journal of Economics*, 15, 2, pp. 501-526.

Bagwell, P. S. and Armstrong, J. (1988), "Coastal shipping", in Freeman, Michael J. and Aldcroft, Derek H. (eds.), pp. 171-217.

Bahamonde Magro, Ángel (ed.) (1993), *Las comunicaciones en la construcción del Estado contemporáneo en España: 1700-1936. El correo, el telégrafo y el teléfono*, Madrid, Ministerio de Obras Públicas, Turismo y Medio Ambiente.

Bahamonde Magro, Ángel; Martínez Lorente, Gaspar and Otero Carvajal, Luis Enrique (eds.) (1995), *Las comunicaciones entre Europa y América: 1500-1993. Actas del I Congreso Internacional de Comunicaciones*, Madrid, Ministerio de Obras Públicas, Transportes y Medio Ambiente.

Bahamonde Magro, Ángel and Otero Carvajal, Luis Enrique (1993), "El teléfono. El nacimiento de un nuevo medio de comunicación. 1877-1936", in Bahamonde Magro, Ángel (ed.), pp. 189-232.

Bairoch, Paul (1976), "Europe's Gross National Product: 1800-1975", *Journal of European Economic History*, 5, 2, pp. 273-340.

Bairoch, Paul (1990), "The Impact of Crop Yields, Agricultural Productivity, and Transport Costs on Urban Growth between 1800 and 1910", in Van der Woude, A. D.; Hayami, Akira and De Vries, Jan (eds.), *Urbanization in History: A Process of Dynamic Interactions*, Oxford, Clarendon Press, pp. 134-151.

Bairoch, Paul and Goertz, Gary (1986), "Factors of Urbanisation in the Nineteenth Century Developed Countries: A Descriptive and Econometric Analysis", *Urban Studies*, 23, pp. 285-305.

Baldassari, Mario; Paganetto, Luigi and Phelps, Edmund S. (eds.) (1994), *International Differences in Growth Rates. Market Globalization and Economic Areas*, New York, St Martin's Press.

Balmaseda, Manuel (1996), *Production Function Estimates of the Rate of Return on Public Infrastructure*, CEMFI Working Paper Nº 9609.

Baltagi, Badi H. and Pinnoi, Nat (1995), "Public Capital Stock and State Productivity Growth: Further Evidence from an Error Components Model", *Empirical Economics*, 20, pp. 351-359.

Barker, Theo C. (1988), "Urban Transport", in Freeman, Michael J. and Aldcroft, Derek H. (eds.), pp. 134-170.

Barker, Theo C. and Gerhold, Dorian (1993), *The Rise and Rise of Road Transport, 1700-1900*, Cambridge, Cambridge University Press.

Barker, Theo C. and Savage, C. I. (1974), *An Economic History of Transport in Britain*, London, Hutchinson and Co.

Barquín Gil, Rafael (1997), "Transporte y precio del trigo en el siglo XIX: creación y reordenación de un mercado nacional", *Revista de Historia Económica*, 15, 1, pp. 17-48.

Barquín Gil, Rafael (1999), "El ahorro social: una perspectiva dinámica", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 337-354.

Barro, Robert J. and Sala-i-Martin, Xavier (1995), *Technological Diffusion, Convergence and Growth*, CEPR Discussion Paper Nº 1255.

Barthe, Andrés (1919), "Las haciendas locales", *Revista Nacional de Economía*, 4, 6, pp. 5-22.

Bartolomé Rodríguez, Isabel (1995), "Los límites de la *hulla blanca* en vísperas de la Guerra Civil: un ensayo de interpretación", *Revista de Historia Industrial*, 7, pp. 109-139.

Bartolomé Rodríguez, Isabel (1999), "La industria eléctrica española antes de la guerra civil: reconstrucción cuantitativa", *Revista de Historia Industrial*, 15, pp. 139-160.

Bartolomé Rodríguez, Isabel (2000), *La intervención del Estado: los mercados eléctricos, integración y regulación*, unpublished research paper.

Baskin, Jonathan Barron (1988), "The Development of Corporate Financial Markets in Britain and the United States, 1600-1914: Overcoming Asymmetric Information", *Business History Review*, 62, pp. 199-237.

Batten, David F. (1990), "Infrastructure as a Network System: Mera Revisited", in Anselin, Luc and Madden, Moss (eds.), *New Directions in Regional Analysis. Integrated and Multi-regional Approaches*, London, Belhaven, pp. 76-89.

Batten, David F. and Karlsson, Charlie (eds.) (1996), *Infrastructure and the Complexity of Economic Development*, Berlin, Springer, Advances in Spatial Science.

Batten, David F. and Thord, Roland (eds.) (1989), *Transportation for the Future*, Berlin, Springer-Verlag.

Becerril y Antón-Miralles, Antonio (1946), "El proceso de amortización en la industria eléctrica española", *Moneda y crédito*, 18, pp. 36-46.

Bello, Severino (1914), *Coste de las obras hidráulicas en España*, Zaragoza, G. Casañal.

Ben-David, Dan and Papell, David H. (2000), "Some Evidence on the Continuity of the Growth Process Among the G7 Countries", *Economic Inquiry*, 38, 2, pp. 320-330.

Benito, José L. de (1935), *Las compañías de ferrocarriles en quiebra. Una sangría agotadora del Estado español*, Madrid.

Berend, Iván and Ránki, György (1982), *The European Periphery and the Industrialisation 1780-1914*, Budapest, Akadémiai Kiadó.

Bergman, Edward M. and Sun, Daoshan (1996), "Infrastructure and Manufacturing Productivity: Regional Accessibility and Development Level Effect", in Batten, David F. and Karlsson, Charlie (eds.), pp. 17-35.

Berndt, Ernst R. and Hansson, Bengt (1992), "Measuring the Contribution of Public Infrastructure Capital in Sweden", *Scandinavian Journal of Economics*, 94, Supplement, pp. S151-S168.

Betrán Pérez, Concepción (1997), "Geografía industrial en España durante el primer tercio del siglo XX", in *La riqueza de las regiones. Análisis espacial de la industrialización*, Proceedings of the 9th Session of the VI Congress of the Asociación Española de Historia Económica, Girona, 15-17 de septiembre, pp. 65-84.

Biehl, Dieter (1984), *The Contribution of Infrastructure to Regional Development. Final Report*, Commission of the European Communities.

Biehl, Dieter (1991), “The Role of Infrastructure in Regional Development”, in Vickerman, Roger W. (ed.), pp. 9-35.

Blum, Jerome (1943), “Transportation and Industry in Austria, 1815-1848”, *Journal of Modern History*, 15, 1, pp. 24-38.

Boag, Geo L. (1923), *The Railways of Spain*, London, The Railway Gazette.

Boldrin, Michele (1992), “Dynamic Externalities, Multiple Equilibria, and Growth”, *Journal of Economic Theory*, 58, pp. 198-218.

Bolea Foradada, Juan Antonio (1986), *Los riegos de Aragón*, Huesca, Grupo Parlamentario Aragonés Regionalista de las Cortés de Aragón.

Boscá, José Emilio; Cutanda, Antonio and Escribá, Javier (2000), *Eficiencia en la provisión de los capitales público y privado en una muestra de países de la OCDE*, unpublished research paper.

Boscá, José Emilio; Escribá, Javier and Dabán, Teresa (1999), “Capital privado e infraestructuras en la producción industrial regional”, *Revista de Economía Aplicada*, 21, pp. 61-94.

Boscá, José Emilio; Escribá, Javier and Murgui, María José (2002), “The Effect of Public Infrastructure on the Private Productive Sector of Spanish Regions”, *Journal of Regional Science*, 42, 2, pp. 301-326.

Bougheas, Spiros; Demetriades, Panicos O. and Morgenroth, Edgar L. W. (1999), “Infrastructure, Transport Costs and Trade”, *Journal of International Economics*, 47, pp. 169-189.

Boyd, J. Hayden and Walton, Gary M. (1972), “The Social Savings from Nineteenth-Century Rail Passenger Services”, *Explorations in Economic History*, 9, 3, pp. 233-254.

Broder, Albert (2000), *Historia económica de la España contemporánea*, Barcelona, Universitat de Barcelona.

Bruinsma, Frank; Nijkamp, Peter and Rietveld, Piet (1990), “Employment Impacts of Infrastructure Investments. A Case Study for the Netherlands”, in Peschel, Karin (ed.), *Infrastructure and the Space-Economy. Essays in Honour of Rolf Funck*, Berlin, Springer-Verlag, pp. 209-226.

Bureau of Economic Analysis (1999), *Fixed Reproducible Tangible Wealth in the United States, 1925-94*, US Department of Commerce.

Butterfield, Peter (1995), “Branch Lines, Wayside Stations and Road Competition”, *Journal of Transport History*, 16, 2, pp. 179-195.

Button, Kenneth (1996), “Ownership, Investment and Pricing of Transport and Communication Infrastructure”, in Batten, David F. and Karlsson, Charlie (eds.), pp. 147-165.

Button, Kenneth J.; Leitham, Scott; McQuaid, Ronald W. and Nelson, John D. (1995), "Transport and Industrial and Commercial Location", *Annals of Regional Science*, 29, pp. 189-206.

Button, Kenneth; Nijkamp, Peter and Priemus, Hugo (eds.) (1998), *Transport Networks in Europe: Concepts, Analysis and Policies*, Cheltenham, Edward Elgar.

Cabezas, Juan Antonio (1974), *Cien años de teléfono en España. Crónica de un proceso técnico*, Madrid, Espasa Calpe.

Cafagna, Luciano (1989), *Dualismo e sviluppo nella storia d'Italia*, Venice, Marsilio.

Cain, Louis P. (1997), "Historical Perspective on Infrastructure and US Economic Development", *Regional Science and Urban Economics*, 27, pp. 117-138.

Cain, P. J. (1972), "Railway Combination and the Government 1900-1914", *Economic History Review*, 25, 4, pp. 623-641.

Cain, P. J. (1988), "Railways 1870-1914: The Maturity of the Private System", in Freeman, Michael J. and Aldcroft, Derek (ed.), pp. 92-133.

Calvo Calvo, Ángel (1998), "El teléfono en España antes de Telefónica (1877-1924)", *Revista de Historia Industrial*, 13, pp. 59-81.

Calvo Calvo, Ángel (2001), "Los inicios de las telecomunicaciones en España: el telégrafo", *Revista de Historia Económica*, 19, 3, pp. 613-635.

Cambó Batlle, Francisco (ed.) (1918-1922), *Elementos para el estudio del problema ferroviario en España*, Madrid, Ministerio de Fomento.

Camps, Enriqueta (1995), *La formación del mercado de trabajo industrial en la Cataluña del siglo XIX*, Madrid, Ministerio de Trabajo y Seguridad Social.

Canning, David (2000), *The Contribution of Infrastructure to Aggregate Output*, unpublished research paper.

Canning, David; Fay, Marianne and Perotti, Roberto (1994), "Infrastructure and Growth", in Baldassari, Mario; Paganetto, Luigi and Phelps, Edmund S. (eds.), pp. 113-147.

Canova, Fabio (1999), "Does Detrending Matter for the Determination of the Reference Cycle and the Selection of Turning Points?", *Economic Journal*, 109, pp. 126-140.

Capel Sáez, Horacio and Tatjer, Mercedes (1994), "La organización de la red telegráfica española", in Capel Sáez, Horacio; López Piñero, José María and Pardo Tomás, José (eds.), *Ciencia e ideología en la ciudad. I Coloquio Interdepartamental. Valencia, 1991*, Valencia, Generalitat Valenciana, Vol. 2, pp. 23-69.

Capello, Roberta and Gillespie, Andrew (1993), "Transport, Communications and Spatial Organisation: Conceptual Framework and Future Trends", in Nijkamp, Peter (ed.), *Europe on the Move. Recent Developments in European Communications and Transport Activity Research*, Aldershot, Avebury, pp. 43-66.

Caron, François (1972), "Recherches sur le capital des voies de communication en France au XIX^e siècle (en particulier le capital ferroviaire)", in Léon, Pierre; Crouzet, François and Gascon, Richard (eds.), *L'industrialisation en Europe au XIX^e siècle.*

Cartographie et typologie, Paris, Centre National de la Recherche Scientifique, pp. 237-266.

Caron, François (1983), “France”, in O’Brien, Patrick (ed.), pp. 28-48.

Carreras, Albert (1983), “El aprovechamiento de la energía hidráulica en Cataluña, 1840-1920. Un ensayo de interpretación”, *Revista de Historia Económica*, 1, 2, pp. 31-63.

Carreras, Albert (coord.) (1989a), *Estadísticas Históricas de España, siglos XIX-XX*, Madrid, Fundación Banco Exterior.

