The expansion of the Spanish railway network (1848–1941): an analysis through the evolution of its companies

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Introduction

Railways emerged in Spain in the mid-nineteenth century. They transformed land transport, facilitated access to ports and connections with neighbouring countries and generated crucial debates about the country's future. However, the expansion of the network was the result of a long and complicated process. The liberal state established a model for public-private collaboration in the construction and management of the infrastructure. On the one hand, the public authorities promoted certain routes and established the policies required for supporting private investment. On the other, companies were able to expand the network in accordance with their own strategies.

The study of private companies and their role in the expansion of the railways began in the 1970s, with the seminal work coordinated by Miguel Artola (1978), "Los Ferrocarriles en España (1844-1943)". Among other aspects, it examined the general characteristics of the largest operators: their annual expansion and stock of rail track, their shareholders, the total amount of goods and number of passengers transported annually, and their declared income. One of the most interesting conclusions were the specific state directives for the development of the "First Order" – or main – lines, which were generally vague and conditioned by the decisions of the companies. With respect to the expansion of each firm, the most relevant contribution was the chapter written by Pedro Tedde (1978), which described how their business strategies changed over time. Even so, his analysis focused on the Compañía

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de Madrid a Zaragoza y Alicante (MZA) and the Caminos de Hierro del Norte de España (Norte).[1] Thus, the information was limited and was not linked to local characteristics or institutions (municipalities, ports, mines, etc.). There were two reasons for this: (i) the limitations of the IT systems made it difficult to analyse the railway while taking the characteristics of the territory into account; and (ii) data was scant, as the sources were mainly the annual reports of MZA and Norte; hence, information about the rest of the companies was limited. These technical conditions and the lack of data also affected subsequent studies of railway history, although new sources have since been incorporated, improving our overall knowledge.[2]

Due to the aforementioned limitations, research into the expansion of the network has mainly focused on the debates for which data was accessible. Some of the most important highlight the relevance of the railway companies in the development of Spain's financial markets (Tortella 1982; Martín Aceña 1985), their influence on political power and legislation (Ortúñez 2016; 2019), and analyse their transport and trade flows (Gómez-Mendoza 1985; Cuellar 2003) and the subsidies model for the construction and operation of the network (Castellví and Barquín 2018).[3] Studies examining the influence and expansion of railways within specific regions have also been relevant (Hernández 1983; Pascual 1984; Ormaechea 1989), as have those analysing the internal structures of different railway companies (Tedde 1980; Vidal Olivares 1999; Pascual 1999) or critical events in the sector (Ortúñez 1999; Cuéllar 2015). Comín *et al.* (1998) and Muñoz Rubio *et al.* (1999) include the majority of these contributions, provide a full description of the development of the network as well as comments on some of its implications. For example, it is noted that the proposals for railway expansion mainly prioritized construction costs, although economic activity was also crucial.[4] The limitations are, however, similar to those already described, as they do not cover all of the different companies or link this process to the whole territory.

Thus, even though there is an extensive literature in this field, to date little work has been done to provide an overview that explores why the rail net-

1. The author also studied (1980) the Compañía de los Ferrocarriles Andaluces (Andaluces).

2. Some of the most significant new sources include reports made by parliamentary commissions, studies carried out by the engineers of the railway companies, annual reports of the companies, and studies by newspapers and specialised journals, such as the Revista de Obras Públicas.

3. One of the most interesting conclusions from the studies by Tortella (1982) and Martín Aceña (1985) is that buying and selling shares and bonds of railway companies significantly contributed to the establishment of the financial market in Spain. Castellví and Barquín's (2018) article analyses the provision of state subsidies for the construction and operation of the railway network and suggests that they represented a greater burden on public finances than was originally believed.

4. Cordero and Menéndez (1978) also pointed this out.

work developed the way it did, particularly considering the investment decisions made by all the railway companies and the links between the latter and the territory and its most relevant features. Regarding the international literature, we have also failed to find studies that have systematically analysed the expansion of other national railway networks considering these variables.[5] To shed further light on the factors that explain the Spanish railway-network expansion, this article fills this gap. We believe that this is essential because (i) knowing how line ownership evolved allows us to consider the private companies' business strategies as drivers of network expansion; furthermore, (ii) linking such strategies with territorial variables allows us to understand the expansion of railways in more depth.

Fully considering the business strategies of railway companies is far from a trivial pursuit, since there were different models for expansion and management (Martí-Henneberg 2013) and, as a result, their effects were heterogeneous.[6] Thus, understanding this process is fundamental for future analyses on the territorial effects of the railway network. For instance, within the British context, Crafts *et al*. (2008) have shown how the management of railway companies was often uneven and inconsistent. Consequently, different companies' railways could have been subject to different influences and produced different effects.

To study these issues, we present a new geocoded database in the Geographic Information Systems format (GIS) in the data section. It includes the first chronology that identifies all the sections of lines, stations and stops in the Spanish network; it also shows which company operated each of them, in each year, throughout the period 1848–1941.[7] Here, it is essential to point out that there are two different track widths in Spain: narrow-gauge and Iberian-gauge (or broad-gauge). Differences in their construction periods, territorial distribution, morphology, size and purpose have obliged us to distinguish between them. This article only focuses on the broad-gauge lines since these were the basis of Spain's national railway network. For most of our study period, the narrow-gauge track mainly was used on an auxiliary network for regional connections and the transport of primary products (Muñoz Rubio 2005; Morillas-Torné 2014).

Then, in the methodological section, the GIS format enabled us to link these data to other geocoded elements in the territory. This allowed us to in-

5. Articles that study specific companies or events affecting the sector are far more common (Van Helten 1978; Crompton 1985).

6. For instance, in Britain railways were built to connect the most dynamic nodes of the country (Bogart *et al.* 2021), whereas in South Africa their objective was to channel primary products from the interior to the coast (Herranz-Loncán and Fourie 2018). Thus, the territorial effects of this technology varied.

7. Hereafter, we will include any references to "stops" within the terms "stations" and "network access points".

terpret the development of the different companies networks by using the previously mentioned literature and by including territorial factors, such as the municipalities and their population, and any ports, borders and/or mines associated with them.[8] Based on a descriptive analysis of these data we were then able to establish when, how and why the different companies consolidated their transport business between the main nuclei with a demand for transport services: urban areas, administrative capitals, mining areas, trading centres and international borders.

Consequently, the first contribution of this article is a new database that (i) reconstructs the expansion of the railway system based on a detailed and comparative study of the results of the investments (in tracks and stations) made by all the companies that operated in Spain, and (ii) takes into account territorial features as a variable to explain the network expansion. The second contribution derives from the analysis of this dataset and confirms that knowing the evolution and business concentration processes of the railway companies and linking them to the territory is necessary if we are to understand the shaping of the Spanish network. Furthermore, our results also indicate that the economic variables that were most important for the profitability of this business, such as population, borders, agricultural and mining production, and port activity, are also the key factors for explaining railway companies' strategies of expansion, and, consequently, the development of the network.

In the next section, we describe the historical context. We will then present the data and methodology, and, finally, the results and the conclusions.

Historical context: the railways in Spain, legislation, state and private companies

The Spanish network experienced very significant expansion after the passing of the Railway Law of 1855 (RL1855), which instituted the guidelines that defined this sector. It established that this transport would operate under a system of public-private collaboration (taking as its main point of reference the French railway law of 1842). The system was characterised by granting 99-year concessions to private companies to construct and operate different lines.[9] It also prioritised the construction of lines that, according to the literature, were selected using political, technical and economic criteria. Broadly

8. We hope to incorporate new data in the future: station flows (goods and passenger) for the network, and barracks and other features for the territories. This will allow us to extend the current knowledge of the development and effects of the railway in Spain.

9. In return, they received public funding for track construction and guaranteed profits (normally of around 5%).

speaking, this law sought to prioritize, using a radial structure, the connections between Madrid and the inland production areas with the main provincial capitals and ports via natural courses.[10] This was the approach that received the greatest parliamentary support as it was considered that it would contribute to Spain's modernisation and economic growth.[11] However, we should bear in mind that the law established the major lines generically, without defining their morphology, which was left in the hands of the civil engineers of the private companies.[12] Furthermore, in the case of non-priority lines, the private companies made their construction proposals in cooperation with state-employed technical engineers.

From the perspective of private capital, and in stark contrast with previous legal uncertainty, this law presented a major business opportunity, as it defined a system of subsidies that greatly enhanced the attractiveness of the sector.[13] These subventions can be divided into support for network construction, exemption from import tariffs, and guarantees of share profits. The first two were the most relevant, with their value being potentially greater than that of the total amount of private capital investment (Castellví and Barquín 2018).

The result of this law was a major boost to the development of the network, adding 4,756 km of new track between 1855 and 1866. However, in 1866 the companies were hit hard by a severe financial crisis that paralyzed many ongoing initiatives. The initial construction boom was characterised by a high level of fragmentation within the market, with many different firms operating lines (up to 15 in 1865, see Figure A.1). Of these, the two that were to become the most important were MZA and Norte. After the crisis of 1866, the development of new railway infrastructure was markedly slower and was mainly carried out by small companies. As a result, the national network continued to be fragmented. The largest increases in concentration occurred from 1877 onwards when a new Railway Law was passed, and the Compañía de los Ferrocarriles Andaluces (Andaluces) was created. This law marked the beginning of a new expansive phase that lasted until 1901, the year considered to

10. Before the arrival of the railway, trade between ports was carried out using maritime shipping. While also remaining important during the period, it was soon overtaken by this new technology (Tafunell and Carreras 2005, p. 515).

11. The appropriateness of adopting a radial pattern in the case of the Bourbon road network of the eighteenth century has been studied by Pablo-Martí *et al.* (2021). This article concludes that the radial design of this network was, from an economic perspective, the optimum solution for the period. This contrasts with the widespread belief that the transport networks in Spain were built solely based on criteria associated with political centralism.

12. In this article we understand "morphology of the network" as the configuration and shaping of the railway lines.

13. The origin of this investment was both national and foreign. However, as the network expanded, foreign capital (particularly from France) became increasingly relevant.

mark its completion.[14] However, the development of the network and the increases in railway market concentration were particularly intense until 1887.

With respect to connectivity, the Law of 1877 promoted the construction of new lines that improved access to the more isolated provinces and the establishment of transversal connections to centres of production and consumption that were far from the existing radial network. Other aspects that were also prioritised included: the construction of branch lines, and the intensification of auxiliary connections between already consolidated lines. Besides, the Law also sought to avoid establishing new routes that would compete with existing ones.

The last phase that we considered in our study began in 1901 and concluded in 1941, with the creation of RENFE, a public company that brought together all of the private broad-gauge companies. During these years the network was finished with: the opening of a few new transversal lines, an increase in the number of narrow-gauge railway initiatives (Figure 1), and the modernisation of the pre-existing network.[15] Regarding market concentration, the most relevant event was the creation of the Compañía del Ferrocarril del Oeste (1927), which was formed by different companies that operated close to the border with Portugal.[16]

In general, the Laws of 1855 and 1877 were aimed at facilitating private investment and establishing the rules of the game. As a result, private companies decided when, where and how to expand their networks and, thereby, Spain's national railway system.[17] Thus, they were responsible for the expansion of the railway in Spain. Finally, we should underline the fact that the previously mentioned periods have conditioned the cut-off points used for the subsequent analysis.

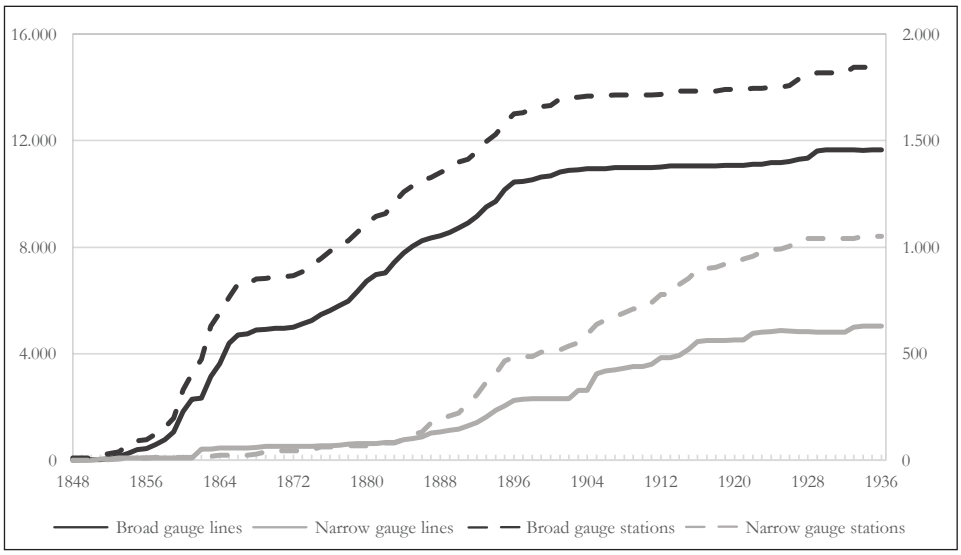
14. In 1901, the Calatayud-Puerto Escandón section was concluded, completing the line that joined the last provincial capital to be connected (Teruel) with the rest of the network.

15. With respect to transport supply, we should mention that from the 1920s onwards, Spain's road network and vehicle fleet began to expand, albeit with only a very limited initial impact.

16. On the trans-border connections with Portugal, see Pereira (2017) and Map A.1.

17. The only clear specifications established by the State were for "attachment points" along the lines. These were particularly relevant municipalities, such as provincial capitals, through which the lines had to pass. The only indications that we could find relating to the technical criteria that conditioned the internal structure of the lines were those highlighted by Cordero and Menéndez (1978). They claim (p. 174) that the Spanish state undertook a planning exercise largely based on economic criteria, as it conducted population studies at distances of 1, 5 and 10 km from the routes followed by the railway track. However, given the geography of the peninsula and Spain's ailing public finances, in areas with complex orography, sections of track tended to be constructed where it was less costly to do so.

FIGURE 1 ▪ *Evolution of railway tracks, stations and stops in Spain (1848–1936)*



Sources: Stations and stops, Esteban-Oliver (2021); Km of track, Anes (1978), pp. 485-486.

Notes: The y axis on the left presents the kilometres of track exploited, while that on the right shows the stock of stations and stops.

Data and methodology

In order to analyse the expansion of the Spanish railway network based on a detailed and comparative study of the investment made by all the companies operating in the territory we created the first "Annual Chronology of the Ownership of Railway Stations and Tracks in Spain for the period 1848-1941" (ACR). This database has been constructed in GIS format in order to link together territorial units relating to different levels: municipalities, judicial districts and provinces, and their respective features: ports, mines, population, etc., with the railways.

To produce this chronology, we first extracted data referring to each location and to the dates on which stations opened and (if this were the case) closed from Esteban-Oliver (2021), while those referring to tracks came from Morillas-Torné (2012) and the HGISe team.[18] We next determined the company that initially operated each section of track, line, and station in Spain between 1848 and 1941, using the *"Cronología de apertura del Ferrocarril de*

18. We have harmonised the sections of track and lines with the location of the stations within the context of this article. Jordi Marti-Henneberg and his team provided us with the rail GIS data (HGISe group http://europa.udl.cat).

Vía Ancha" by García Raya (2006).[19] After compiling this information, we incorporated data relating to the evolution of the ownership of these lines. To do this, we used a working paper that provided the date of the creation and closure of railway companies operating in Spain.[20] In cases in which closure was the result of a merger or take-over, the document indicated the year and the company that took control of the assets in question. With these data, we updated the ownership of each line, section of track and/or station, for the year(s) in which the previously assigned operator ceased to do business. Briefly stated, the database shows the company that owned any access, section of track or railway line within the network, as of 31 December on any year within the period.[21] The result of this process was the first ACR for Spain.

From this, we then extracted two variables: (i) the georeferenced annual expansion of the lines and of the stations belonging to each company; and (ii) the total number of kilometres of lines and the number of stations belonging to each firm in each year. In this respect, we present a list of all the broad-gauge track companies that have operated in Spain (Table A.1, in Annex A) and show the annual evolution of their respective networks (in km), (Table A.2). We also provide a complete chronology of the mergers and takeovers affecting the companies MZA, Norte, Andaluces, Compañía de los Caminos de Hierro de Barcelona a Francia y Figueras (BFF) and Oeste (Figures B.1 and B.2, B.3, B.4 and B.5 of Annex B).

After producing the ACR, we integrated it into a GIS in order to analyse it in connection with the different characteristics of the territory. Data relating to borders and to the areas and locations of the different municipalities was obtained from the *Mapa del Instituto Geográfico Nacional of 2018* (IGN 2018).[22] Data referring to population at the municipal level (de facto) was obtained from the censuses of 1860, 1877, 1887, 1900, 1910, 1920 and 1930, and was provided by Beltrán-Tapia et al. (2019).[23] We obtained the average eleva-

19. We chose as the "initial operating companies" those which set in motion and managed a line for the first time. We have not considered the ownership of the companies to determine who operated each one, rather the management.

20. Unpublished working paper. We are grateful to Dr Domingo Cuéllar for his contribution.

21. Although this article analyses the broad-gauge network, we have also reconstructed the evolution of the ownership of the narrow-gauge. To do this, we followed an identical methodology. However, we obtained data referring to the original operating companies from Muñoz Rubio (2005). In order to compile the chronology of mergers and takeovers in the narrow-gauge network, we used secondary sources, including regional and case studies. One of the most relevant and useful was Spanishrailway.com.

22. We used current borders and municipal centres (2018), because there is no historical database of these variables available for the period 1848–1941.

23. We used the *de facto* population as opposed to the *de jure* because the 1860 census did not include reliable data for the latter. We are grateful to the authors for ceding the database. For more information, see: https://www.bde.es/f/webbde/SES/Secciones/Publicaciones/PublicacionesSeriadas/EstudiosHistoriaEconomica/Fic/roja74.pdf.

tion and slope of the terrain from the *Copernicus Land Monitoring System*. The data for the location and production of the mining industry was facilitated by Palacios-Mateo (2021). Finally, in order to identify the ports that were operative during the period and the goods that were transported, we used the *"Estadísticas del comercio de cabotaje"* (1857-1914), the "*Estadísticas del comercio exterior de España"* (1857-1914), and the current Nomenclator.[24]

As previously mentioned, in order to link the ACR to the territory and its characteristics in GIS we needed to define an "access to the network" variable. We determined this indicator by calculating the distance from the port, mine and the centre of each municipality to the nearest station.[25] To establish the threshold according to which we considered to be access, we used the cross-section estimates presented in Esteban-Oliver (2020). These show that the Spanish railway network fundamentally affected those municipalities whose town centres were located less than one hour away from the nearest station. Then, we carried out estimates to account for access in the key years of the study: 1866, 1877, 1887, 1900, and 1941. Finally, we defined the results of these estimates as "Municipal access to the railway network provided by the rail companies".

After describing the data, we will now explain the methodology of the study, which involved a descriptive analysis of the variables introduced above.

First, we studied the asset structure and the development of each company's network over time using the kilometres of track and the total number of stations that the company managed each year. Analysing these variables enabled us to discover in which years the companies' networks expanded and through which process: purchases of existing lines or the construction of new tracks.

Second, we examined the territorial expansion of the different railway companies. To do this we analysed the GIS database. The study of this information, together with that of the variables described in the previous paragraph, helped us to understand the logic underlying the expansion of each company, as we were able to identify where and when this occurred. We were also able to show how the expansion of their networks is reflected in the municipal access to railway services. In this sense, we then highlighted the locations of provincial capitals, ports with customs offices, mines, and international borders due to their political, economic and administrative importance.

24. Table A.3 and Table A.4 show the years and the companies that connected with provincial capitals and ports in the period 1848–1941. We located the ports using the National Topographic Map (MTN) with a scale of 1:50,000. For more information on this map, see https://www.ign.es/web/resources/docs/IGNCnig/CBG-Cartografia-IGN.pdf.

25. The *municipal centre* is the place where the main church in the municipality is located (IGN 2018). This methodology has often been used in similar studies (Bogart et al. 2021), (Esteban-Oliver 2020).

Finally, and as a preliminary step in the proposed analyses, we grouped together some of the railway companies that were operative during the study period. This classification was necessary in order to save space, as individually studying the expansion of each company over time and across the whole territory would have made the study unfeasible in article format.[26] Nevertheless, we highlighted most of the relevant firms. The criteria employed was based on the size and historical importance of each company. The former was assessed using the database, while the latter was evaluated using the literature mentioned in the introduction. We identify four particularly relevant companies: MZA, Norte, Andaluces, and Oeste. The remaining ones were grouped together under the name "Other Companies", although we excluded any company that subsequently became part of one of the big four (since the year in which this occurs).[27] It should be noted that this group includes firms that were highly heterogeneous in terms of their scope of territorial action, years of operation, size, etc.

Below, we present the results obtained from using this analysis methodology with these data.

Expansion strategies of the companies in terms of time and assets (1848–1941)

Figure 2 shows the annual evolution of the total number of kilometres of track operated by each of the previously established groups.[28] By analysing this information and that presented in Annex B, we were able to know how (acquisitions or new construction) and when the railway companies expanded in Spain.