Carreras, Albert (1989b), “La industria”, in Carreras, Albert (coord.), pp. 169-247.

Carreras, Albert (1990a), “Fuentes y datos para el análisis regional de la industrialización española”, in Nadal Oller, Jordi and Carreras, Albert (eds.), pp. 3-20.

Carreras, Albert (1990b), *Industrialización española: estudios de historia cuantitativa*, Madrid, Espasa-Calpe.

Carreras, Albert (1995), “Transport History and the Location of Economic Activity”, in Carreras, Albert; Giuntini, Andrea and Kunz, Andreas (eds.), pp. 45-48.

Carreras, Albert (1997), “La industrialización: una perspectiva a largo plazo”, *Papeles de Economía Española*, 73, pp. 35-60.

Carreras, Albert (1999), “Los ferrocarriles en Europa: algunas perspectivas históricas”, in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 33-53.

Carreras, Albert; Giuntini, Andrea and Kunz, Andreas (eds.) (1995), *XIX and XX Centuries Transport History: Current Trends and New Problems*, Florence, European University Institute Working Paper HEC No. 95/2.

Casañas Vallés, Magí (1977), “El ferrocarril en España, 1844-1868. Consideraciones en torno a una crisis”, *Investigaciones Económicas*, 4, pp. 39-68.

Casares Alonso, Aníbal (1973), *Estudio histórico-económico de las construcciones ferroviarias españolas en el siglo XIX*, Madrid, Instituto Iberoamericano de Desarrollo Económico.

Caves, Douglas W.; Christensen, Laurits R.; Tretheway, Michael W. and Windle, Robert J. (1985), “Network Effects and the Measurement of Returns to Scale and Density for U.S. Railroads”, in Daughety, Andrew F. (ed.), *Analytical Studies in Transport Economics*, Cambridge, Cambridge University Press, pp. 97-120.

Ceballos Teresí, J.G. (1932), *Economía, finanzas, cambios. La realidad económica y financiera de España en los 30 años del presente siglo*, Madrid, El Financiero.

Cendal Búrdalo, Juan José (1999), “Compañía de Explotación de los Ferrocarriles de Madrid a Cáceres y Portugal y del Oeste de España. Intercambio de mercancías por los empalmes de la red y complementariedad entre sus líneas. 1897-1925”, in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 563-583.

Centraal Bureau Voor de Statistiek (1994), *1899-1994. Vijfennegentig Jaren Statistiek in Tijdreeksen*, CBS.

Centro de Estudios Históricos de Obras Públicas y Urbanismo (1994), *Puertos españoles en la historia*, Madrid, Ministerio de Obras Públicas, Transportes y Medio Ambiente.

Cercos Pérez, Ramiro (1968), "La riqueza portuaria", in Universidad Comercial de Deusto, Vol. 2, pp. 559-624.

Chandler, Alfred D. Jr. (1965), "The Railroads: Innovators in Modern Business Administration", in Mazlish, Bruce (ed.), *The Railroad and the Space Program: An Exploration in Historical Analogy*, Cambridge (MA), The MIT Press, pp. 127-162.

Chu, C. Y. Cyrus (1997), "Population Density and Infrastructure Development", *Review of Development Economics*, 1, 3, pp. 294-304.

Clarida, Richard H. (1993), *International Capital Mobility, Public Investment and Economic Growth*, NBER Working Paper Nº 4506.

Clark, C.; Wilson, F. and Bradley, J. (1969), "Industrial Location and Economic Potential in Western Europe", *Regional Studies*, 3, 2, pp. 197-212.

Clark, Kinnear (1894), *Tramways, their Construction and Working*, London, Crosby Lockwood & Son.

Coatsworth, John H. (1979), "Indispensable Railroads in a Backward Economy: The Case of Mexico", *Journal of Economic History*, 39, 4, pp. 939-960.

Coll Martín, Sebastián and Sudrià Triay, Carles (1987), *El carbón en España, 1770-1961. Una historia económica*, Madrid, Turner.

Comfort, A. M. (1988), "Alternatives to Infrastructure? Possible Ways Forward for the ERDF: A Perspective from Luxembourg", *Regional Studies*, 22, 6, pp. 542-551.

Comín Comín, Francisco (1993), "Estado y crecimiento económico en España: lecciones de la historia", *Papeles de Economía Española*, 57, pp. 32-56.

Comín Comín, Francisco (1996), *Historia de la Hacienda Pública. II, España (1808-1995)*, Barcelona, Crítica.

Comín Comín, Francisco (1999), "Los efectos económicos del ferrocarril sobre la economía española (1855-1935)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús; and Vidal Olivares, Javier (eds.), pp. 255-271.

Comín Comín, Francisco and Martín Aceña, Pablo (1984), "La política monetaria y fiscal durante la Dictadura y la Segunda República", *Papeles de Economía Española*, 20, pp. 236-265.

Comín Comín, Francisco and Martín Aceña, Pablo (eds.) (1996), *La empresa en la historia de España*, Madrid, Civitas.

Comín Comín, Francisco; Martín Aceña, Pablo; Muñoz Rubio, Miguel and Vidal Olivares, Javier (1998), *150 Años de Historia de los Ferrocarriles Españoles*, Madrid, Fundación de los Ferrocarriles Españoles.

Compañía de los Caminos de Hierro del Norte de España (1940), *Compañía de los Caminos de Hierro del Norte de España (1858-1939). Historia. Actuación. Concesiones. Ingresos. Gastos y balance*, Madrid, Espasa Calpe.

Cordero, Ramón and Menéndez, Fernando (1978), "El sistema ferroviario español", in Artola, Miguel (ed.), Vol. 1, pp. 161-338.

Costa, J. da Silva; Ellson, Richard W. and Martin, Randolph C. (1987), "Public Capital, Regional Output and Development: Some Empirical Evidence", *Journal of Regional Science*, 27, 3, pp. 419-437.

Costa Campí, María Teresa (1981), "Iniciativas empresariales y capitales extranjeros en el sector servicios de la economía española durante la segunda mitad del siglo XIX", *Investigaciones Económicas*, 14, pp. 45-83.

Crafts, Nicholas F. R. (2000), *The Solow Productivity Paradox in Historical Perspective*, unpublished research paper.

Cubel Montesinos, Antonio (1997), "Capital privado y capital público en el crecimiento económico español, 1900-1935", in *Actas del II Encuentro de Historia Económica, Valencia, 3 y 4 de abril de 1997*, Valencia, Universidad Internacional Menéndez y Pelayo, Vol. 1, pp. 59-81.

Cubel Montesinos, Antonio and Palafox Gamir, Jordi (1997), "El stock de capital en la economía española, 1900-1958", *Revista de Historia Industrial*, 12, pp. 113-126.

Cubel Montesinos, Antonio and Palafox Gamir, Jordi (1998), "La continuidad del crecimiento económico de España. 1850-1936", *Revista de Historia Económica*, 16, 3, pp. 619-643.

Cubel Montesinos, Antonio and Palafox Gamir, Jordi (1999), "Una perspectiva histórica del stock de capital ferroviario en España", in Mas, Matilde; Pérez, Francisco and Uriel, Ezequiel (eds.), pp. 15-59.

Cucarella, Vicent (1999), "El *stock* de capital ferroviario en España y sus provincias, 1845-1997", en Mas, Matilde; Pérez, Francisco and Uriel Ezequiel (eds.), pp. 61-172.

Cuellar Villar, Domingo (2001), "Un modelo ferroviario de ciclo minero: auge y caída del ferrocarril en el Sureste andaluz", *II Congreso de Historia Ferroviaria*, Aranjuez, Febrero de 2001.

Cuéllar Villar, Domingo and Sánchez Picón, Andrés (1999), "El impacto económico de un ferrocarril periférico. La Compañía de Caminos de Hierro del Sur de España (1889-1929)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 619-643.

Cunningham, Brysson (1914), *The Dock and Harbour Engineers Reference Book*, London, Charles Griffin & Co. Ltd.

Dasgupta, Sudipto and Nanda, Vikram (1993), "Bargaining and Brinkmanship: Capital Structure Choice by Regulated Firms", *International Journal of Industrial Organization*, 11, pp. 475-497.

David, Paul A. (1969), "Transport Innovation and Economic Growth: Professor Fogel On and Off the Rails", *Economic History Review*, 22, 3, pp. 506-525.

Dawson, Philip (1897), *Electric Railways and Tramways. Their Construction and Operation. A Practical Handbook*, London, Engineering.

Deane, Phyllis (1968), "New Estimates of Gross National Product for the United Kingdom", *Review of Income and Wealth*, 14, 2, pp. 95-112.

Debande, Olivier (1997), "Le rôle du secteur privé dans le financement des infrastructures. Une mise en perspective historique", *Revue Économique*, 48, 2, pp. 197-229.

De Casso Ortiz de Villajos, Fernando (1968), "La red de carreteras del Estado. Evaluación por el método de valoración de la red existente a precio de coste actual", in Universidad Comercial de Deusto, Vol. 2, pp. 357-391.

De Jong, Herman J. (1992), "Dutch Inland Transport in the Nineteenth Century: A Bibliographical Review", *Journal of Transport History*, 13, 1, pp. 1-22.

De la Fuente, Ángel; Caminal, Ramón; Esteban, Joan Maria and Vives, Xavier (1994), *Crecimiento y convergencia regional en España y Europa*, Bellaterra, Instituto de Análisis Económico.

De la Puerta Rueda, Natividad (1994), *El puerto de Bilbao como reflejo del desarrollo industrial de Vizcaya*, Bilbao, Autoridad Portuaria de Bilbao.

Del Moral Ruiz, Joaquín (1981), "Mercado, transportes y gasto público en la España interior: el Canal de Castilla, 1751-1919", *Hacienda Pública Española*, 69, pp. 125-138.

Del Moral Ruiz, Joaquín (1984), *Hacienda central y haciendas locales en España, 1845-1905*, Madrid, Instituto de Estudios de Administración Local.

De Long, J. Bradford (1992), "Productivity Growth and Machinery Investment: A Long Run Look, 1870-1980", *Journal of Economic History*, 52, 2, pp. 307-324.

De Long, Bradford and Summers, Lawrence H. (1994), "How Robust is the Growth-Machinery Nexus?", in Baldassari, Mario; Paganetto, Luigi and Phelps, Edmund S. (eds.), pp. 5-54.

Denison, Edward F. (1957), "Theoretical Aspects of Quality Change, Capital Consumption, and Net Capital Formation", in *Problems of Capital Formation. Concepts, Measurement, and Controlling Factors. Studies in Income and Wealth Volume Nineteen*, Princeton, Princeton University Press, pp. 215-284.

De Rus, Ginés (1999), "Economía y política del transporte: principios y tendencias", *Papeles de Economía Española*, 82, pp. 2-17.

De Urquijo y De la Fuente, José Luis (1968), "Patrimonio de la Dirección General de Correos y Telecomunicación", in Universidad Comercial de Deusto, Vol. 2, pp. 689-722.

Diamond, Derek and Spence, Nigel (1989), *Infrastructure and Industrial Costs in British Industry*, London, Her Majesty's Stationery Office.

Diewert, W. Erwin (1986), *The Measurement of the Economic Benefits of Infrastructure Services*, Berlin, Springer-Verlag.

Dogdson, J.S. (1993), "British Railway Cost Functions and Productivity Growth, 1900-1912", *Explorations in Economic History*, 30, pp. 151-181.

Domínguez Martín, Rafael and Pérez González, Patricio (2001), "Cantabria: del mercado colonial al marcado nacional", in Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.), pp. 66-94.

Doornik, Jurgen A.; Hendry, David F. and Nielsen, Bent (1998), "Inference in Cointegrating Models: UK M1 Revisited", *Journal of Economic Surveys*, 12, 5, pp. 533-572.

Draper, María and Herce, José A. (1994), "Infraestructuras y crecimiento: un panorama", *Revista de Economía Aplicada*, 3, 6, pp. 129-168.

Duffy-Deno, Kevin T. and Eberts, Randall W. (1991), "Public Infrastructure and Regional Economic Development: A Simultaneous Equations Approach", *Journal of Urban Economics*, 30, pp. 329-343.

Duggal, Vijaya G.; Saltzman, Cynthia and Klein, Lawrence R. (1999), "Infrastructure and Productivity: A Nonlinear Approach", *Journal of Econometrics*, 92, pp. 47-74.

Dugonjic, Vlasta (1989), "Transportation: Benign Influence or an Antidote to Regional Inequality?", *Papers of the Regional Science Association*, 66, pp. 61-76.