First, we observed that MZA experienced relatively uniform growth and early expansion. This was mostly based on the construction of its own network (60%).[29] In contrast, Norte had later and less even growth due to frequent acquisitions of consolidated companies. The lines associated with these purchases consequently represented almost 70% of the total number of kilo-

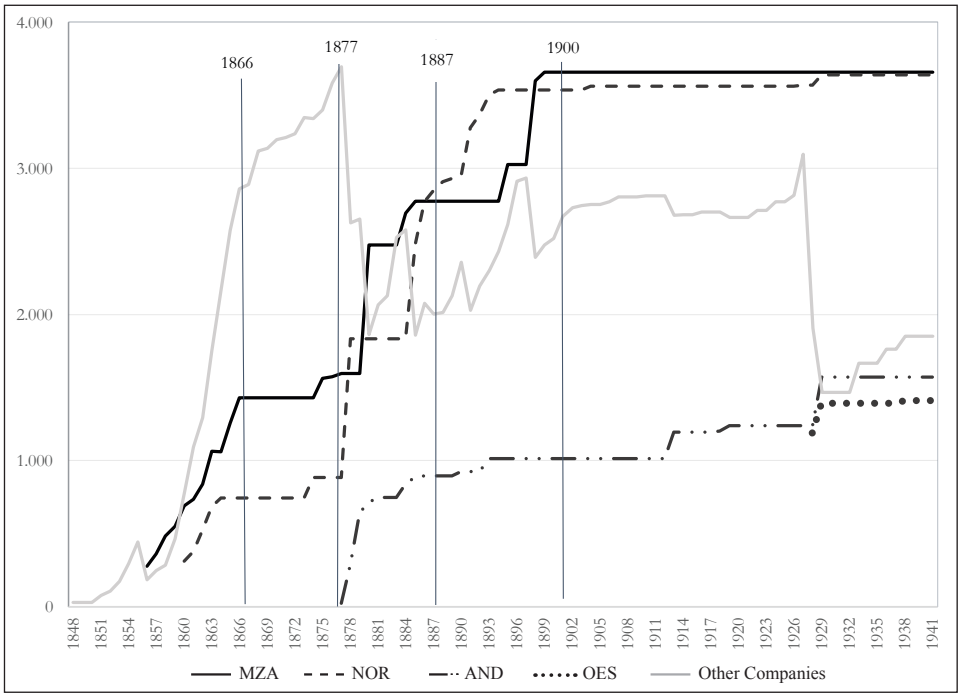
26. In Graph A.1 we present the number of active companies during the period 1848-1941. Note that the result fluctuates at around 15 to 20. This number complicates a comparative study of each of them. The heterogeneity between these companies (shareholding, size and territory of operation) can also entangle the analysis.

27. Although Oeste merged with Andaluces in 1936, we have kept them separate as the operability of this integration was compromised by the Civil War (1936_1939).

28. We should stress that we only show some of the time cuts in Table A.2 but we know the total number of kilometres of track operated by all of the companies of the network on a year-by-year basis.

29. Graph A.2 shows the evolution of the percentage of the network controlled by MZA and Norte that was derived from the acquisition of other companies.

FIGURE 2 ▪ *Evolution of the kilometres of track operated by the companies (1848–1941)*



Sources: Own research, based on Cuellar and Morillas-Torné (2012).

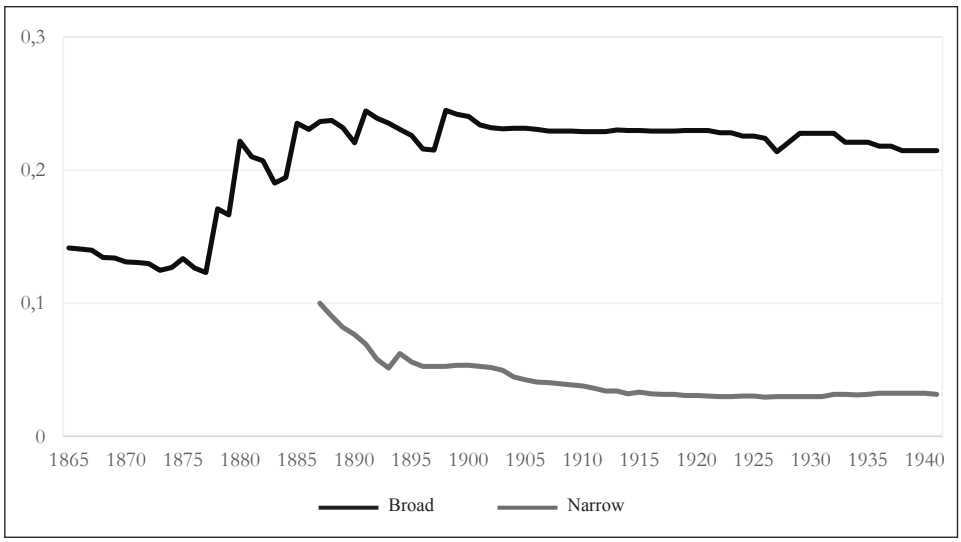
Notes: We divided the evolution over time according to the reference years referred to in Section 2.

metres of track that this company controlled and operated. From its creation (1877–1880) until 1928, Andaluces controlled around 1,000 km of the network. Most of its expansion resulted from takeovers, as the company was created at a time when the most profitable/relevant lines were already operating. The most feasible option was to acquire already established firms to develop its network. Finally, we examined the historical trajectories of Oeste and the "Other Companies", which were smaller. We were able to observe that their networks followed a relatively heterogeneous evolution. This was because of the creation of new companies and lines, and the result of mergers and takeovers involving previously consolidated ones. It was particularly interesting to note their rapid expansion between 1855 and 1877, as from then and until the creation of Oeste, they operated between 2,000 and 3,000 km of track. Finally, and in regards to Oeste, note that the period during which it was operative was very short, and the size of its network hardly varied until it eventually became part of RENFE in 1941.[30]

30. See Annex C to understand how the chronology of the network was reflected in the shares of the lines that the different companies had.

Our results point out and quantify that the "smaller" companies undertook the construction and set up a large part of the network (particularly the non-trunk lines). However, from 1877 onwards, there was a gradual market concentration into the hands of MZA, Norte and Andaluces. These firms noted that a larger network implied much lower fixed costs, so they made use of their greater financial resources (which were a product of easier access to international capital markets) to build new lines and acquire smaller companies. This growth was also favoured by the fact that many of the smaller companies' shares were trading at low prices due to their complicated financial situation, which was a result of the 1866 economic crisis (Tedde 1978). Our results also show that from 1900 onwards, the broad-gauge network virtually ceased to expand, and when it did, most of the construction initiatives were carried out by "small" companies (FCA, FSE, etc.), some of which were later gradually absorbed by either MZA, Norte or Andaluces. It is interesting to compare this evolution with that of the narrow-gauge network which, after 1900, was considerably expanded by many small companies (Figure 1 and A.1). Furthermore, and contrary to what happened to the broad-gauge network, the concentration of ownership of narrow-gauge lines declined (Figure 3).

FIGURE 3 ▪ *Herfindahl concentration index for railway lines in Spain (1848–1941)*



Source: See Figure 2 and Muñoz (2005).

Note: The Herfindahl concentration index is a calculation based on the number of kilometres of track in service in each year and operated by broad-gauge (*ancha*) and narrow-gauge (*estrecha*) companies, respectively. According to Herfindahl, markets with indexes of around 0.25 tended to be in a worrying situation in terms of concentration.

TABLE 1 ▪ *Features and municipal access to the networks of the different railway companies (1866–1941)*

	MZA					Norte					Andaluces			Other Companies					Oeste
	1866*	**1877**	**1887**	**1900**	**1941**	**1866**	**1877**	**1887**	**1900**	**1941**	**1887**	**1900**	**1941**	**1866**	**1877**	**1887**	**1900**	**1941***	**1941**
Total stations and stops	249 (29%)**	269 (26)	363 (27)	520 (31)	524 (28)	154 (17)	190 (18)	508 (38)	634 (38)	648 (35)	118 (8.9)	134 (8)	214 (11)	468 (54)	592 (56)	344 (25)	383 (23)	203 (11)	292 (15)
Total kms of track	1,296 (25)	1,559 (26)	2,672 (31)	3,659 (33)	3,655 (29)	723 (14)	891 (15)	2,740 (31)	3,656 (33)	3,803 (31)	793 (9.1)	1,067 (9.6)	1,646 (13.4)	3,057 (60)	3,564 (59)	2,505 (29)	2,667 (24)	1,741 (14)	1,409 (12)
Number of municipalities with access to their respective networks	197 (2.4)	208 (2.6)	286 (3.5)	531 (6.7)	531 (6.7)	207 (2.6)	222 (2.8)	540 (6.8)	710 (9)	731 (9.2)	70 (0.8)	85 (1.1)	134 (1.7)	463 (5.8)	606 (7.6)	439 (5.5)	414 (5.2)	311 (4.0)	274 (3.4)
Inhabitants with access to the different networks (thousands)	1,235 (8.1)	1,497 (9.3)	1,877 (11)	3,096 (17)	4,926 (22)	646 (4.3)	864 (5.3)	2,478 (15)	3.617 (20)	5,646 (25)	1,073 (6.3)	1,258 (7.0)	1,530 (6.7)	2,182 (14)	2,939 (18)	2,071 (12)	1,651 (10)	2,036 (9.0)	1,974 (8.7)
Access to ports	7 (6.0)	8 (6.8)	9 (7.4)	20 (17)	20 (17)	4 (3.4)	5 (4.3)	9 (7.4)	16 (14)	16 (13)	9 (7.4)	9 (7.8)	12 10)	20 (17)	29 (25)	25 (21)	17 (15)	9 (7.5)	6 (5.0)
Access to provincial capitals	9 (19)	10 (21)	15 (31)	19 (40)	19 (40)	7 (15)	8 (17)	23 (48)	25 (52)	25 (52)	7 (14)	8 (16)	9 (19)	24 (50)	29 (60)	14 (29)	12 (25)	7 (15)	8 (16)

Sources: For stations and km of track, see Figure 1. Population data, Beltrán et al. 2019. * The total population and % of the population with access to the network in 1866 was calculated using the census of 1860, and those for 1941 were based on the census of 1930. ** The % of the total represented by each value is shown in parenthesis.

The territorial expansion of the railway companies (1848–1941)

In this section we analyse the expansion of the companies' networks (kms of track and stations) in the territory (ports, population, etc.) To do this, we used the periods, groups and variables established in Sections 2 and 3. Additionally, we have created a series of maps showing three key aspects that help to understand the territorial expansion of the MZA and Norte networks: (i) the sections of track under their management, (ii) those that still belonged to other companies but were subsequently taken over, and (iii) the rest of the network. We also created another series of maps that relate to companies that were never acquired by the two previously mentioned. Finally, Table 1 presents the features of, and relationships between, the rail companies' network and the territory.[31]

1848–1866: The first period of network expansion

As previously mentioned, the construction of the railway network began in 1848. However, the period of greatest expansion was between 1855 and 1866. This growth was conditioned by public subsidies and by the private companies' investment. The most important of these were MZA and Norte, which sought to establish their lines as the heart of the network (Tedde 1978, p. 115). To do this, they planned to construct lines that connected the most relevant places in the country, thereby almost "obliging" other operators to channel traffic towards their tracks. This would enable them to control the most substantial flows on the peninsula with relatively little investment. In this sense, the growth strategies of both firms were characterised by moderation, with the boards of directors of both MZA (*Memoria*, 31 May 1858, p. 24) and Norte (*Memoria*, 12 September 1860, pp. 5-6) urging caution with respect to incurring additional costs.