Eberts, Randall W. (1986), *Estimating the Contribution of Urban Infrastructure to Regional Growth*, Working Paper 8610, Federal Reserve Bank of Cleveland.

Echaide, Ignacio Mª (1929), *Red telefónica de la Diputación de Guipúzcoa. Resumen descriptivo, histórico y estadístico para la Exposición Ibero-Americana de Sevilla*, San Sebastián, Diputación de Guipúzcoa.

Eichengreen, Barry (1994), *Financing Infrastructure in Developing Countries. Lessons from the Railway Age*, The World Bank, Policy Research Working Paper 1379.

El problema de los ferrocarriles españoles. Antecedentes, datos, soluciones (1933), Madrid, Gráfica Administrativa.

Englund, Peter; Persson, Torsten and Svensson, Lars E. O. (1992), "Swedish Business Cycles: 1861-1988", *Journal of Monetary Economics*, 30, pp. 343-371.

Equipo Urbano (1972), "Simulación de una red de transportes: el caso de los ferrocarriles españoles", *Revista de Geografía*, 6, 1, pp. 34-54.

Escribá-Pérez, Francisco Javier and Ruiz-Tamarit, José Ramón (1995), "Economic Measurement of Capital and Profitability", *Recherches Economiques de Louvain*, 61, 4, pp. 433-459.

Evans, Andrew W. (1991), "A Theoretical Model for Local Roads Grants", *Urban Studies*, 28, 2, pp. 219-231.

Feinstein, Charles H. (1965), *Domestic Capital Formation in the United Kingdom 1920-1938*, Cambridge, Cambridge University Press.

Feinstein, Charles H. (1972), *National Income*, *Expenditure and Output of the United Kingdom 1855-1965*, Cambridge, Cambridge University Press.

Feinstein, Charles H. (1988), "Part II. National Statistics, 1760-1920", in Feinstein, Charles H. and Pollard, Sidney (eds.), pp. 258-401.

Feinstein, Charles H. and Pollard, Sidney (eds.) (1988), *Studies in Capital Formation in the United Kingdom, 1750-1920*, Oxford, Clarendon Press.

Fenoaltea, Stefano (1982), "The Growth of the Utilities Industries in Italy, 1861-1913", *Journal of Economic History*, 42, 3, pp. 601-627.

Fenoaltea, Stefano (1983), "Italy", in O'Brien, Patrick (ed.), pp. 48-120.

Fenoaltea, Stefano (1984), "Le costruzioni ferroviarie in Italia, 1861-1913", *Rivista di Storia Economica*, 1, 1, pp. 61-94.

Fernald, John G. (1999), "Roads to Prosperity? Assessing the Link Between Public Capital and Productivity", *American Economic Review*, 89, 3, pp. 619-638.

Fernández Clemente, Eloy (1998), *De la utopía de Costa a la intervención del Estado: un siglo de obras hidráulicas en España*, Santander, Universidad Internacional Menéndez y Pelayo, unpublished research paper.

Fernández Ordóñez, José A. (1986), *Catálogo de treinta canales españoles anteriores a 1900*, Madrid, Colegio de Ingenieros de Caminos, Canales y Puertos.

Finn, Mary (1993), "Is All Government Capital Productive?", *Federal Reserve Bank of Richmond Economic Quarterly*, 79, 4, pp. 53-80.

Fishlow, Albert (1965), *American Railroads and the Transformation of the Ante-bellum Economy*, Cambridge (MA), Harvard University Press.

Fishlow, Albert (1966), "Productivity and Technological Change in the Railroad Sector, 1840-1910", in Brady, Dorothy S. (ed.), *Output, Employment and Productivity in the United States After 1800*. *Studies in Income and Wealth Volume Thirty*, New York, National Bureau of Economic Research , pp. 583-646.

Flynn, Roderick and Preston, Paschal (1999), "The Long-Run Diffusion and Techno-Economic Performance of National Telephone Networks: A Case Study of Ireland, 1922-1998", *Telecommunications Policy*, 23, pp. 437-457.

Fogel Robert William (1960), *The Union Pacific Railroad. A Case in Premature Enterprise*, Baltimore, The John Hopkins Press.

Fogel, Robert William (1964), *Railroads and American Economic Growth: Essays in Econometric History*, Baltimore.

Fogel, Robert William (1967), "The Specification Problem in Economic History", *Journal of Economic History*, 27, 3, pp. 283-308.

Fogel, Robert William (1979), "Notes on the Social Saving Controversy", *Journal of Economic History*, 39, 1, pp. 1-54.

Foreman-Peck, James S. (1987), "Natural Monopoly and Railway Policy in the Nineteenth Century", *Oxford Economic Papers*, 39, pp. 699-718.

Foreman-Peck, James S. (1990), “Railways and Late Victorian Economic Growth”, in Foreman-Peck, James S. (ed.), *New Perspectives on the Late Victorian Economy*, Cambridge, Cambridge University Press, pp. 73-95.

Foreman-Peck, James S. and Lains, Pedro (2000), “European Economic Development. The Core and the Southern Periphery”, in Pamuk, evket and Williamson, Jeffrey G. (eds.), pp. 76-106.

Fraile Balbín, Pedro (1991), *Industrialización y grupos de presión. La economía política de la protección en España 1900-1950*, Madrid, Alianza.

Frax Rosales, Esperanza (1981), *Puertos y comercio de cabotaje en España, 1857-1934*, Madrid, Servicio de Estudios del Banco de España, Estudios de Historia Económica, nº 2.

Frax Rosales, Esperanza and Madrazo, Santos (2001), “El transporte por carretera, siglos XVIII-XX”, *Transportes, Servicios y Telecomunicaciones*, 1, pp. 31-53.

Frax Rosales, Esperanza and Matilla Quiza, María Jesús (1988), “Transporte, comercio y comunicaciones”, in Artola, Miguel (ed.), *Enciclopedia de Historia de España. Vol. 2. Economía. Sociedad*, Madrid, Alianza, pp. 191-263.

Frax Rosales, Esperanza and Matilla Quiza, María Jesús (1994), “Transporte y comercio marítimo en los siglos XVIII y XIX”, in Centro de Estudios Históricos de Obras Públicas y Urbanismo, pp. 77-100.

Frax Rosales, Esperanza; Matilla Quizá, María Jesús; Muñoz Rubio, Miguel and Sáiz González, José Patricio (1996), “La innovación tecnológica en los puertos españoles en el siglo XIX a través del sistema de patentes”, in Guimerá Ravina, Agustín and Romero, Dolores (eds.), pp. 275-291.

Freeman, Michael J. (1983), “Introduction”, in Aldcroft, Derek H. and Freeman, Michael J. (eds.), *Transport in the Industrial Revolution*, Manchester, Manchester University Press, pp. 1-29.

Freeman, Michael J. and Aldcroft, Derek H. (eds.) (1988), *Transport in Victorian Britain*, Manchester, Manchester University Press.

Fremdling, Rainer (1980), “Freight Rates and State Budget: The Role of the National Prussian Railways 1880-1913”, *Journal of European Economic History*, 9, 1, pp. 21-39.

Fremdling, Rainer (1983), “Germany”, in O’Brien, Patrick (ed.), pp. 121-147.

Frost, M. E. and Spence, N. A. (1995), “The Rediscovery of Accessibility and Economic Potential: The Critical Issue of Self-Potential”, *Environment and Planning A*, 27, pp. 1833-1848.

Frybourg, Michel and Nijkamp, Peter (1998), “Assessing Changes in Integrated European Transport Networks Operations”, in Button, Kenneth; Nijkamp, Peter an Priemus, Hugo (eds.), pp. 15-34.

Fujita, Masahisa; Krugman, Paul and Venables, Anthony J. (2000), *The Spatial Economy: Cities, Regions and International Trade*, Cambridge (MA), The MIT Press.

Fujita, Masahisa and Thisse, Jacques François (1996), “Economics of Agglomeration”, *Journal of the Japanese and International Economies*, 10, 4, pp. 339-378.

Fusi Aizpúrua, Juan Pablo and Palafox Gamir, Jordi (1997), *España: 1808-1996. El desafío de la modernidad*, Madrid, Espasa Calpe.

Gabinete de Investigación de la Universidad Comercial de Deusto (1968), “Producción y distribución de energía eléctrica”, in Universidad Comercial de Deusto, Vol. 4, pp. 667-681.

Gallego Palomares, José Ángel (2001), “El ferrocarril como factor ordenador del mercado del vino. La Mancha: emergencia y crisis del sector vitivinícola (1865-1890)”, *II Congreso de Historia Ferroviaria*, Aranjuez, Febrero de 2001.

Gallup, John Luke; Sachs, Jeffrey D. and Mellinger, Andrew D. (1999), “Geography and Economic Development”, *International Regional Science Review*, 22, 2, pp. 179-232.

García Delgado, José Luis and Carrera Troyano, Miguel (2001), “Madrid, capital económica”, in Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.), pp. 209-237.

García García, Carmen and Comín Comín, Francisco (1995), “Reforma liberal, centralismo y haciendas municipales en el siglo XIX”, *Hacienda Pública Española*, 133, pp. 81-106.

Garcia-Milà, Teresa (1990), “Un modelo dinámico con capital público y su estimación por simulación”, *Investigaciones Económicas*, 14, 3, pp. 369-383.

Garcia-Milà, Teresa (1994), “Impacto de la inversión pública en el crecimiento económico”, in Jiménez, J. C. (ed.), *El Estado en la economía española. VIII Jornadas de Alicante sobre Economía Española*, Madrid, Civitas, pp. 173-191.

Garcia-Milà, Teresa; McGuire, Therese J. and Porter, Robert H. (1996), “The Effect of Public Capital in State-Level Production Functions Reconsidered”, *Review of Economics and Statistics*, 78, 1, pp. 177-180.

García Ortega, Pedro (1982), *Historia de la legislación española de caminos y carreteras*, Madrid, Ministerio de Obras Públicas y Urbanismo.

Garrabou, Ramon (2000), “La organización del trabajo en el mundo rural y sus evoluciones históricas. Época contemporánea”, *Historia Agraria*, 20, pp. 25-38.

Garrabou, Ramon and Sanz Fernández, Jesús (1985a) (eds.), *Historia agraria de la España contemporánea. Vol. 2. Expansión y crisis (1850-1900)*, Barcelona, Crítica.

Garrabou, Ramon and Sanz Fernández, Jesús (1985b), “La agricultura española durante el siglo XIX: ¿inmovilismo o cambio?”, in Garrabou, Ramon and Sanz Fernández, Jesús (eds.), pp. 7-191.

Garrido Bartolomé, Manuel (1968), “Embalses”, in Universidad Comercial de Deusto, Vol. 4, pp. 683-742.

Genicot, Leopold (1946), “Etudes sur la construction des routes en Belgique”, *Bulletin de l’Institut de Recherches Économiques et Sociales*, XII, 5, pp. 495-559.

Germán Zubero, Luis (1999), “Red ferroviaria y evolución del comercio interregional de la economía aragonesa, 1875-1930”, in Muñoz Rubio, Miguel; Sanz Fernández, Jesús; and Vidal Olivares, Javier (eds.), pp. 517-532.

Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.) (2001), *Historia económica regional de España, siglos XIX y XX*, Barcelona, Crítica.

Gerschenkron, Alexander (1962), *Economic Backwardness in Historical Perspective: A Book of Essays*, Cambridge (MA), Belknap Press of Harvard University Press.

Giebens, A. (1926), “Les grands travaux d’irrigation en Espagne”, *Revue des Questions Scientifiques*, 90, pp. 402-451.

Gil Carretero, Santos (1968), “Los transportes urbanos colectivos”, in Universidad Comercial de Deusto, Vol. 2, pp. 453-477.

Girard, L. (1966), “Transport”, in Habakkuk, H. J. and Postan, M. (eds.), *The Cambridge Economic History of Europe. Vol. VI. The Industrial Revolutions and After: Incomes, Population and Technological Change (I)*, Cambridge, Cambridge University Press, pp. 212-273.

Giuntini, Andrea (1999), “El ferrocarril italiano, de sus orígenes a hoy”, in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 81-103.

Glaeser, Edward L.; Kallal, Hedi D.; Scheinkman, José A. and Shleifer, Andrei (1992), “Growth in Cities”, *Journal of Political Economy*, 100, 6, pp. 1126-1152.

Gómez Díaz, Donato and Céspedes Lorente, José (1996), “Ausentes, transeúntes y nacidos en otra provincia, un sistema de flujos y stock para evaluar la movilidad migratoria española, 1860-1930”, in González Portilla, Manuel and Zarraga, K. (eds.), *Los movimientos migratorios en la construcción de las sociedades modernas*, Bilbao, Universidad del País Vasco, pp. 31-83.