These strategies were, in fact, reflected in the territorial distribution of their lines. First, we analysed MZA (Map 1), whose lines provided the basis of the network connecting Madrid to the main provincial capitals and ports on the east and south of the country. Despite the relatively limited length of its track (1,296 km), it is significant to underline that, by 1866, the company had already connected nine of the 48 provincial capitals on the peninsula. Furthermore, via the Madrid-Mediterranean trunk line, it also connected with seven ports, including Cartagena and Alicante, which were regarded as

31. Note that the "Other Companies" category includes all of the operators that had not yet been taken over by Norte, MZA, Andaluces or Oeste. Therefore, the networks of these companies can been coloured either on the Map of MZA, or on that of Norte, or on the map that includes the rest of the network.

fundamental on account of their military and trading importance (Álvarez-Palau et al. 2022). The result of this expansion was that the lines of MZA came to include: 249 points of access, connecting 197 municipalities with a total population of over 1.2 million inhabitants (Table 1). Its network was therefore the most extensive and, given the municipal, port and administrative connections that it established, the most important in Spain at that time.[32] In addition to the above, in Map 1 it is possible to observe part of the strategy that the company would subsequently follow: expanding into Catalonia and Andalusia by acquiring existing companies (TMB, CRB, BFF and FCS).

Secondly, we analysed Norte, whose initial strategy was similar to that of MZA. Map 2 shows the territorial distribution of its lines and that of the companies that it was to acquire and had active lines. We can observe that the area of action of these companies, and therefore the future of Norte, was to be along the Mediterranean coast and in the northern half of the country, and particularly in Aragon, Navarre, Old Castile and the Cantabrian coast. However, in line with its initial strategy, the presence of the company remained limited to the Madrid-Irun trunk line. This line was, however, of enormous economic and political importance, as it connected Madrid to the only border crossing with France (Map A.1), visited seven provincial capitals, and passed through densely populated areas of the agricultural part of Castile (Map A.3).[33] With respect to ports, Norte's access was more limited; it had connections with only four, with San Sebastian the most important of these. In summary, Norte's railway network had 154 points of access and its lines connected 207 municipalities with a total population of almost 650,000 inhabitants (Table 1). This meant that, although its network was not very extensive, it contained a large number of stations per km of track that provided railway access to a large number of small and medium-sized municipalities in Old Castile.

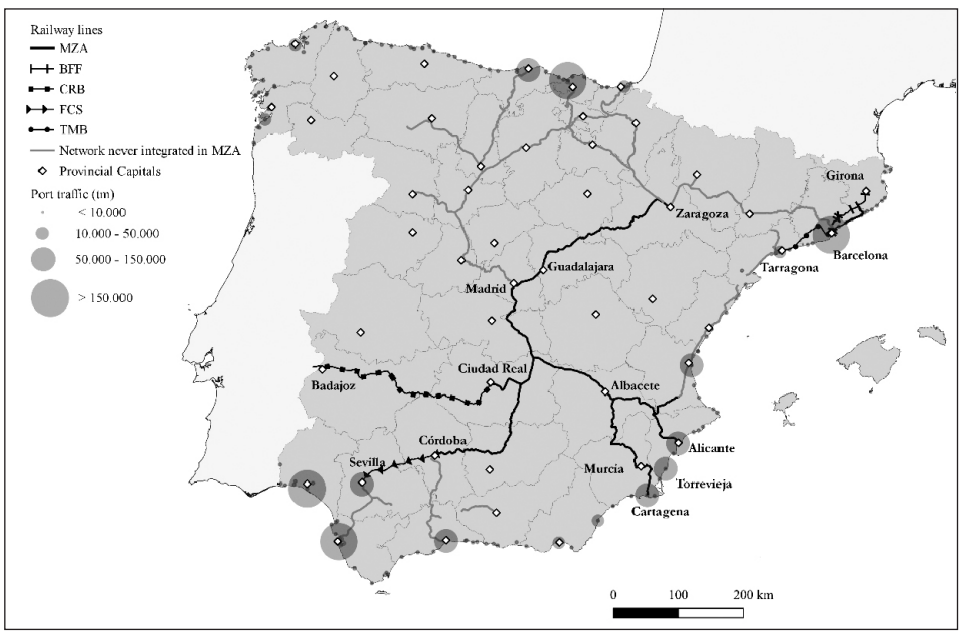
We also repeated this exercise for the firms that we included in the "Other Companies" category. This group includes firms with many and varied trajectories and histories. While some were taken over by MZA or Norte, others developed independently and later became part of Andaluces or Oeste, or even remained independent and self-reliant until the creation of RENFE. Their size and territorial scope was also heterogeneous. We could, however, note a number of general patterns. The small companies subsequently acquired by MZA and Norte (Maps 1 and 2, respectively)) mostly operated in Aragon, Catalonia and along the Mediterranean and Cantabrian coasts.

32. This is also affirmed by MZA's board of directors in 1865: "The central location of our network, which forms the trunk from which branches lead off in all directions and towards every part of the peninsula, gives us such advantages…" (Tedde 1978, p. 57).

33. As a result, the product that accounted for the highest volume of traffic carried on the lines of Norte's network was Castilian wheat (Anes 1978, pp. 496-498).

Those that were not (Map 3), largely operated in Andalusia (FCM, SJP and UMR) and in the north-east of the country (MZV). Whatever the case, and in line with the literature (Ormaechea 1989; Pascual 1999), we believe that the business rationale of operating in territories with easier access to local capital and better potential traffic, associated with greater populations and levels of economic activity, largely explains why, by 1866, most of the smaller companies were located in the most populated and productive areas of Spain: Andalusia, Catalonia, and the Ebro Valley (Map A.3).[34] It is also interesting to observe that these companies provided access to a large number of provincial capitals (24) and ports (20), including the most important ones (Bilbao, Cádiz and Barcelona). However, as we shall see below, MZA, Norte and Andaluces progressively acquired the majority of these smaller companies, particularly those operating adjacent to their trunk lines, and whose tracks led to the most important population centres, borders and ports on the periphery.

MAP 1 ▪ *Territorial distribution of MZA's rail network (1866), its future takeovers, and port traffic (1860)*

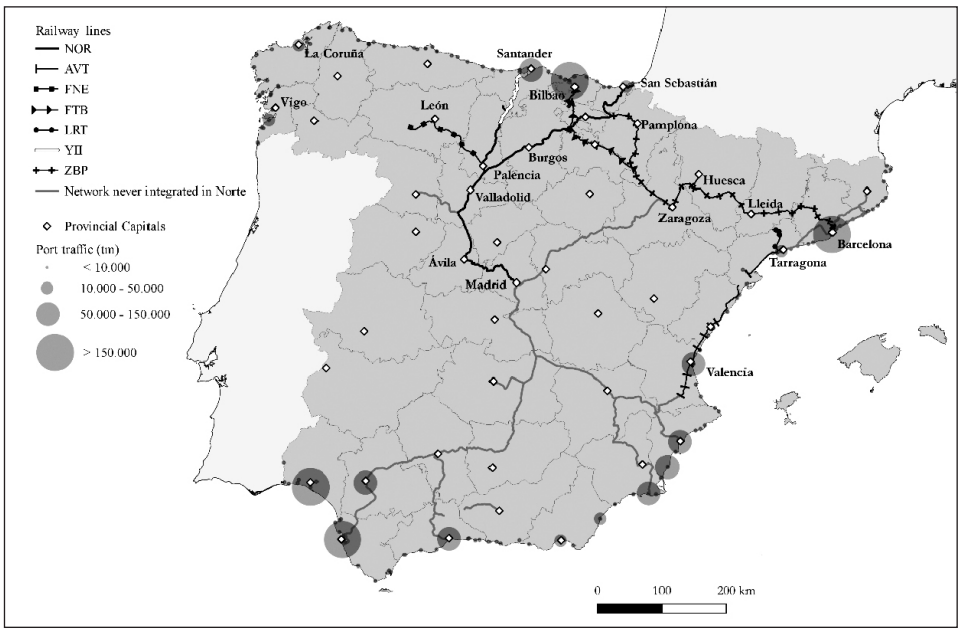


Sources: Lines: Morillas-Torné (2012); Ports: External trade and cabotage statistics and MTN 50.

Notes: The map shows the lines of MZA and of all the companies that eventually formed part of its network in black with different symbols (see legend). The part of the national network that was never integrated into the MZA network is shown in light grey. The spheres show the ports' locations and volumes of traffic with customs.

34. In these regions, the origins of many of the railway companies were associated with local capital; this contrasted with the creation of MZA and Norte, whose shareholders were mainly French.

MAP 2 ▪ *Territorial distribution of Norte's rail network (1866), its future takeovers, and port traffic (1860)*

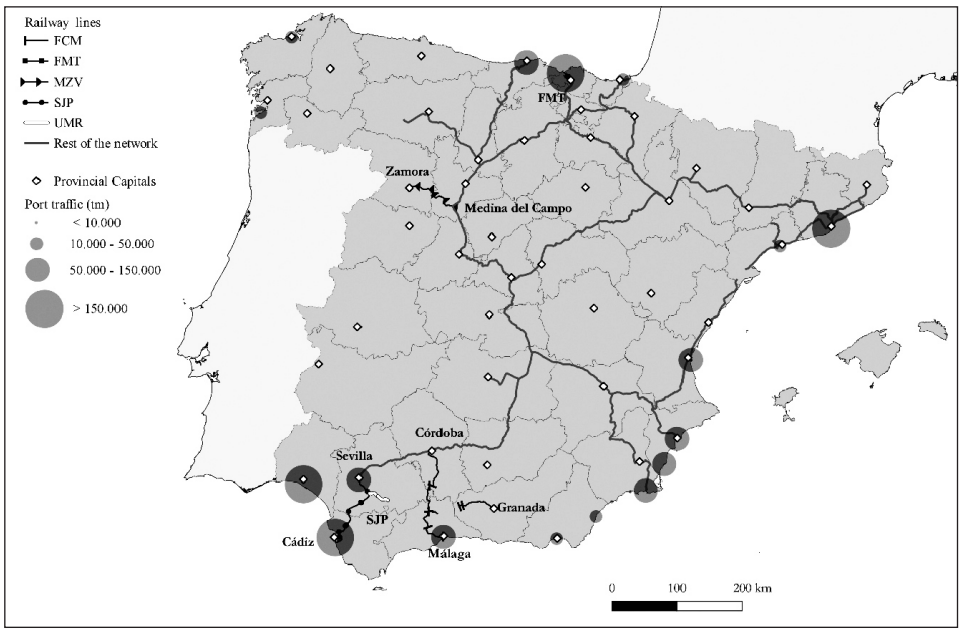


Sources: See Map 1.

Notes: The map shows the lines of Norte and of the companies that eventually formed part of its network in black with different symbols (see legend). The part of the national network that was never integrated into the Norte network is shown in light grey.

Finally, we should also point out that this first wave of railway expansion meant that 32 of 47 provincial capitals on the peninsula, and all of the large trading ports (except Huelva), were connected to Madrid. We believe that this showed the clear preference of the railway companies to adhere to the premises of the Railway Law of 1855. We think that this was a result not only of public subsidies offered to promote certain itineraries, but also because these lines were also the ones that established the most profitable routes.