Gómez Mendoza, Antonio (1981), *Railways and Spanish Economic Growth in the Late 19h Century*, University of Oxford, PhD Thesis.

Gómez Mendoza, Antonio (1982), *Ferrocarriles y cambio económico en España (1855-1913). Un enfoque de nueva historia económica*, Madrid, Alianza.

Gómez Mendoza, Antonio (1983), “The Role of Horses in a Backward Economy: Spain in the Nineteenth Century”, in Thompson, F. M. L. (ed.), *Horses in European Economic History. A Preliminary Canter*, London, The British Agricultural Society, pp. 143-155.

Gómez Mendoza, Antonio (1989a), *Ferrocarril, industria y mercado en la modernización de España*, Madrid, Espasa Calpe.

Gómez Mendoza, Antonio (1989b), “Transportes y Comunicaciones”, in Carreras, Albert (ed.), pp. 269-323.

Gómez Mendoza, Antonio (1991), “Las obras públicas, 1850-1935” in Comín Comín, Francisco and Martín Aceña, Pablo (eds.), *Historia de la empresa pública en España*, Madrid, Espasa Calpe, pp. 177-204.

Gómez Mendoza, Antonio (1995), "Europe's Cinderella: Inland Navigation in nineteenth-century Spain", in Kunz, Andreas and Armstrong, John (eds.), pp. 131-145.

Gómez Mendoza, Antonio (1997), "Transportes" in *Historia de España de Don Ramón Menéndez Pidal. Vol. XXXIII. Los fundamentos de la España liberal (1834-1900). La sociedad, la economía y las formas de vida*, Madrid, Espasa Calpe, pp. 465-515.

Gómez Mendoza, Antonio (1998), "Along Broad Lines. The Economic History of Spanish Railways, 1973-96", *Journal of Transport History*, 19, 1, pp. 1-17.

Gómez Mendoza, Antonio (1999a), "Caballo de sangre, caballo de vapor en el transporte de fines del siglo XIX", in Carreras, Albert; Pascual, Pere; Reher, David and Sudrià, Carles (eds.), *Doctor Jordi Nadal. La industrialització i el desenvolupament econòmic a Espanya*, Barcelona, Universitat de Barcelona, Vol. 1, pp. 721-735.

Gómez Mendoza, Antonio (1999b), "Los transportes y el comercio interior en la España del siglo XIX", in Anes Álvarez, Gonzalo (ed.), pp. 223-249.

Gómez-Santos, Marino (1969), *El metro de Madrid. Medio siglo al servicio de la ciudad 1919-1969*, Madrid, ESCELICER.

González-Páramo, José Manuel (1995), "Infraestructuras, productividad y bienestar", *Investigaciones Económicas*, 19, 1, pp. 155-168.

González Paz, José and De Cossío Cosio, Rafael (1968), "El patrimonio nacional de carreteras. Introducción", in Universidad Comercial de Deusto, Vol. 2, pp. 353-356.

González Peláez, Miguel Ángel (1995), "Una aproximación estadística a la evolución de la red telegráfica española (1900-1930)", in Bahamonde Magro, Ángel; Martínez Lorente, Gaspar and Otero Carvajal, Luis Enrique (eds.), pp. 179-211.

González Portilla, Manuel; Montero, Manuel; Garmendia, José María; Novo, Pedro A. and Macías, Olga (1995), *Ferrocarriles y desarrollo. Red y mercados en el País Vasco, 1856-1914*, Bilbao, Universidad del País Vasco.

Gramlich, Edward M. (1994), "Infrastructure Investment: A Review Essay", *Journal of Economic Literature*, 32, 3, pp. 1176-1196.

Granger, Clive W. J. (1993), "What are we Learning about the Long-Run?", *Economic Journal*, 103, pp. 307-317.

Green, Alan G. (1986), "Growth and Productivity in the Canadian Railway Sector, 1871-1926", in Engerman, Stanley L. and Gallman, Robert E. (eds.), *Long-Term Factors in American Economic Growth*, Chicago, The University of Chicago Press, pp. 779-817.

Griffiths, Richard T. (1982), "The Creation of a National Dutch Economy: 1795-1909", *Tijdschrift voor Geschiedenis*, 95, pp. 513-537.

Groote, Peter (1996), *Infrastructure and Dutch Economic Development. A New Long Run Data Set for the Netherlands 1800-1913*, Utrecht/Groningen, Koninklijk Nederlands Aardrijkskundig Genootschap/Faculteit der Ruimtelijke Wetenschappen.

Groote, Peter; Jacobs, Jan and Sturm, Jan-Egbert (1999), "Infrastructure and Economic Development in the Netherlands, 1853-1913", *European Review of Economic History*, 2, pp. 233-251.

Grupo de Estudios de Historia Rural (1985), "Contribución al análisis histórico de la ganadería española, 1865-1929", in Garrabou, Ramon and Sanz Fernández, Jesús (eds.), pp. 229-278.

Guimerá Ravina, Agustín (1996), "El sistema portuario español (siglos XVI-XX): perspectivas de investigación", in Guimerá Ravina, Agustín and Romero Muñoz, Dolores (eds.), pp. 125-141.

Guimerá Ravina, Agustín and Romero Muñoz, Dolores (eds.) (1996), *Puertos y sistemas portuarios (Siglos XVI-XX): Actas del Coloquio Internacional "El sistema portuario español", Madrid, 19-21 octubre, 1995*, Madrid, Ministerio de Fomento.

Hadfield, Charles (1986), *World Canals. Inland Navigation Past and Present*, London, David and Charles.

Hakfoort, Jacco (1996), "Public Capital, Private Sector Productivity and Economic Growth: A Macroeconomic Perspective", in Batten, David F. and Karlsson, Charlie (eds.), pp. 61-72.

Haldrup, Niels (1998), "An Econometric Analysis of I(2) Variables", *Journal of Economic Surveys*, 12, 5, pp. 595-650.

Hansen, Niles M. (1965), "Unbalanced Growth and Regional Development", *Western Economic Journal*, 4, pp. 3-14.

Hansen, Walter G. (1959), "How Accessibility Shapes Land Use", *Journal of the American Institute of Planners*, 25, 2, pp. 73-76.

Harley, C. Knick (1982), "Oligopoly Agreement and the Timing of American Railroad Construction", *Journal of Economic History*, 42, 2, pp. 797-823.

Hart, T. (1983), "Transport and the Economic Development: The Historical Dimension", in Button, Kenneth J. and Gilligwater, D. (eds.), *Transport, Location and Spatial Policy*, Aldershot, Gower, pp. 12-22.

Hawke, Gary R. (1970), *Railways and Economic Growth in England and Wales*, Oxford, Clarendon Press.

Hawke, Gary R. and Higgins, Jim (1983), "Britain", in O'Brien, Patrick (ed.), pp. 170-202.

Hedin, Lars-Erik (1967), "Some Notes on the Financing of the Swedish Railroads 1860-1914", *Economy and History*, 10, pp. 3-37.

Henderson, Vernon; Kuncoro, Ari and Turner, Matt (1995), "Industrial Development in Cities", *Journal of Political Economy*, 103, 5, pp. 1067-1090.

Hernández, Telesforo Marcial (1983), *Ferrocarriles y capitalismo en el País Valenciano*, Valencia, Ayuntamiento de Valencia.

Hernández, Telesforo Marcial (1999), "Sociedades ferroviarias, mercado y transporte en el País Valenciano (1844-1914)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús; and Vidal Olivares, Javier (eds.), pp. 415-431.

Hernández Andreu, Juan (1981), "Orígenes, expansión y limitaciones del sector eléctrico en España, 1900-1936", *Información Comercial Española*, 577, pp. 137-150.

Hernández Marco, José Luis (1999), "El ferrocarril como ampliador de los espacios económicos portuarios. La cía del Norte y algunos puertos septentrionales españoles entre 1878 y 1930", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús; and Vidal Olivares, Javier (eds.), pp. 597-618.

Heyman, Hans (1965), "The Objectives of Transportation", in Fromm, Gary (ed.), *Transport Investment and Economic Development*, Washington, The Brookings Institution, pp. 18-33.

Hildebrand, K.-G. (1978), "Labour and Capital in the Scandinavian Countries in the Nineteenth and Twentieth Century", in Mathias, Peter and Postan, M. M. (eds.), pp. 590-628.

Hirschman, Albert O. (1958), *The Strategy of Economic Development*, New Haven, Yale University Press.

Hoffmann, Walther G. (1965), *Das Wachstum del Deutschen Wirtschaft seit der mitte des 19. Jahrhunderts*, Berlin, Springer-Verlag.ç

Hofman, André A. (1992), "Capital Accumulation in Latin America: A Six Country Comparison for 1950-1989", *Review of Income and Wealth*, 38, 4, pp. 365-401.

Hofman, André A. (1993), "Long Run Growth in Spain and Smaller Latin American Countries. A Comparative Perspective", *SPES/EHES Conference on Long Run Economic Growth in the European Periphery*, Coruña.

Holgersson, Bengt and Nicander, Eric (1968), "The Railroads and the Economic Development in Sweden during the 1870s", *Economy and History*, 11, pp. 3-51.

Holtz-Eakin, Douglas (1994), "Public-Sector Capital and the Productivity Puzzle", *Review of Economics and Statistics*, 76, 1, pp. 12-21.

Holtz-Eakin, Douglas and Lovely, Mary E. (1996), "Scale Economies, Returns to Variety and the Productivity of Public Infrastructure", *Regional Science and Urban Economics*, 26, 2, pp. 105-123.

Hulten, Charles R. (1992), "Growth Accounting When Technical Change is Embodied in Capital", *American Economic Review*, 82, 4, pp. 964-980.

Hulten, Charles R. And Schwab, Robert M. (1993), "Infrastructure Spending: Where do we Go from Here?", *National Tax Journal*, 46, 3, pp. 261-273.

Humplick, Frannie (1996), "Does Multiplicity Matter more than Ownership in the Efficiency of Infrastructure Services?", in Batten, David F. and Karlsson, Charlie (eds.), pp. 125-146.

Iglesias, Arturo (1981), "Estado y ferrocarriles, 1914-1941", in RENFE (ed.), pp. 147-163.

Instituto Nacional de Estadística (1965), *Estadística de transporte ferroviario. Años 1865-1965*, Madrid, INE.

Irving, R. J. (1978), "The Profitability and Performance of British Railways, 1870-1914", *Economic History Review*, 31, 1, pp. 46-66.

Istituto Centrale di Statistica (1976), *Sommario di statistiche storiche dell'Italia, 1861-1975*, Roma, ICS.

Jackson, G. (1988), "The Ports", in Freeman, Michael J. and Aldcroft, Derek H. (eds.), pp. 218-252.

Jenks, Leland H. (1944), "Railroads as an Economic Force in American Development", *Journal of Economic History*, 4, 1, pp. 1-20.

Johansson, B. (1993), "Infrastructure, Accessibility and Economic Growth", *International Journal of Transport Economics*, 20, 2, pp. 131-156.

Juez Gonzalo, Emerenciana-Paz (1992), *El mundo social de los ferrocarriles españoles de 1857 a 1917*, Madrid, Universidad Complutense de Madrid, PhD Thesis.

Junta Central de Puertos (n.d.), *Libro de puertos*, Madrid, Ministerio de Fomento.

Jutikkala, Enno (1970), "The Problem of Railway Ownership in 19th Century Finland", *Scandinavian Economic History Review*, 18, 1, pp. 66-68.

Kahan, Arkadius (1978), "Capital Formation During the Period of Early Industrialization in Russia, 1890-1913", in Mathias, Peter and Postan, M. M. (eds.), pp. 265-307.

Kahn, Alfred E. (1988), *The Economics of Regulation. Principles and Institutions*, Cambridge (MA), The MIT Press.

Katus, László (1983), "Transport Revolution and Economic Growth in Hungary", in Komlos, John (ed.), *Economic Development in the Habsburgh Monarchy in the Nineteenth Century. Essays*, New York, Columbia University Press, pp. 183-204.

Kaukiainen, Yrjö (2001), "Shrinking the World: Improvements in the Speed of Information Transmission, c. 1820-1870", *European Review of Economic History*, 5, pp. 1-28.

Keaton, Mark H. (1990), "Economies of Density and Service Levels on U.S. Railroads: An Experimental Analysis", *Logistics and Transportation Review*, 26, 3, pp. 211-227.

Keefer, Philip (1996), "Protection Against a Capricious State: French Investment and Spanish Railroads, 1845-1875", *Journal of Economic History*, 56, 1, pp. 170-192.