MAP 3 ▪ *Territorial distribution of the rail networks of companies that were not to be absorbed by Norte or MZA (1866) and port traffic (1860)*



Sources: See Map 1.

Notes: The map shows the lines that were never incorporated into the rail networks of Norte and MZA in black with different symbols (see legend). The companies that were eventually incorporated into the networks of Norte and MZA are shown in light grey.

1866–1877: The financial crisis

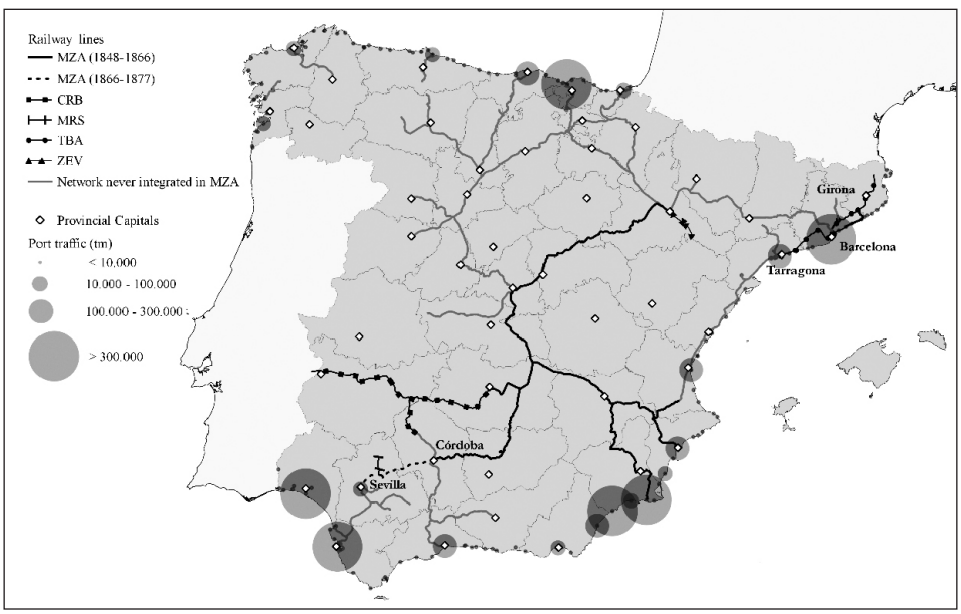
The period 1866–1877 was characterised by a severe economic and production crisis that soon affected the railway companies and limited their expansion (Figure 1).

In Map 4, it is possible to observe how this situation affected MZA. The only relevant difference with respect to 1866 was its acquisition of the FCS. This was considered a priority as it provided "the natural prolongation of its Andalusia line", connecting Madrid and Seville (*Memoria* 5 October 1875, p. 3), which was a populated provincial capital and a major port. In fact, the early construction of this line can be explained by the fact that the board of FCS foresaw that the route would be of priority interest for MZA and that, as eventually occurred, MZA would be willing to pay a high share price for its acquisition (Tedde 1978, p. 50). This acquisition resulted in modest growth in the total length of its tracks (+300 kms) but in a significant increase in the population that it served (+270,000 inhabitants). Amongst the other smaller companies that were to be taken over by MZA, it is relevant to highlight the

creation and growth of TBA, which grouped with the two most important Catalan companies (BFF and TMB) and expanded its network as far as Figueras, on the French border (+68 km).[35]

The expansion of Norte was limited to just 170 km, which was the result of its acquisition of FAS (1873). This purchase was fundamental, as it enabled Norte to transport wheat from the interior of Castile to the port of Santander (Map 5).[36] On the other hand, some of the smaller companies that would later be taken over by Norte added more extra kilometres to their networks. The two most relevant were the FNE, which, with the objective of linking the Castilian Plateau to the north-east of Spain and the Atlantic ports, continued to expand its network in León and Galicia (+278 km); and the AVT, which constructed an extra 43 km of track to connect Valencia with Catalonia. On the other, the expansion of the rest of the smaller companies was moderate (Map 6). However, FCM, UMR, CFT, MZV and CEB significantly developed their lines in the south-east of Andalusia and the western part of the Meseta (adding 47, 39, 30, 50 and 71 km, respectively).

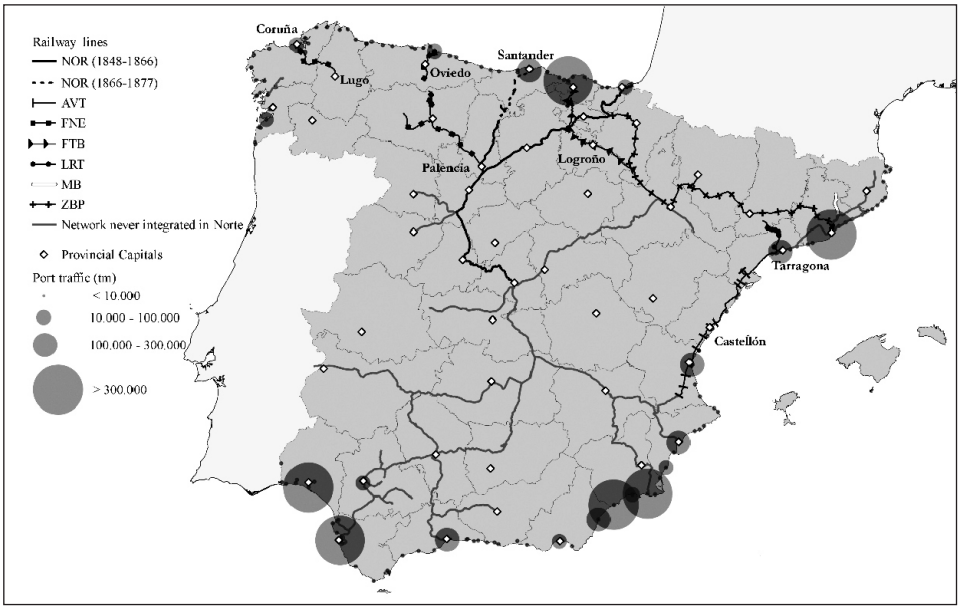
MAP 4 ▪ *Territorial distribution of MZA's rail network (1877), its future takeovers and port traffic (1880)*



Sources and notes: See Map 1.

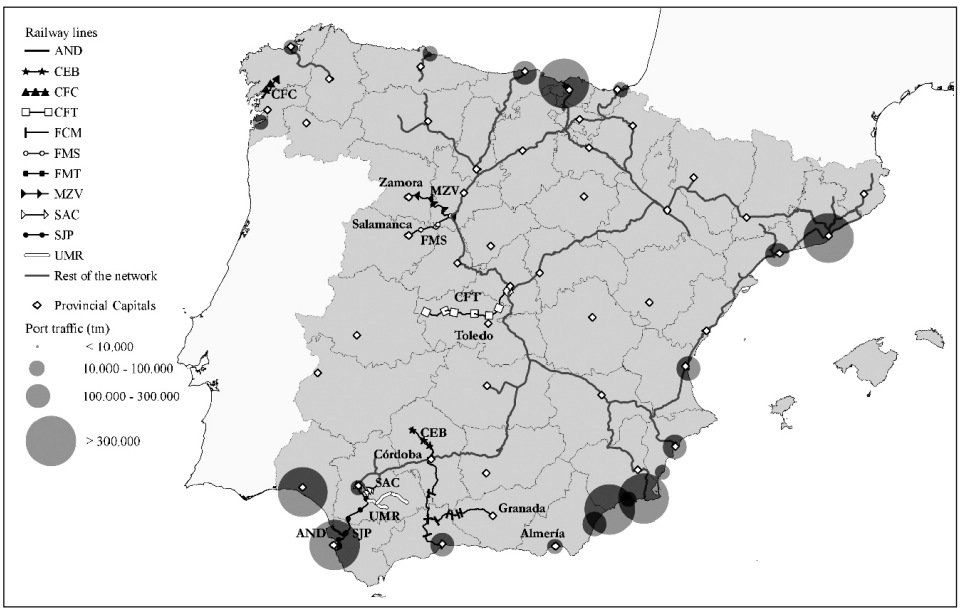
35. For complete details of the construction and financing process of the Catalan network, see Pascual, P. (1999).
36. Before its acquisition, FAS was the company with which Norte carried out most of its exchanges; these essentially involved wheat and coal destined for the port of Santander (Tedde 1978, p. 111).

MAP 5 ▪ *Territorial distribution of Norte's rail network (1877), its future takeovers and port traffic (1880)*



Sources and notes: See Map 2.

MAP 6 ▪ *Territorial distribution of the rail networks of companies that were not to be absorbed by Norte or MZA (1877), their future takeovers and port traffic (1880)*



Sources and notes: See Map 3.

1877–1887: Major acquisitions and greater market concentration

The third period began with the passing of the Railway Law of 1877 and finished in 1887. In light of the paralysis of the development of the network after 1866, this law sought to encourage the construction of new lines, particularly to connect the most isolated provinces (Teruel, Soria) and develop transversal lines. This new legislation, and a prevailing climate of economic dynamism, produced a significant expansion of the network. However, the most notable characteristic of the period was a large increase in the concentration of the market due to the new expansionist strategies of MZA, Norte and, to a lesser extent, Andaluces. This was motivated by the factors highlighted in the 4.1 section.

These new strategies implied major growth in the MZA network (Map 7). It expanded by 1,000 km as a result of the construction and purchase of lines that shared the point of origin and destination but followed a different route, and of transversal lines that complemented and connected its already established network on the South Meseta. The construction of the Madrid-Ciudad Real line, running almost parallel to the Madrid-Córdoba, the creation of a transversal connection between Seville and the Ciudad Real-Badajoz line (acquired from CRB), and the "purchase" of the Aranjuez-Cuenca line (barely one month after its inauguration), were just a few examples of this new policy.[37] The creation of these new lines can therefore be explained by the business objective of monopolizing the agricultural and mining traffic in the southern part of the plateau. Our data (Table 1, Map 7) show that these flows were probably channelled outwards and towards the main consumption nuclei on the peninsula because, in these ten years, MZA established rail connection with the great exporting port of Huelva and also linked to four new provincial capitals and 40% more municipalities.[38]

The expansion of Norte's network was even greater, since during this decade it tripled its total number of km of lines to equal that of MZA. In Map 8, it is possible to observe how this growth was concentrated in the northern half of Spain and seemed to be conditioned by two premises: connecting the Atlantic coast to the Mediterranean and the northern ports to the Meseta. As mentioned, its preferred mechanism for expansion was through the acquisition of previously consolidated companies. It is particularly relevant to highlight ZPB (1878), whose purchase enabled Norte to connect its Madrid-Irún line from the Basque Provinces to Navarre, Aragon and Catalonia.

37. The Ciudad Real-Badajoz (CRB) line connected the highly important mines of Almadén and Bélmez (See Map A.2) and enabled the company to control traffic to the Portuguese border. MZA will later establish a second connection to Portugal in Huelva (Map A.1).