Kenwood, A. G. (1965), "Railway Investment in Britain, 1825-1875", *Economica*, 32, 127, pp. 313-322.

Kessides, Christine (1996), "A Review of Infrastructure's Impact on Economic Development", in Batten, David F. and Karlsson, Charlie (eds.), pp. 213-230.

Kim, Sukkoo (1995), "Expansion of Markets and the Geographic Distribution of Economic Activities: The Trends in U.S. Regional Manufacturing Structure, 1860-1987", *Quarterly Journal of Economics*, 110, 4, pp. 881-908.

Kindleberger, Charles P. (1965), *Economic Development*, New York, McGraw-Hill.

Krantz, Olle (1972), "The Competition Between Railways and Domestic Shipping in Sweden 1870-1914", *Economy and History*, 15, pp. 18-40.

Krantz, Olle (1995), “Inland Navigation and Economic Growth in Sweden in the Nineteenth Century”, in Kunz, Andreas and Armstrong, John (eds.), pp. 79-103.

Krantz, Olle (2000), “The Transport and Communications Sector in Economic Development: Views from the Historical National Accounts”, *Scandinavian Economic History Review*, 48, 2, pp. 5-29.

Krugman, Paul (1991), “Increasing returns and Economic Geography”, *Journal of Political Economy*, 99, 3, pp. 483-499.

Krugman, Paul (1995), *Development, Geography and Economic Theory*, Cambridge (MA), MIT Press.

Krugman, Paul and Venables, Anthony J. (1995), “Globalization and the Inequality of Nations”, *Quarterly Journal of Economics*, 90, 4, pp. 857-880.

Kunz, Andreas (1992), “La modernisation d’un transport encore préindustriel pendant l’ere industrielle: le cas des voies navigables de l’Allemagne Imperiale de 1871 à 1918”, *Histoire, Économie et Société*, 11, 1, pp. 19-31.

Kunz, Andreas (1994), “Inland Navigation, Industrialisation and Economic Development in Nineteenth Century Europe”, *Journal of Transport History*, 15, 2, pp. 197-200.

Kunz, Andreas (1995), “Inland Transport and European Economic Development in the Nineteenth Century. The Case of Inland Waterways”, in Carreras, Albert; Giuntini, Andrea and Kunz, Andreas (eds.), pp. 27-32.

Kunz, Andreas and Armstrong, John (eds.) (1995a), *Inland Navigation and Economic Development in Nineteenth-Century Europe*, Mainz, Von Zabern.

Kunz, Andreas and Armstrong, John (1995b), “Introduction”, in Kunz, Andreas and Armstrong, John (eds.), pp. 1-9.

Kuznets, Simon (1957), “Quantitative Aspects of the Economic Growth of Nations. II. Industrial Distribution of National Product and Labor Force”, *Economic Development and Cultural Change*, 5, 4, Supplement, pp. 1-111.

Laffut, Michel (1983), “Belgium”, in O’Brien, Patrick (ed.), pp. 203-226.

Laffut, Michel (1992), “Le bilan du rôle des chemins de fer dans le développement de la Belgique du XIX siècle”, *Histoire, Économie et Société*, 11, 1, pp. 82-90.

Lakshmanan, T. R. (1989), “Infrastructure and Economic Transformation”, in Andersson, Åke E.; Batten, David F.; Johansson, Börje and Nijkamp, Peter (eds.), *Advances in Spatial Theory and Dynamics*, Amsterdam, North Holland, pp. 241-261.

Leclerq, Yves (1990), “L’Etat, les enterprises ferroviaires et leur profits en France (1830-1860)”, *Histoire, Économie et Société*, 9, 1, pp. 39-63.

Léon, Paul (1904), “La navigation intérieure en France”, *Revue Économique Internationale*, 33, 3, pp. 549-592.

Lepetit, Bernard (1994), *The Pre-Industrial Urban System: France, 1740-1840*, Cambridge, Cambridge University Press.

Levine, Ross and Renelt, David (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review*, 82, 4, pp. 942-963.

Lévy-Leboyer, Maurice (1978), "Capital Investment and Economic Growth in France, 1820-1930", in Mathias, Peter and Postan, M. M. (eds.), pp. 231-295.

Lightner, David L. (1983), "Railroads and the American Economy: The Fogel Thesis in Retrospect", *Journal of Transport History*, 4, 2, pp. 20-34.

Limão, Nuno and Venables, Anthony J. (2000), *Infrastructure, Geographical Disadvantage, Transport Costs and Trade*, unpublished research paper.

Llopis Agelán, Enrique (2001), "El legado económico del Antiguo Régimen desde la óptica regional", in Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.), pp. 507-524.

Llopis Agelán, Enrique and Jerez Méndez, Miguel (2001), "El mercado de trigo en Castilla y León, 1691-1788: arbitraje espacial e intervención", *Historia Agraria*, 25, pp. 13-68.

Llorente Chala, Juan Carlos (1979), "El sector de producción y distribución de energía eléctrica durante la década 1920-1930", *Cuadernos Económicos de I.C.E.*, 10, pp. 535-577.

Looney, Robert and Frederiksen, Peter (1981), "The Regional Impact of Infrastructure Investment in Mexico", *Regional Studies*, 15, 4, pp. 285-296.

López Hernández, Enrique (1968), "Patrimonio de la Compañía Telefónica Nacional de España", in Universidad Comercial de Deusto, Vol. 2, pp. 723-741.

López-Morell, Miguel Ángel (1999), "El papel de los Rothschild en la construcción de los ferrocarriles en España (1855-1874)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 669-691.

López-Morell, Miguel Ángel (2001), "Salamanca y la construcción del ferrocarril de Aranjuez", *II Congreso de Historia Ferroviaria*, Aranjuez, Febrero de 2001.

Lucas, Robert E. (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics*, 22, pp. 3-42.

Luna Rodrigo, Gloria (1988), "La población urbana en España, 1860-1930", *Boletín de la Asociación de Demografía Histórica*, 6, 1, pp. 25-68.

Lynde, Catherine and Richmond, James (1992), "The Role of Public Capital in Production", *Review of Economics and Statistics*, 74, 1, pp. 37-44.

Macías, Olga (1999), "Los ferrocarriles y el desarrollo económico del País Vasco (1856-1936)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 457-476.

Maddison, Angus (1995a), *Explaining the Economic Performance of Nations. Essays in Time and Space*, Aldershot, Edward Elgar.

Maddison, Angus (1995b), *Monitoring the World Economy*, Paris, OECD.

Madrazo, Santos (1984), *El sistema de comunicaciones en España, 1750-1850*, Madrid, Turner.

Maizels, Alfred (1968), *Exports and Economic Growth in Developing Countries*, Cambridge, Cambridge University Press.

Maristany y Gibert, E. (1889), "Memoria sobre las mejoras que, con arreglo a los adelantos modernos, y bajo el punto de vista de la seguridad de la explotación, pueden introducirse en el material fijo y móvil y en los sistemas de frenos y señales de los ferrocarriles españoles", *Revista de Obras Públicas*, 37, 1, pp. 3-13.

Marshall, Alfred (1916), *Principles of Economics*, London, MacMillan.

Martin, P. and Rogers, C. A. (1995), "Industrial Location and Public Infrastructure", *Journal of International Economics*, 39, pp. 335-351.

Martín Aceña, Pablo (1981), "España y el patrón oro, 1880-1913", *Hacienda Pública Española*, 69, pp. 267-290.

Martín Aceña, Pablo (1994), "Spain during the Classical Gold Standard Years, 1880-1914", in Bordo, Michael D. and Capie, Forrest (eds.), *Monetary Regimes in Transition*, Cambridge, Cambridge University Press, pp. 135-172.

Martínez Vara, Tomás (1999), "La integración del mercado del trigo en el Norte y la Castilla del Duero, 1800-1860. Algunas reflexiones", *Historia Agraria*, 19, pp. 43-73.

Martínez Vara, Tomás (2001), "Los costes laborales en una empresa líder: la Compañía de los Ferrocarriles de Madrid a Zaragoza y a Alicante, 1919-1935", *II Congreso de Historia Ferroviaria*, Aranjuez, Febrero de 2001.

Mas, Matilde; Maudos, Joaquín; Pérez, Francisco and Uriel, Ezequiel (1996), "Infrastructures and Productivity in the Spanish Regions", *Regional Studies*, 30, 7, pp. 641-649.

Mas, Matilde; Pérez, Francisco and Uriel, Ezequiel (eds.) (1995/1998), *El stock de capital en España y sus comunidades autónomas*, Bilbao, Fundación BBV.

Mas, Matilde; Pérez, Francisco and Uriel Ezequiel (eds.) (1999), *El "stock" de capital ferroviario en España y sus provincias: 1845-1997*, Bilbao, Fundación BBV.

Mateo del Peral, Diego (1978), "Los orígenes de la política ferroviaria en España (1844-1877)", in Artola, Miguel (ed.), Vol. 1, pp. 29-159.

Mathias, Peter and Postan, M. M. (eds.) (1978), *The Cambridge Economic History of Europe. Vol. VII. The Industrial Economies: Capital, Labour and Enterprise. Part I. Britain, France, Germany and Scandinavia*, Cambridge, Cambridge University Press.

McClelland, Peter D. (1972), "Social Rates of Return on American Railroads in the Nineteenth Century", *Economic History Review*, 25, 3, pp. 471-488.

McCloskey, Donald M. (1987), *Econometric History*, London, McMillan.

McMillin, W. Douglas and Smyth, David J. (1994), “A Multivariate Time Series Analysis of the United States Aggregate Production Function”, *Empirical Economics*, 19, pp. 659-673.

Menéndez Pidal, Gonzalo (1951), *Los caminos en la Historia de España*, Madrid, Ediciones Cultura Hispánica.

Mera, Koichi (1973), “Regional Production Functions and Social Overhead Capital: An Analysis of the Japanese Case”, *Regional and Urban Economics*, 3, 2, pp. 157-185.

Merger, Michèle (1990), “La concurrence rail-navigation interieure en France 1850-1914”, *Histoire, Economie et Société*, 9, 1, pp. 65-94.

Metzer, Jacob (1976), “Railroads in Tsarist Russia: Direct Gains and Implications”, *Explorations in Economic History*, 13, pp. 85-111.

Metzer, Jacob (1977), *Some Economic Aspects of Railroad Development in Tsarist Russia*, New York, Arno Press.

Metzer, Jacob (1984), “Railroads and the Efficiency of Internal Markets: Some Conceptual and Practical Considerations”, *Economic Development and Cultural Change*, 33, 1, pp. 61-70.

Miller, Edward (1990), “Can a Perpetual Inventory Capital Stock Be Used for Production Function Parameter Estimation?”, *Review of Income and Wealth*, 36, 1, pp. 67-82.

Milward, Alan S. and Saul, S. B. (1977), *The Development of the Economies of Continental Europe, 1850-1914*, London, Allen and Unwin.

Ministerio de Obras Públicas (1940), *Plan General de Obras Públicas*, Madrid, Talleres Penitenciarios de Alcalá.

Mira Rodríguez, José and Llagunes Farras, Enrique (1968), “El capital ferroviario”, in Universidad Comercial de Deusto, Vol. 2, pp. 479-558.

Mitchell, B. R. (1964), “The Coming of the Railway and United Kingdom Economic Growth”, *Journal of Economic History*, 24, 3, pp. 315-336.

Mitchell, B.R. (1988), *British Historical Statistics*, Cambridge, Cambridge University Press.

Mitchell, B.R. (1998), *International Historical Statistics. Europe 1750-1993*, London, McMillan.

Molina de Dios, Ramon (2001), “El ferrocarril y la articulación del espacio económico de Mallorca (1875-1950). La ilustración de un intento fallido: el Ferrocarril del Norte”, *II Congreso de Historia Ferroviaria*, Aranjuez, Febrero de 2001.

Molinas, César and Prados de la Escosura, Leandro (1989), “Was Spain Different? Spanish Historical Backwardness Revisited”, *Explorations in Economic History*, 26, pp. 385-402.

Monclús, Francisco Javier and Oyón, José Luis (1996), “Transporte y crecimiento urbano en España, mediados s. XIX-finales s. XX”, *Ciudad y Territorio. Estudios Territoriales*, 28, 107-108, pp. 217-240.

Moorstern, Richard and Powell, Raymond P. (1966), *The Soviet Capital Stock, 1928-1962*, Homewood, Yale University, The Economic Growth Center.

Moreno, Rosina; Artís, Manuel; López-Bazo, Enrique and Suriñach, Jordi (1997), "Evidence of the Complex Link Between Infrastructure and Regional Growth", *International Journal of Development Planning Literature*, 12, 1-2, pp. 81-108.