38. The connection to this port was fundamental as it mobilised an enormous volume of goods, particularly minerals destined for export.

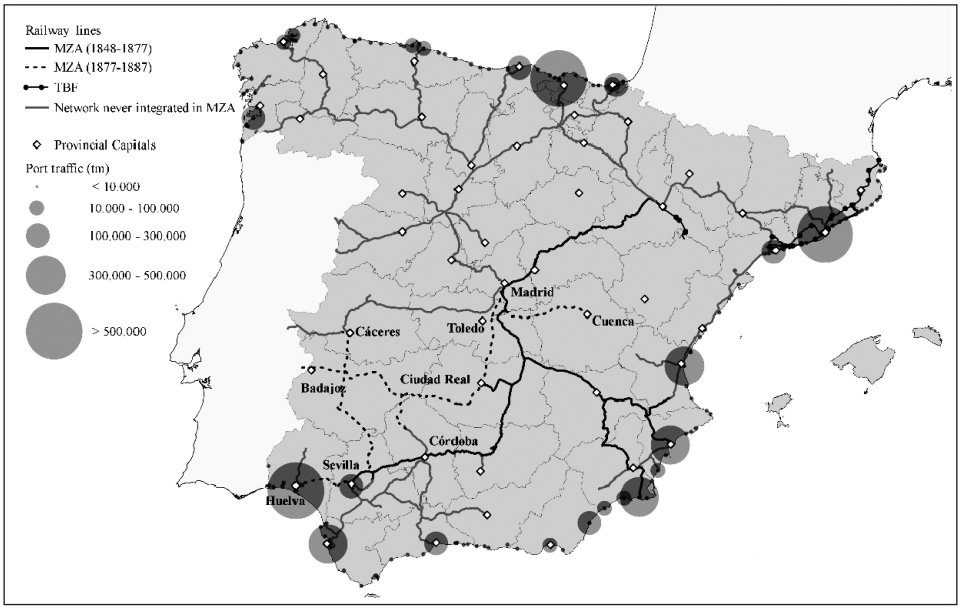
The acquisition of AGL in 1885 (FNE until 1880) was also relevant as this gave Norte the control of almost all of the traffic flows in the north-west of Spain. The result of these investments was fundamental for Norte as it implied establishing connections, through its own network, with some of the country's most dynamic provincial capitals (Barcelona, Zaragoza, etc.) and ports (Bilbao, Tarragona, Barcelona, etc.). Norte also obtained a monopoly in the inland transportation of coal from Asturias, iron from Vizcaya (See Map A.2), and of the flows between Castile and Catalonia, which were of tremendous importance during this period.[39] This spectacular expansion was also reflected in the increase in the number of municipalities and size of the population with access to the Norte network, which tripled. Finally, it is possible to observe the future strategy of the company, which was to expand along the Levante coast.

Companies other than MZA and Norte also actively expanded during this period. The trajectory of Andaluces was particularly noteworthy. Between 1877 and 1880, this company amalgamated practically all of the other companies that had previously operated in the southwest of the country (SJC, UMR, FCM and CEB). The objective of this integration was to develop a more extensive network to reduce fixed costs and increase the total volume of traffic (Tedde 1980). This strategy meant that, barely 10 years after its creation, Andaluces grew to have almost 900 km of track and 118 stations that provided access to 70 municipalities with one million inhabitants. The most important of these included Cádiz, Málaga and Seville, not only on account of their administrative importance and population size, but also because of their considerable port traffic.

With respect to other companies, it was possible to observe a clear geographical pattern, with almost all of them being located in the west of Spain (MZV, FSP, CMF, etc.) or along the eastern coast and in Catalonia (AVT and TBF) (Map 9). This was because most of the "small" companies operating along the Cantabrian coast and on the northern Meseta had already been taken over by Norte, while MZA continued to control the majority of the connections on the southern Meseta. As a result of these acquisitions, the total length of track operated by small companies was reduced by 800 kms. Even so, in total, they continued to provide access to more than two million people and 439 municipalities. These results could largely be explained by the routes operated by TBF and AVT, which connected very densely populated areas (Map A.3).

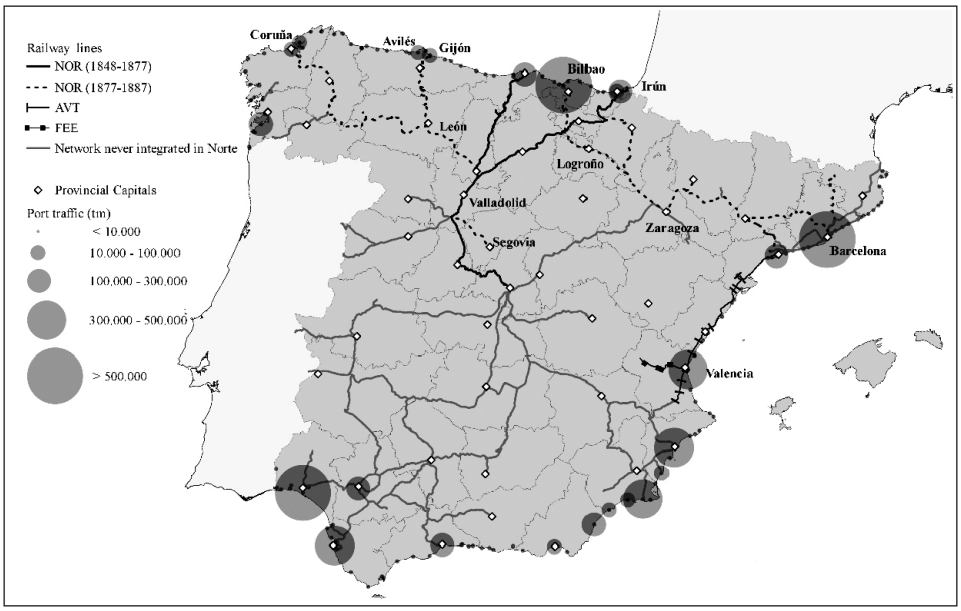
39. The control of Asturian coal transport to Valladolid and Madrid was of particular importance, as these inland areas were the places with the greatest consumption.

MAP 7 ▪ *Territorial distribution of MZA's network (1887), its future takeovers and port traffic (1890)*



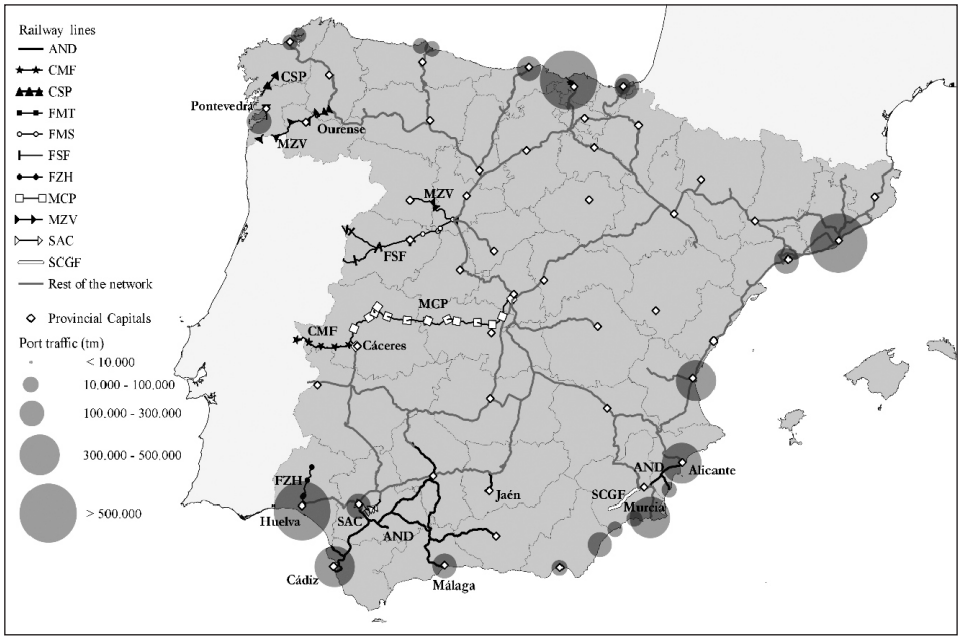
Sources and notes: See Map 1.

MAP 8 ▪ *Territorial distribution of Norte's network (1887), its future takeovers and port traffic (1890)*



Sources and notes: See Map 2.

MAP 9 ▪ *Territorial distribution of the rail networks of companies that were not to be absorbed by Norte or MZA (1887) and port traffic (1890)*



Sources and notes: See Map 3.

1887–1900: Competition between MZA and Norte

Spain's broad-gauge rail network was almost entirely completed between 1887 and 1901. Furthermore, MZA and Norte finalised their expansion processes with the construction of new tracks and the acquisition of the most important operators that were still independent during this period. In this respect, the attention of both companies was directed towards Catalonia, and the Levante, which gave rise to intense competition for the control of traffic flows in these territories. This change of territorial strategy by MZA was motivated by (i) its decision to prevent Norte from controlling all of the border crossings with France, which would have effectively "isolated" its own network in Catalonia, and (ii) its interest in the profitable traffic along the Castile-Catalonia line (Tedde 1978).

This new strategy explains the construction of the line from Barcelona to Ariza and Valladolid via the southern part of Catalonia (1891) and the takeover of TBF (1898). The infrastructure allowed MZA to compete for traffic between Castile and Catalonia and to connect the south of Spain (from Huelva) with the border in Figueras, thereby preventing Norte from controlling

all border crossings with France.[40] Territorially speaking, the final result of the railway investment strategies of MZA was a radial network centred in Madrid, and that connected the most important ports and provincial capitals of the Levante, Catalonia and the South Meseta with the capital and to each other. In this way, (i) the company monopolised the most dynamic flows of goods and passengers in the southern half of the peninsula, and (ii) was able to "compete" with Norte in the Castile-Barcelona line and in Catalonia (Map 10).

During this period, Norte also completed its network after the acquisition of the AVT (1891) and FEE (1893) (Map 11). The purchase of the former was of particular importance as it gave Norte a connection to the coastal municipalities on the eastern side of the peninsula, which was an area with a high volume of agricultural exports (citrus fruits, wines, etc.), considerable industrial production and a large population (Map A.4).[41] This acquisition also formed part of its competitive tussle with MZA, and prevented the latter from controlling all of the Mediterranean ports. This expansion caused an extraordinary increase in the number of ports, municipalities and people with access to its network (Table 1). In summary, through these acquisitions, Norte's railway investment strategies created a territorial structure whose salient features were: (i) connecting Madrid and the northern Meseta with the most important Cantabrian and Atlantic ports; and (ii) connecting Castile, Navarre and the north of Aragon with Catalonia and the eastern coast. Although an analysis of transport flows is not one of the objectives of this article, it is interesting to mention that this territorial distribution conferred Norte with a virtual monopoly of the essential wheat and coal traffic in the northwest. It also gave the company control of most freight flows between Catalonia and Valencia.[42] Another factor to note was the great importance that Norte's network had for connecting the country's administrative centres: of Spain's 48 provincial capitals on the peninsula, Norte had connections to 25.