Moreno, Rosina; López-Bazo, Enrique and Artís, Manuel (2002), "Public Infrastructure and the Performance of Manufacturing Industries: Short- and Long-Run Effects", *Regional Science and Urban Economics*, 32, pp. 97-121.

Moreno Fernández, J. (1999), "El ancho de la vía: un parámetro controvertido", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 723-738.

Moreno Lázaro, Javier (2000), "El impacto del ferrocarril en las relaciones económicas entre la Montaña y la Meseta, 1850-1913", in *Relaciones económicas entre el interior y la periferia en la España moderna y contemporánea*, Workshop of the Fundación Duques de Soria, Soria, 17-21 July.

Moreno Lázaro, Javier (2001), "La precaria industrialización de Castilla y León", in Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.), pp. 182-208.

Morilla Critz, José (1999), "Red ferroviaria, productos agrícolas y mercado regional en Andalucía (1860-1920)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 495-515.

Morrison, Catherine J. and Schwartz, Amy Ellen (1996), "State Infrastructure and Productive Performance", *American Economic Review*, 86, 5, pp. 1095-1111.

Mulhall, Michael G. (1909) [1898], *The Dictionary of Statistics*, London, Routledge.

Munnell, Alice H. (1992), "Policy Watch: Infrastructure Investment and Economic Growth", *Journal of Economic Perspectives*, 6, 4, pp. 189-198.

Muñoz Rubio, Miguel (1999), "El Estado como empresario ferroviario", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 299-336.

Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.) (1999), *Siglo y medio del ferrocarril en España, 1848-1998. Economía, Industria y Sociedad*, Madrid, Fundación de los Ferrocarriles Españoles.

Muñoz Rubio, Miguel and Vidal Olivares, Javier (2001), "Los ferrocarriles en la historiografía española", *Transportes, Servicios y Telecomunicaciones*, 1, pp. 81-111.

Murphy, Kevin M.; Schleifer, Andrei and Vishny, Robert W. (1989), "Industrialization and the Big Push", *Journal of Political Economy*, 97, 5, pp. 1003-1026.

Nadal Ariño, Javier (1995), "El servicio telefónico en el Estado liberal: análisis comparado de las dos primeras décadas de existencia del teléfono en los Estados Unidos, Alemania, Francia y España", in Bahamonde Magro, Ángel; Martínez Lorente, Gaspar and Otero Carvajal, Luis Enrique (eds.), pp. 213-230.

Nadal Oller, Jordi (1975), *El fracaso de la revolución industrial en España, 1814-1913*, Barcelona, Ariel.

Nadal Oller, Jordi (1987), "La industria fabril española en 1900. Una aproximación", in Nadal Oller, Jordi; Carreras, Albert and Sudrià Triay, Carles (eds.), pp. 23-61.

Nadal Oller, Jordi and Carreras, Albert (eds.) (1990), *Pautas regionales de la industrialización española (siglos XIX y XX)*, Barcelona, Ariel.

Nadal Oller, Jordi; Carreras, Albert and Sudrià Triay, Carles (eds.) (1987), *La economía española en el siglo XX. Una perspectiva histórica*, Barcelona, Ariel.

Nadal Oller, Jordi and Sudrià Triay, Carles (1993), "La controversia en torno al atraso económico español en la segunda mitad del siglo XIX", *Revista de Historia Industrial*, 3, pp. 199-227.

Nicolau, Roser (1989), "La población", in Carreras, Albert (coord.), pp. 40-90.

Niemeijer, A. Frits J. (1995), "Waterways and the Dutch Economy in the Nineteenth Century", in Kunz, Andreas and Armstrong, John (eds.), pp. 213-235.

Nijkamp, Peter and Rienstra, Sytze A. (1998), "The Publi-Private Nexus in Financing Infrastructure Investment", in Button, Kenneth; Nijkamp, Peter and Priemus, Hugo (eds.), pp. 183-201.

Núñez Romero-Balmas, Gregorio (1996a), "Infraestructuras y servicios urbanos: notas para un debate" *Ciudad y Territorio. Estudios Territoriales*, 28, 109, pp. 593-604.

Núñez Romero-Balmas, Gregorio (1996b), "Servicios urbanos colectivos en España durante la industrialización: entre la empresa privada y la gestión pública", in Comín Comín, Francisco and Martín Aceña, Pablo (eds.), pp. 399-419.

Núñez Romero-Balmas, Gregorio (1998), *Local Life and Municipal Services in Spain at the Beginning of the XX Century*, unpublished research paper.

Nurkse, Ragnar (1953), *Problems of Capital Formation in Underdeveloped Countries*, Oxford, Blackwell.

O'Brien, Patrick (1977), *The New Economic History of Railways*, London, Croom Helm.

O'Brien, Patrick (ed.) (1983a), *Railways and the Economic Growth of Western Europe*, London, McMillan.

O'Brien, Patrick (1983b), "Transport and Economic Development in Europe, 1789-1914", in O'Brien, Patrick (ed.), p. 1-27.

Ohkawa, Kazushi; Ishiwate, Shigeru; Yamada, Saburo and Ishi, Hiromitsu (1966), *Estimates of Long-Term Economic Statistics of Japan since 1868. Vol. 3. Capital Stock*, Tokyo, Toyo Keizai Shinpo Sha.

Ohkawa, Kazushi; Takamatsu, Nobukiyo and Yamamoto, Yuzo (1974), *Estimates of Long-Term Economic Statistics of Japan since 1868. 1. National Income*, Tokyo, Toyo Keizai Shinponsha.

Ojeda, Germán (2001), “Asturias: de la vieja a la nueva economía”, in Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.), pp. 46-65.

Olariaga, Luis (1921), *La cuestión de las tarifas y el problema ferroviario español*, Madrid, Calpe.

Olivé Roig, Sebastián (1995), “Influencia del ferrocarril en el nacimiento del telégrafo en España”, in Bahamonde Magro, Ángel; Martínez Lorente, Gaspar and Otero Carvajal, Luis Enrique (eds.), pp. 147-156.

Ormaechea, Ángel María (1989), *Ferrocarriles en Euskadi 1855-1936*, Bilbao, Eusko Trenbideak.

Ortúñez Goicolea, Pedro Pablo (1999), “La configuración de la red nacional y las grandes compañías ferroviarias: Norte y MZA, 1913-1936”, in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 273-297.

Otero Carvajal, Luis Enrique (1995), “El Estado y la red telegráfica en España (1852-1936)”, in Bahamonde Magro, Ángel; Martínez Lorente, Gaspar and Otero Carvajal, Luis Enrique (eds.), pp. 133-145.

Ottaviano, Gianmarco I.P. and Puga, Diego (1997), *Agglomeration in the Global Economy: A Survey of the “New Economic Geography”*, CEPR Discussion Paper nº 1699.

Otto, Glenn D. and Voss, Graham M. (1996), “Public Capital and Private Production in Australia”, *Southern Economic Journal*, 62, 3, pp. 723-738.

Otto, Glenn D. and Voss, Graham M. (1998), “Is Public Capital Provision Efficient?”, *Journal of Monetary Economics*, 42, pp. 47-66.

Oum, Tae Hoon; Waters II, W.G. and Yu, Chunyan (1999), “A Survey of Productivity and Efficiency Measurement in Rail Transport”, *Journal of Transport Economics and Policy*, 33, 1, pp. 9-42.

Oum, Tae Hoon and Zhang, Yimin (1997), “A Note on Scale Economies in Transport”, *Journal of Transport Economics and Policy*, 31, pp. 309-315.

Overman, Henry; Redding, Stephen and Venables, Anthony J. (2001), *Trade and Geography: A Survey of Empirics*, unpublished research paper.

Paccoud, Thierry (1983), *Stock of Fixed Assets in Industry in the Community Members States: Towards Greater Comparability*, Luxembourg, Statistical Office of the European Communitites, Studies on National Accounts, 2.

Page, Eusebio (1871), “Datos estadísticos sobre los ferro-carriles de la Península, y consecuencias principales que de los mismos se desprenden”, *Revista de Obras Públicas*, 19, 11, pp. 130-134.

Page, Eusebio and Saavedra, Eduardo (1854), “Ancho de vía de los ferro-carriles”, *Revista de Obras Públicas*, 2, 11, pp. 136-139.

Palafox Gamir, Jordi (1980), “La gran depresión de los años treinta y la crisis industrial española”, *Investigaciones Económicas*, 11, pp. 5-46.

Palafox Gamir, Jordi (1991), *Atraso económico y democracia. La Segunda República y la economía española, 1892-1936*, Barcelona, Crítica.

Pamuk, evket and Williamson, Jeffrey G. (eds.) (2000), *The Mediterranean Response to Globalization before 1950*, London, Routledge.

Pascual Domènech, Pere (1991), "La modernització dels mitjans de transport a la Catalunya del segle XIX", in Nadal Oller, Jordi (ed.), *Història econòmica de la Catalunya contemporània. 3. S. XIX. Indústria, transports i finances*, Barcelona, Enciclopèdia Catalana, pp. 233-335.

Pascual Domènech, Pere (1998), *Ferrocarrils i demanda de productes siderúrgics*, unpublished research paper.

Pascual Domènech, Pere (1999a), "Ferrocarriles y crecimiento económico en Cataluña", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 391-413.

Pascual Domènech, Pere (1999b), *Los caminos de la era industrial. La construcción y financiación de la Red Ferroviaria Catalana (1843-1898)*, Barcelona, Edicions Universitat de Barcelona.

Pascual Domènech, Pere (2000), "La gran decepción. La rentabilidad de las acciones de los ferrocarriles catalanes (1849-1943)", *Revista de Historia Industrial*, 17, pp. 11-59.

Peña Sánchez de Rivera, Daniel and Sánchez-Albornoz, Nicolás (1983), *Dependencia dinámica entre precios agrícolas. El trigo en España, 1857-1890. Un estudio empírico*, Madrid, Servicio de Estudios del Banco de España.

Peralta, E. (1891), "Los ferrocarriles en Inglaterra", *Revista de Obras Públicas*, 39, 22, pp. 365-371.

Pérez Moreda, Vicente (1999), "Población y economía en la España de los siglos XIX y XX", in Anes Álvarez, Gonzalo (ed.), pp. 7-62.

Pérez Sarrión, G. (1995), "Hydraulic Policy and Irrigation Works in Spain in the Second Half of the Eighteenth-Century", *Journal of European Economic History*, 24, 1, pp. 131-143.

Perpiñá, Román (1952), *De estructura económica y economía hispana*, Madrid, Rialp.

Perroux, François (1955), "Note sur la notion de «pôle de croissance»", *Economie Appliquée*, 8, 1-2, pp. 307-320.

Pesaran, M. Hashem and Smith, Ron P. (1998), "Structural Analysis of Cointegrating VARs", *Journal of Economic Surveys*, 12, 5, pp. 471-505.

Pieper, Paul E. (1990), "The Measurement of Construction Prices: Retrospect and Prospect", in Berndt, Ernst R. and Triplett, Jack E. (eds.), *Fifty Years of Economic Measurement. The Jubilee of the Conference on Research in Income and Wealth*, Chicago, University of Chicago, pp. 239-268.

Pinheiro, Magda de Avelar (1979), "Investimentos estrangeiros, política financeira e caminhos-de-ferro em Portugal na segunda metade do século XIX", *Análise Social*, 15, 58, pp. 265-286.

Platt, D. C. M. (1984), *Foreign Finance in Continental Europe and the United States, 1815-1870. Quantities, Origins, Functions and Distribution*, London, Allen & Unwin.

Pollins, Harold (1969), “Aspects of Railway Accounting Before 1868”, in Reed, M. C. (ed.), *Railways in the Victorian Economy*, Newton Abbot, David & Charles, pp. 138-161.

Pons Novell, Jordi and Tirado Fabregat, Daniel A. (2001), *Discontinuidades en el crecimiento económico en el periodo 1870-1994: España en perspectiva comparada*, FEDEA Working Paper EEE 98.

Ponsard, Claude (1983), *History of Spatial Economic Theory*, Berlin, Springer-Verlag.

Pounds, Norman J. G. (1985), *An Historical Geography of Europe, 1800-1914*, Cambridge, Cambridge University Press.

Prados de la Escosura, Leandro (1988), *De imperio a nación. Crecimiento y atraso económico en España (1780-1930)*, Madrid, Alianza.

Prados de la Escosura, Leandro (1992), “Crecimiento, atraso y convergencia en España e Italia: introducción”, in Prados de la Escosura, Leandro and Zamagni, Vera (eds.), *El desarrollo económico en la Europa del Sur. España e Italia en perspectiva histórica*, Madrid, Alianza, pp. 27-55.