The development of the railway in the south-west of Spain had been carried out by a number of different companies prior to the creation of Andalu-

40. The struggle between MZA and Norte for the control of TBF was representative of the territorial competition between the two companies. While this was not constant, it was marked by relevant incidents (such as that of ZPB) which persisted over time (Tedde 1978, pp. 71-80).

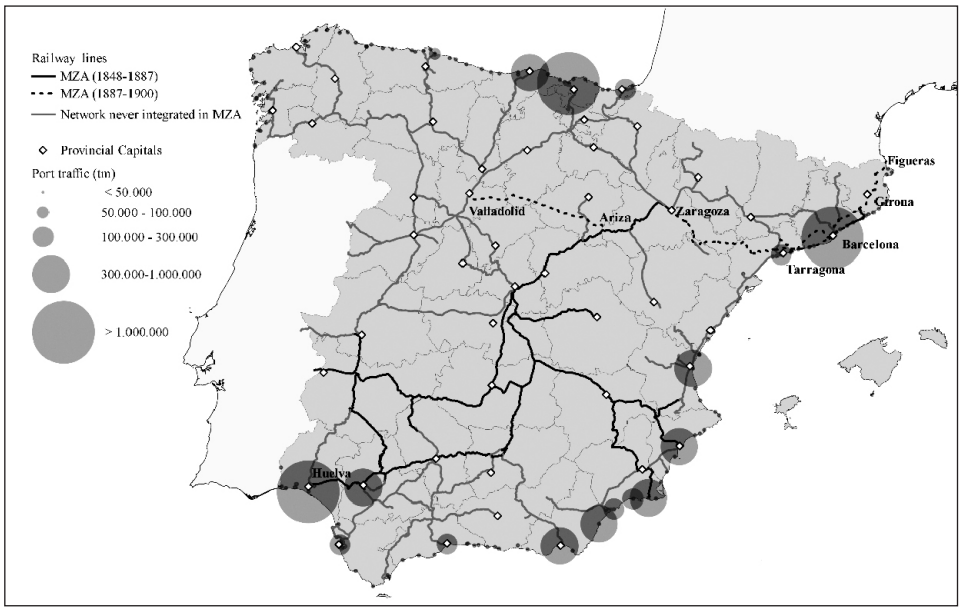
41. The transportation of citrus fruit destined for exportation was particularly relevant (Gallego and Pinilla, 1996).

42. Norte's strategy for expansion was closely linked to the objective of monopolising the coal and wheat flows (two products which were expected to generate a high volume of traffic) from the Meseta, to consumption points on the national periphery and in Madrid. We should also point out that the definitive structure of its lines was highly conditioned by expansion strategies that had been approved by its board in 1860 (Tedde 1978, pp. 106-116).

ces. Then, from 1877 onwards, this company began to take over most of the lines in the region. However, over this period, its network only expanded by 100 km, and this was essentially due to the completion of the Cordoba to Jaen line. In the case of the "Other Companies" group, we did see notable changes (Map 12). First, and as already commented, the two largest independent operators from the previous period (AVT and TBF) were taken over by Norte and MZA, respectively. Even so, and as we can observe from Table 1, the total number of kilometres of track that these companies operated increased during this period. This can be explained by the development of new lines on the western part of the Meseta, in eastern Andalusia and in the southern part of Aragon.

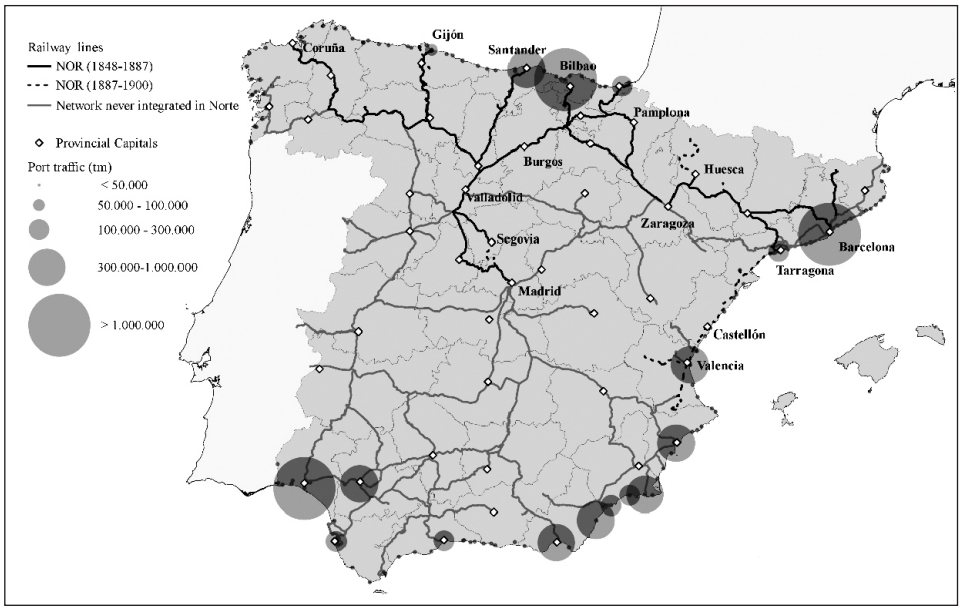
In the west of Spain, this development was mostly associated with the company MCO (formerly MCP), which concluded the northern half of the Vía de la Plata, that directly connected Spain's southern and northern Atlantic coasts. In Andalusia, the development of new lines was particularly intense in Almería and Granada. These provinces had been previously ignored, but the finalisation of the majority of the "priority" lines, combined with the richness of their subsoil, and a growing international demand for minerals, enhanced their attractiveness to railway investors. These new lines were operated by the companies CSE and LBA, both associated with British mining interests (Cuellar 2003). Finally, it is relevant to highlight the activity of the company FCA, which undertook a considerable expansion project in the south of Aragon. Its line had a dual use, as it linked Teruel to the network, and also connected Valencia to the Cantabrian coast without the need to detour through Catalonia or Madrid (Germán Zubero 1999). All of the above implied significant changes in the territorial distribution of the "small" companies. Their main activity shifted from initiatives in Catalonia and along the Levante, to the west of Spain, Andalusia and the south of Aragon. These areas were further from the major trade flows and had a lower density of municipalities and population. Therefore, although their total kilometres of track increased, their access to municipalities, population and ports reduced significantly.

MAP 10 ▪ *Territorial distribution of the MZA network (1900) and port traffic (1900)*



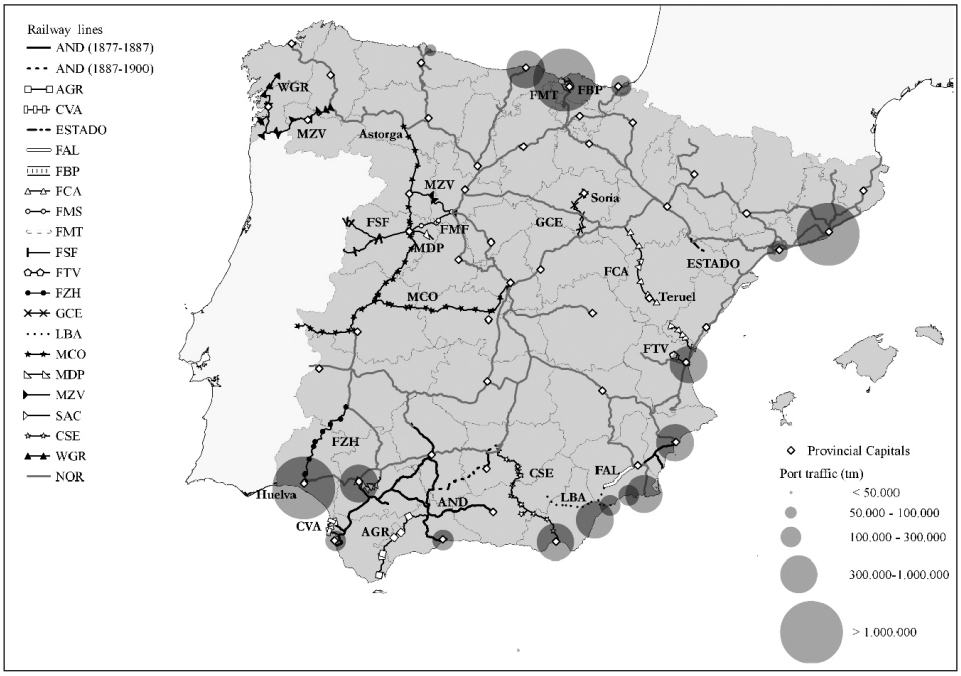
Sources and notes: See Map 1.

MAP 11 ▪ *Territorial distribution of the Norte network (1900) and port traffic (1900)*



Sources and notes: See Map 2.

MAP 12 ▪ *Territorial distribution of the rail networks of companies that were not to be absorbed by Norte or MZA (1900) and port traffic (1900)*



Sources and notes: See Map 3.

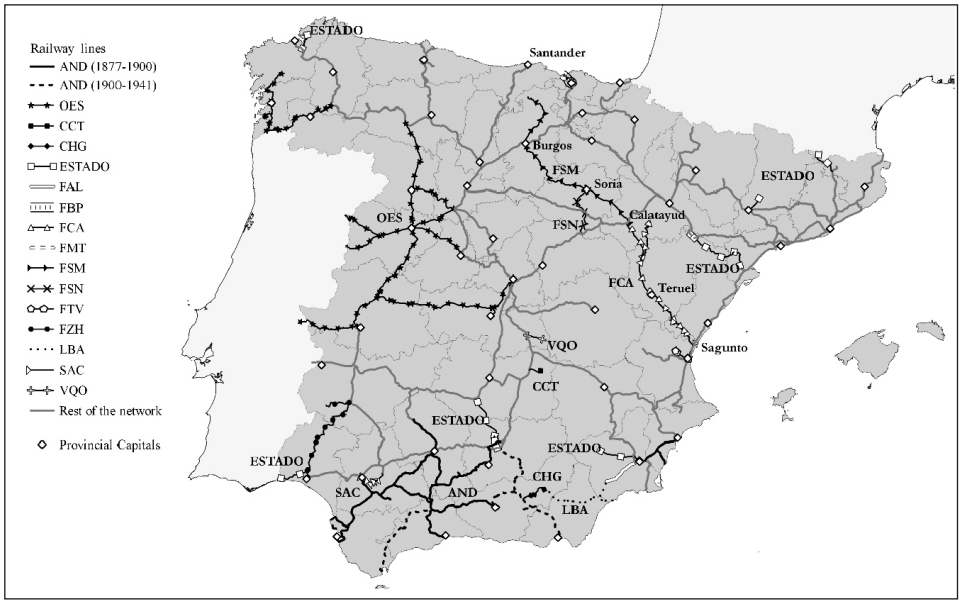
1900–1941: Maturity and crisis of the sector

Between 1900 and 1941, neither MZA nor Norte expanded their networks; instead, they focused their limited investment on improving existing lines by doubling and electrifying the tracks, buying modern trains, etc. It is, however, relevant to highlight the case of FCA. As previously mentioned, this company began its operations in 1898 and sought to connect the Cantabrian coast with the Levante, via Aragon. Seeing it as possible competition, Norte took over the company in 1926, but never integrated its network, with FCA remaining as an affiliate company.