Prados de la Escosura, Leandro (1995), *Spain's Gross Domestic Product, 1850-1993: Quantitative Conjectures*, Madrid, Universidad Carlos III Working Paper DT 95-05/06.

Prados de la Escosura, Leandro (1997), “Política económica liberal y crecimiento en la España contemporánea: un argumento contrafactual”, *Papeles de Economía Española*, 73, pp. 83-107.

Prados de la Escosura, Leandro (2000), “International Comparisons of Real Product, 1820-1990: An Alternative Data Set”, *Explorations in Economic History*, 37, pp. 1-41.

Prados de la Escosura, Leandro (forthcoming), *El progreso económico de España, 1850-2000*, Madrid, Fundación BBVA.

Pratt, Edwin A. (1908), *Railways and Nationalisation*, London, P.S. King & Son.

Pred, Allan R. (1966), *The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800-1914. Interpretive and Theoretical Essays*, Cambridge (MA), MIT Press.

Price, Roger (1975), *The Economic Modernisation of France*, London, Croom Helm.

Price, Roger (1983), *The Modernization of Rural France: Communication Networks and Agricultural Market Structure in Nineteenth Century France*, London, Hutchinson.

Puffert, Douglas (1995), “L’intégration technique du réseau ferroviaire européen”, in Merger, Michèle; Carreras, Albert and Giuntini, Andrea (eds.), *Les réseaux européens trasnationaux XIX^{e}-XX^{e}, quels enjeux?*, Nantes, Ouest Éditions, pp. 303-318.

Puffert, Douglas (2000), “The Standardization of Track Gauge on North American Railways, 1830-1890”, *Journal of Economic History*, 60, 4, pp. 933-960.

Puga, Diego (1996), *Urbanization Patterns: European versus Less Developed Countries*, CEPR Discussion Paper Nº 305.

Puga, Diego and Venables, Anthony J. (1999), "Agglomeration and Economic Development: Import Substitution vs. Trade Liberalisation", *Economic Journal*, 109, pp. 292-311.

Pumain, Denise (1982), "Chemin de fer et croissance urbaine en France au XIX^{e} siècle", *Annales de Géographie*, 91, 507, pp. 529-550.

Ramírez, María Teresa (2001), "Los ferrocarriles y su impacto sobre la economía colombiana", *Revista de Historia Económica*, 19, 1, pp. 81-122.

Reher, David S. (2001), "Producción, precios e integración de los mercados regionales de grano en la España preindustrial", *Revista de Historia Económica*, 19, 3, pp. 539-572.

Reher, David S. and Ballesteros, Esmeralda (1993), "Precios y salarios en Castilla la Nueva: la construcción de un índice de salarios reales, 1501-1991", *Revista de Historia Económica*, 11, 1, pp. 101-151.

Reis, Jaime (2000), "How Poor Was the European Periphery before 1850? The Mediterranean vs. Scandinavia", in Pamuk, evket and Williamson, Jeffrey G. (eds.), pp. 17-44.

RENFE (1958), *Los ferrocarriles en España, 1848-1958*, Madrid, RENFE.

RENFE (ed.) (1981), *Los ferrocarriles y el desarrollo económico de Europa Occidental durante el siglo XIX*, Madrid, RENFE.

Renkin, J. (1904), "Les Chemins de Fer de l'État Belge", *Revue Économique Internationale*, 3, 3, pp. 593-632.

Reseña Geográfica y Estadística de España (1888), Madrid.

Rietveld, Piet (1995), "Infrastructure and Spatial Economic Development", *Annals of Regional Science*, 29, pp. 117-119.

Rietveld, Piet and Boonstra, Jaap (1995), "On the supply of network infrastructure", *Annals of Regional Science*, 29, pp. 207-220.

Rietveld, Piet and Wintershoven, Patrick (1998), "Border Effects and Spatial Autocorrelation in the Supply of Network Infrastructure", *Papers in Regional Science*, 77, 3, pp. 265-276.

Ringrose, David R. (1972), *Los transportes y el estancamiento económico de España (1750-1850)*, Madrid, Tecnos.

Ringrose, David R. (1974), "España en el siglo XIX: transportes, mercado interior e industrialización", *Hacienda Pública Española*, 27, pp. 81-86.

Roca Sagalés, Oriol and Pereira, Alfredo M. (1998), "Impacto de la inversión en infraestructuras sobre el producto, la ocupación y la inversión privada en España", *Revista Española de Economía*, 15, 3, pp. 403-432.

Rodrigo y Alharilla, Martín (1999), “La dimensión ferroviaria del «holding» Comillas”, in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 693-707.

Rodríguez Saiz, Luis (1979), “La política de transportes en la Dictadura de Primo de Rivera”, *Cuadernos Económicos de I.C.E.*, 10, pp. 443-462.

Romer, Paul (1986), “Increasing Returns and Long-Run Growth”, *Journal of Political Economy*, 92, pp. 1002-1037.

Romer, Paul (1990), “Endogenous Technological Change”, *Journal of Political Economy*, 98, S71-S101.

Romero Muñoz, Dolores and Sáenz Sanz, Amaya (1996), “La construcción de los puertos: siglos XVI-XIX”, in Guimerá Ravina, Agustín and Romero Muñoz, Dolores (eds.), pp. 185-212.

Rosenstein-Rodan, P.N. (1943), “Problems of Industrialisation of Eastern and South-Eastern Europe”, *Economic Journal*, 43, 210-211, pp. 202-211.

Rossi, Nicola; Sorgato, Andrea and Toniolo, Gianni (1993), “I conti economici italiani: una ricostruzione statistica, 1890-1990”, *Rivista di Storia Economica*, 10, 1, pp. 1-47.

Rostow, Walt W. (1960), *The Stages of Economic Growth: A Non-Communist Manifesto*, Cambridge, Cambridge University Press.

Sáenz Ridruejo, Fernando (1994), “Evolución de los puertos españoles durante el siglo XIX”, in Centro de Estudios Históricos de Obras Públicas y Urbanismo, pp. 101-116.

Sampité, A. (1888), *Les chemins de fer à faible trafic en France. Lignes Secondaires des grands réseaux, chemins de fer d’interêt local et tramways à vapeur. Établissement et explotation*, Paris, Librairie Polytechnique, Baudry et Cie.

Sánchez-Albornoz, Nicolás (1977), *España hace un siglo: una economía dual*, Madrid, Alianza.

Sánchez Alonso, Blanca (1995), *Las causas de la emigración española, 1880-1930*, Madrid, Alianza.

Sánchez-Alonso, Blanca (2000a), “European Emigration in the Late Nineteenth Century: The Paradoxical Case of Spain”, *Economic History Review*, 53, 2, pp. 309-330.

Sánchez-Alonso, Blanca (2000b), “Those Who Left and Those Who Stayed Behind: Explaining Emigration from the Regions of Spain, 1880-1914”, *Journal of Economic History*, 60, 3, pp. 730-755.

Sánchez-Alonso, Blanca (2000c), “What Slowed Down the Mass Emigration from Spain before World War II? A Comparison with Italy”, in Pamuk, evket and Williamson, Jeffrey G. (eds.), pp. 297-318.

Sánchez de Toca, Joaquín (1895), *Los caminos de hierro y el gobierno*, Madrid, Hijos de M. G. Hernández.

Sánchez de Toca, Joaquín (1911), *Reconstitución de España en vida de Economía Política actual*, Madrid, Jaime Ratés Martín.

Sánchez de Toca, Joaquín (1917), *Ferrocarriles secundarios. Discusión del proyecto en el Senado. Sesiones celebradas los días 1, 5, 6 y 7 de Julio de 1916 y conferencia parlamentaria ultimando la discusión iniciada para procurar inmediato acuerdo de unanimidad*, Madrid, Imprenta de Ramona Velasco, Viuda de P. Pérez.

Sauer, George (1869), *The Telegraph in Europe. A Complete Statement on the Rise and Progresses of Telegraphy in Europe, Showing the Cost of Construction and Working Expenses of Telegraphic Communications in the Principal Countries, etc. etc.*, Paris.

Schleifer, Andrei and Vishny, Robert W. (1997), "A Survey of Corporate Governance", *Journal of Finance*, 52, 2, pp. 737-783.

Schulze, Max-Stephan (2000), "Patterns of Growth and Stagnation in the Late Nineteenth Century Habsburg Economy", *European Review of Economic History*, 4, pp. 311-340.

Schumpeter, Joseph A. (1939), *Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, New York, McGraw-Hill.

Scott, Maurice FG. (1993), "Explaining Economic Growth", *American Economic Review*, 83, 2, pp. 421-425.

Segreto, Luciano (1993), "Aspetti e problemi dell'industria elettrica in Europa tra le due guerre", in Galasso, Giuseppe (ed.), *Storia dell'industria elettrica in Italia. 3. Expansione e oligopolio. 1926-1945*, Roma, Laterza, Vol. 1, pp. 325-298.

Serrano Rodríguez, Antonio (1999), "Introducción: el ferrocarril y la configuración del territorio, 1848 a 1930", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús; and Vidal Olivares, Javier (eds.), pp. 851-902.

Sherrington, C. E. R. (1969) [1934], *A Hundred Years of Inland Transport, 1830-1933*, London, Frank Cass and Co.

Siddall, William R. (1969), "Railroad Gauges and Spatial Interaction", *Geographical Review*, 59, 1, pp. 29-57.

Silvestre Rodríguez, Javier (2001a), "Viajes de corta distancia: una visión espacial de las migraciones interiores en España, 1877-1930", *Revista de Historia Económica*, 19, 2, pp. 247-283.

Silvestre Rodríguez, Javier (2001b), *¿Viajes de ida y vuelta?: migraciones interiores e integración del mercado de trabajo en España, 1914-1931*, unpublished research paper.

Simpson, James (1989), "La producción agraria y el consumo español en el siglo XIX", *Revista de Historia Económica*, 7, 2, pp. 355-388.

Sintes Olives, F. F. and Vidal Burdils, F. (1933), *La industria eléctrica en España. Estudio económico-legal de la producción y consumo de electricidad y material eléctrico*, Barcelona, Montaner y Simón.

Smith, Adam (1930) [1776], *An Inquiry into the Nature and Causes of the Wealth of Nations*, London, Methuen.

Spiegel, Yossef (1994), "The Capital Structure and Investment of Regulated Firms Under Alternative Regulatory Regimes", *Journal of Regulatory Economics*, 6, pp. 297-319.

Statistisk Sentralbyrå (1978), *Historisk Statistikk 1978*, Oslo, SS.

Stern, Nicholas (1991), "The Determinants of Growth", *Economic Journal*, 101, pp. 122-133.

Sturm, Jan-Egbert; Jacobs, Jan and Groote, Peter (1999), "Output Effects of Infrastructure Investment in the Netherlands, 1853-1913", *Journal of Macroeconomics*, 21, 2, pp. 355-380.

Sturm, Jan-Egbert; Kuper, Gerard H. and De Haan, Jakob (1998), "Modelling Government Investment and Economic Growth on a Macro Level: A Review", in Brakam, Steven; Van Ees, Hans and Kuipers, Simon K, (eds.), *Market Behaviour and Macroeconomic Modelling*, London, MacMillan, pp. 359-406.

Suárez de Tangil y Angulo, Fernando (1954), *Las obras públicas en España y los gobiernos de autoridad. Discurso de recepción del Académico de número Excmo. Sr. D. Fernando…*, Madrid, Real Academia de Ciencias Morales y Políticas.

Suárez-Villa, Luis (1996), "Innovative Capacity, Infrastructure and Regional Policy", in Batten, David F. and Karlsson, Charlie (eds.), pp. 251-269.

Sudrià Triay, Carles (1983), "Notas sobre la implantación y el desarrollo de la industria del gas en España, 1840-1901", *Revista de Historia Económica*, 1, 2, pp. 97-118.

Sudrià Triay, Carles (1987), "Un factor determinante: la energía", in Nadal Oller, Jordi; Carreras, Albert and Sudrià Triay, Carles (eds.), pp. 312-363.

Sudrià Triay, Carles (1997a), "La restricción energética al desarrollo económico de España", *Papeles de Economía Española*, 73, pp. 165-187.

Sudrià Triay, Carles (1997b), "Redistribución de la actividad industrial en España durante la segunda revolución tecnológica (1900-1975)", in *La riqueza de las regiones. Análisis espacial de la industrialización*, Proceedings of the 9th Session of the VI Congress of the Asociación Española de Historia Económica, Girona, 15-17 de septiembre, pp. 405-420.

Sudrià Triay, Carles and Pascual Domènech, Pere (1999), "Financing a Railway Mania: Capital Formation and the Demand for Money in Catalonia, 1840-66", *Financial History Review*, 6, pp. 127-145.

Summerhill, William (1997), "Transport Improvements and Economic Growth in Brazil and Mexico", in Haber, Stephen (ed.), *How Latin America Fell Behind. Essays on the Economic Histories of Brazil and Mexico, 1800-1914*, Stanford, Stanford University Press, pp. 93-117.

Summerhill, William (1998), "Railroads in Imperial Brazil, 1854-1889", in Coatsworth, John H. and Taylor, Alan M. (eds.), *Latin America and the World Economy Since*

1800, Cambridge (MA), Harvard University, David Rockefeller Center for Latin American Studies, pp. 383-405.

Szostak, Rick (1991), *The Role of Transportation in the Industrial Revolution. A Comparison of England and France*, Montreal, McGill-Queen's University Press.

Tafunell, Xavier (2000), "La rentabilidad financiera de la empresa española, 1880-1981: Una estimación en perspectiva sectorial", *Revista de Historia Industrial*, 18, pp. 71-112.

Takahashi, Takaaki (1998), "On the Optimal Policy of Infrastructure Provision Across Regions", *Regional Science and Urban Economics*, 28, pp. 213-235.

Tedde de Lorca, Pedro (1978), "Las compañías ferroviarias en España (1855-1935)", in Artola, Miguel (ed.), Vol. 2, pp. 9-354.

Tedde de Lorca, Pedro (1980), "La Compañía de los Ferrocarriles Andaluces (1878-1920): una empresa de transportes en la España de la Restauración", *Investigaciones Económicas*, 12, pp. 27-76.

Tedde de Lorca, Pedro (1996), "La expansión de las grandes compañías ferroviarias españolas: Norte, MZA y Andaluces", in Comín Comín, Francisco and Martín Aceña, Pablo (eds.), pp. 265-284.

Thompson, Gregory L. (1991), "Myth and Rationality in Management Decision-Making: The Evolution of American Railroad Product Costing, 1870-1970", *Journal of Transport History*, 12, 1, pp. 1-10.

Tilly, R. H. (1978), "Capital Formation in Germany in the Nineteenth Century", in Mathias, Peter and Postan, M. M. (eds.), pp. 382-441.

Tinbergen, Jan (1967), *Development Planning*, London, World University Library.

Tirado Fabregat, Daniel A.; Paluzié, Elisenda and Pons Novell, Jordi (2002), "Economic Integration and Industrial Location: The Case of Spain Before World War I", *Journal of Economic Geography*, 2, pp. 343-363.

Tirado Fabregat, Daniel A. and Pons Novell, Jordi (2001), "¿Hubo convergencia económica entre los países europeos antes de la I Guerra Mundial?", *Revista de Historia Económica*, 19, 1, pp. 123-152.

Toniolo, Gianni (1983), "Railways and Economic Growth in Mediterranean Countries: Some Methodological Remarks", in O'Brien, Patrick (ed.), pp. 227-236.

Torá, José Luis (1983), "La red eléctrica nacional", *Papeles de Economía Española*, 14, pp. 209-216.

Tortella Casares, Gabriel (1973), *Los orígenes del capitalismo en España. Banca, industria y ferrocarriles en el siglo XIX*, Madrid, Tecnos.

Tortella Casares, Gabriel (1981a), "Discusión y resumen de las ponencias", in RENFE (ed.), pp. 185-196.

Tortella Casares, Gabriel (1981b), "La economía española, 1830-1900", in Tuñón de Lara, Manuel (ed.), *Historia de España*, Madrid, Labor, Vol. 8, pp. 9-167.

Tortella Casares, Gabriel (1994a), *El desarrollo de la España contemporánea. Historia económica de los siglos XIX y XX*, Madrid, Alianza.

Tortella Casares, Gabriel (1994b), "Patterns of Economic Retardation and Recovery in South-Western Europe in the Nineteenth and Twentieth Centuries", *Economic History Review*, 47, 1, pp. 1-21.

Tortella Casares, Gabriel (1999), "Introducción. La paradoja del ferrocarril español", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús; and Vidal Olivares, Javier (eds.), pp. 249-253.

Toutain, J.-C. (1967), *Les transports en France de 1830 à 1965. Économies et sociétés, Nº 8*, Paris, Presses Universitaires de France, Cahiers de l'I.S.E.A.

Universidad Comercial de Deusto (1968), *Riqueza Nacional de España*, Bilbao, Universidad Comercial de Deusto.

Uriol Salcedo, José Ignacio (1968a), "La red de carreteras del Estado. Evaluación por el método de formación histórica del capital", in Universidad Comercial de Deusto, Vol. 2, pp. 393-426.

Uriol Salcedo, José Ignacio (1968b), "La red de carreteras provinciales y caminos vecinales" in Universidad Comercial de Deusto, Vol. 2, pp. 427-430.

Uriol Salcedo, José Ignacio (1979), "Los transportes interiores en el siglo XVIII y en los primeros años del siglo XIX. Transportes de personas (3)", *Revista de Obras Públicas*, 126, pp. 871-882.

Uriol Salcedo, José Ignacio (1992), *Historia de los caminos de España*, Madrid, Colegio de Ingenieros de Caminos, Canales y Puertos.

Valdaliso Gago, Jesús María (1991), *Los navieros vascos y la marina mercante en España, 1860-1935. Una historia económica*, Bilbao, Herri-Ardularitzaren Euskal Erakundea.

Valdaliso Gago, Jesús María (1997), *La navegación regular de cabotaje en España en los siglos XIX y XX. Guerras de fletes, conferencias y consorcios navieros*, Vitoria, Eusko Jaurlaritzaren Argitalpen Zerbitzu Nagusia.

Vamplew, Wray (1972), "Railways and the Scottish Transport System in the Nineteenth Century", *Journal of Transport History*, 1, 3, pp. 133-145.

Van der Knaap, G. A. (1978), *A Spatial Analysis of the Evolution of an Urban System: The Case of the Netherlands*, Utrecht, Drukkerij Elinkwijk BV.

Vega Armentero, R. (1884), *Una cuestión grave. Los ferrocarriles españoles*, Madrid, Imprenta de Ramón Moreno y Ricardo Rojas.

Veiga Alonso, Xosé R. (1999), "La utopía ferroviaria de la Galicia decimonónica: la línea Palencia-A Coruña (1858-1883)", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 585-596.

Venables, Anthony J. (1996), "Equilibrium Locations of Vertically Linked Industries", *International Economic Review*, 37, 2, pp. 341-359.

Venables, Anthony J. and Gasiorek, Michael (1998), *The Welfare Implications of Transport Improvements in the Presence of Market Failure*, unpublished report.

Vickerman, Roger W. (ed.) (1991a), *Infrastructure and Regional Development*, London, Pion.

Vickerman, Roger W. (1991b), "Other Regions' Infrastructure in a Region's Development", in Vickerman, Roger W. (ed.), pp. 61-74.

Vickerman, Roger W. (1994), "Transport Infrastructure and Region Builiding in the European Community", *Journal of Common Market Studies*, 32, 1, pp. 1-24.

Vickerman, Roger W. (1995a), "Accessibility and Peripheral Regions", in Coccossis, Harry (ed.), *Overcoming Isolation: Information and Transportation Networks in Development Strategies for Peripheral Areas*, Berlin, Springer, pp. 29-40.

Vickerman, Roger W. (1995b), "Location, Accessibility and Regional Development: The Appraisal of Trans-European Networks", *Transport Policy*, 2, 4, pp. 225-234.

Vickerman, Roger W.; Spiekermann, Klaus and Wegener, Michael (1999), "Accessibility and Economic Development in Europe", *Regional Studies*, 33, 1, pp. 1-15.

Vidal Olivares, Javier (1992), *Transportes y mercado en el País Valenciano (1850-1914)*, Valencia, Edicions Alfons el Magnànim.

Vidal Olivares, Javier (1996a), "El impacto de la construcción y explotación de los ferrocarriles en el País Valenciano, 1840-1914", in Azagra, J.; Mateu, E. and Vidal Olivares, Javier (eds.), *De la sociedad tradicional a la economía moderna. Estudios de historia valenciana contemporánea*, Alicante, Instituto de Cultura "Juan Gil-Albert", pp. 274-290.

Vidal Olivares, Javier (1996b), "Las compañías ferroviarias y la difusión de las modernas formas de gestión empresarial en España, 1850-1914", in Comín Comín, Francisco and Martín Aceña, Pablo (eds.), pp. 285-301.

Vidal Olivares, Javier (1999a), "Introducción", in Muñoz Rubio, Miguel; Sanz Fernández, Jesús and Vidal Olivares, Javier (eds.), pp. 381-390.

Vidal Olivares, Javier (1999b), "La estructura de la propiedad, de la organización y la gestión de una gran empresa ferroviaria: la *Compañía de los Caminos de Hierro del Norte de España*, 1858-1936", *Revista de Historia Económica*, 17, 3, pp. 623-662.

Vidal Raich, Esther (1994), *La distorsión política de las redes de transporte: el caso de los ferrocarriles transpirenaicos, 1844-1928,* Barcelona, University of Barcelona, PhD Thesis.

Vieira, António Lopes (1980), "Os transportes rodoviários em Portugal, 1900-1940", *Revista de História Económica e Social*, 5, pp. 57-94.

Villanueva Larraya, Gregoria (1991), *La "política hidráulica" durante la Restauración (1874-1923),* Madrid, Universidad Nacional de Educación a Distancia.

Ville, Simon P. (1990), *Transport and the Development of the European Economy, 1750-1918*, London, MacMillan.

Ville, Simon P. (1994), “Transport and Communications”, in Aldcroft, Derek H. and Ville, Simon P. (eds.), *The European Economy, 1750-1914. A Thematic Approach*, Manchester, Manchester University Press, pp. 184-215.

Vitali, Ornello (1975), “La stima degli investimenti e dello stock di capitale”, in Fuà, Giorgio (ed.), *Lo sviluppo economico in Italia. Storia dell’Economia Italiana negli ultimi cento anni. Volume III. Studi di settore e documentazione di base*, Milano, Franco Angeli, pp. 490-549.

Vogelsang, Timothy J. (1997), “Wald-Type Tests for Detecting Breaks in the Trend Function of a Dynamic Time Series”, *Econometric Theory*, 13, pp. 818-849.

Wais San Martín, Francisco (1987) [1967], *Historia de los ferrocarriles españoles*, Madrid, Fundación de los Ferrocarriles Españoles.

Webb, Augustus D. (1911), *The New Dictionary of Statistics. A Complement to the Fourth Edition of Mulhall’s “Dictionary of Statistics”*, London, Routledge.

Webb, Herbert Laws (1911), *The Development of the Telephone in Europe*, London, Electrical Press.

Weitzman, M. L. (1970), “Optimal Growth with Scale Economies in the Creation of Overhead Capital”, *Review of Economic Studies*, 37, 4, pp. 555-570.

Wellington, Arthur Mellon (1898), *The Economic Theory of the Location of Railways. An Analysis of the Conditions Controlling the Laying Out of Railways to Effect the Most Judicious Expenditure of Capital*, New York, John Wiley and Sons.

Wellisz, Stanislaw H. (1963), “Regulation of Natural Gas Pipeline Companies: An Economic Analysis”, *Journal of Political Economy*, 71, 1, pp. 30-43.

White, Colin M. (1976), “The Concept of Social Saving in Theory and Practice”, *Economic History Review*, 29, 1, pp. 82-100.

Williamson, Jeffrey G. (1974), *Late Nineteenth Century American Development: A General Equilibrium Approach*, Cambridge, Cambridge University Press.

Williamson, Jeffrey G. (2000), “Real Wages and Relative Factor Prices around the Mediterranean, 1500-1940”, in Pamuk, evket and Williamson, Jeffrey G. (ed.), pp. 45-75.

Wilson, Wesley W. (1997), “Cost Saving and Productivity in the Railroad Industry”, *Journal of Regulatory Economics*, 11, pp. 21-40.

Winston, Clifford (1985), “Conceptual Developments in the Economics of Transportation: An Interpretive Survey”, *Journal of Economic Literature*, 23, pp. 57-94.

Woodruff, William (1966), *Impact of Western Man: A Study of Europe’s Role in the World Economy, 1750-1960*, London, MacMillan.

Youngson, A. J. (1967), *Overhead Capital. A Study in Development Economics*, Edinburgh, Edinburgh University Press.

Zapata Blanco, Santiago (2001), “Apéndice estadístico”, in Germán Zubero, Luis; Llopis Agelán, Enrique; Maluquer de Motes, Jordi and Zapata Blanco, Santiago (eds.), pp. 561-596.