In contrast, Andaluces and other small companies did construct new track. Map 13 shows three areas of clearly differentiated expansion: the south-east of the peninsula, the western part of the Meseta, and the Celtiberian Range (Teruel and Soria). In the south-east of Spain, CSE was taken over by Andaluces in 1929,[43] resulting in the company controlling most of the railway lines in that region.

43. Although Andaluces had controlled CSE since 1916, the definitive integration between the two networks did not took place until 1929. The profits of CSE had been disappointing since its establishment, which was a further incentive for its sale to Andaluces (Tedde 1980).

MAP 13 ▪ *Territorial distribution of the lines of the companies not integrated into the network of either Norte or MZA (1941)*



Sources and notes: See Map 3.

The development of the network in the west was more complex as, until well into the twentieth century, a myriad of small companies operated lines with only a low volume of traffic and few kilometres of track. Faced with increasing financial problems during this period, these companies progressively merged.[44] The culmination of this process saw the creation of the Compañía del Oeste (1927-1928), which, with state support, brought together practically all of the companies operating in the region.[45] The objective of these mergers was to improve profitability by increasing traffic and reducing fixed costs. However, surges in operating costs led the new company into a very delicate situation, culminating in its integration into RENFE.[46]

Smaller companies that were never absorbed by any of the four largest companies were also active. The majority had been created in the twentieth century, and their development was linked to connecting secondary areas. Perhaps their most noteworthy actions were the Levante-Atlantic transversal

44. An example is the merger between CFO and MCP, forming the company MCO in 1895.

45. The Compañía de Ferrocarriles del Oeste progressively absorbed the companies: MZV, WGR, MCO, MDP, FMS, FSF. For more information, see Graph B.5.

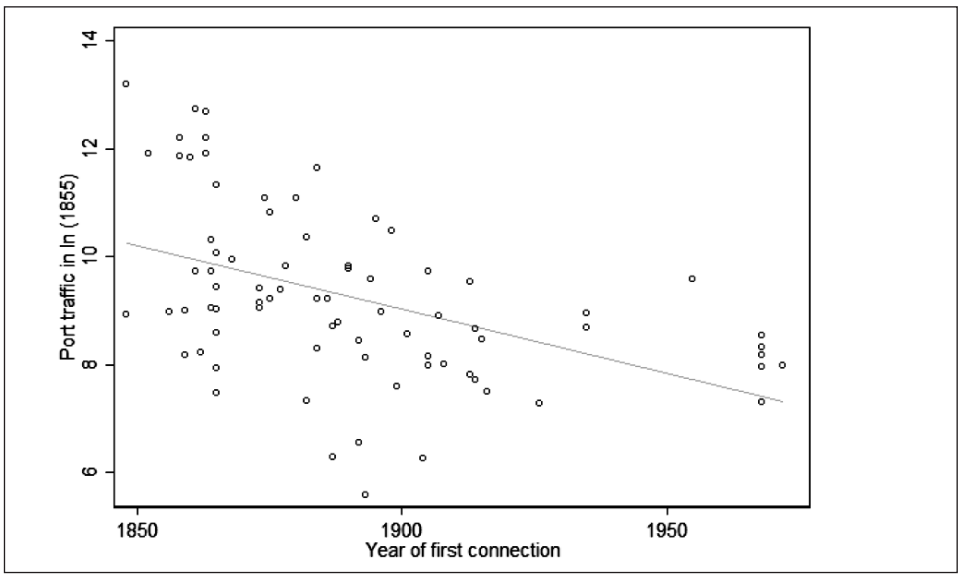
46. From the first decade of the twentieth century, the exploitation costs of the railway sector increased significantly, compromising the profitability of the companies. The reasons were the scarcity of productive factors (due to the First World War) and the increase in labour costs.

connections and those that extended railway coverage and joined certain unique mining and border territories to the rail network. With respect to the former, we could highlight the example of FCA and the Santander-Mediterranean line (FSM). The objective of both parties was to establish a direct line from the Levante to the Cantabrian ports. FCA constructed 294 km of new track and completed the Valencia-Calatayud line to achieve this. On the other hand, the construction of the Santander-Mediterranean line did not begin until almost the end of the period (1924) and its purpose was to connect Santander with Calatayud, where the line would link with the track that the FCA already had in operation. However, technical problems compromised completion of this line, as although work on it was practically completed (including 353 km of track in 1941), it was never finished.

From an overall perspective, this analysis confirms the importance of the railway companies' policies of expansion and business concentration in understanding the development of the Spanish network. Following their initial strategies, it is possible to observe how these firms prioritized the expansion of railways in the most dynamic regions. The majority of their lines started in Madrid. They crossed the agricultural and mining areas of the interior to connect to the most important provincial capitals, the most populated municipalities, Spain's international borders, mining areas, and the busiest ports on the Iberian Peninsula. Subsequently, after the financial crisis of 1866, the companies modified their initial strategies, seeking to extend these trunk lines into other important urban areas, ports and neighbouring centres of production and consumption. To achieve this, they opted for the acquisition of previously established firms and for the construction of new lines. The objectives of this growth were to increase the volume of traffic within the established network, prevent competition from alternative lines, and reduce their fixed operating costs. In this sense, Table 1 shows that the percentage of the ports, provincial capitals and population connected by any of these companies' networks was always significantly bigger than that of the number of municipalities, especially in the earlier periods. In addition, Figures 4, 5 and 6 help us quantify this. The first one shows a correlation between the year of connection to the railway network and the volume of port traffic in the previous years. Figure 5 shows that the most populated provincial capitals were first connected. Finally, Figure 6 shows that amongst the municipalities with more than 10,000 inhabitants, those with the greatest populations tended to be the ones closest to the railway network in 1866.[47]

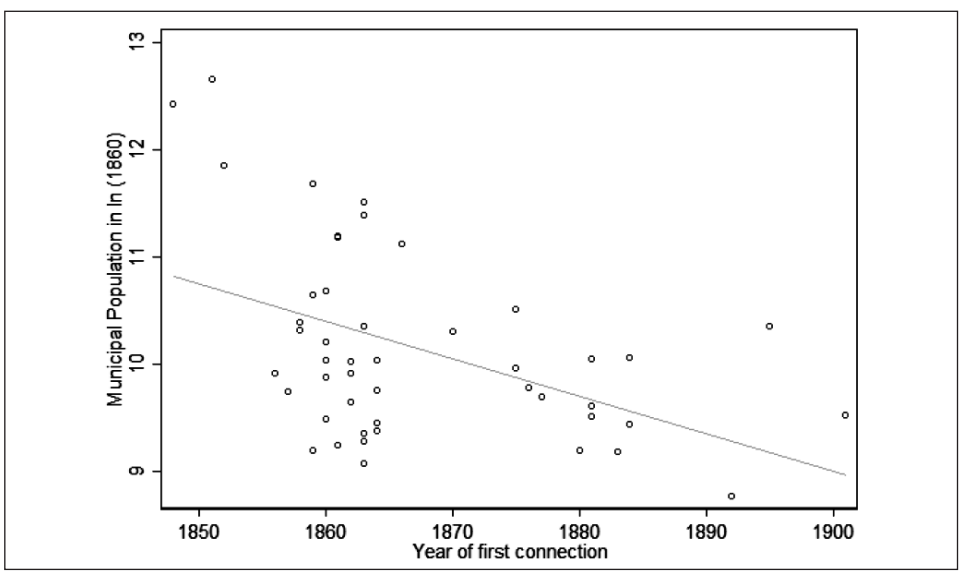
47. We only correlate port traffic, provincial capitals and municipalities with more than 10,000 inhabitants with the year of connection or distance to railways because using the whole sample would have caused causality problems involving non-targeted municipalities that just happened to be between two targeted nodes (non-targeted were prevalent in most of the sample).

FIGURE 4 ▪ *Port traffic (1855) and year of first railway connection of Spanish port location in the peninsula*



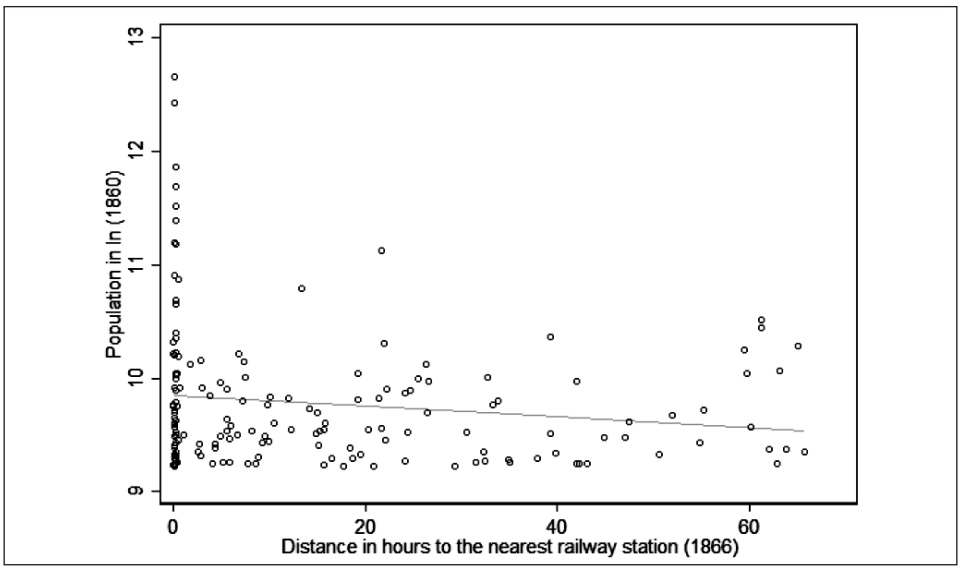
Sources for port traffic: External trade and cabotage statistics for Spain; Year of First Connection: Table A.4.
Notes: N=75.

FIGURE 5 ▪ *Municipal population (1860) and year of first railway connection of Spanish provincial capitals in the peninsula*



Sources for Municipal population: 1860 census; Year of first connection: Table A.3.
Notes: N= 47.

FIGURE 6 ▪ *Municipal population (1860) and distance to the nearest railway station (1866)*



Sources for Municipal population: 1860 census; Distance to the nearest station: Esteban-Oliver (2021).
Notes: N=165; the municipalities of the sample have more than 10.000 inhabitants.

Conclusions

In this article, we have described and examined the development of the Spanish railway system from the second half of the nineteenth century up to the early 1940s, incorporating – for the first time – a chronology of all of the private companies and their processes of expansion. The other novelty of the text is that we have linked this process to the territory and it's features. To do this, we have created the first database that determines the ownership of the different sections of track, lines and stations, in the period 1848–1941, on a year-by-year basis. We have then linked the expansion of these companies to their local territory by integrating this chronology into a GIS that also includes various spatial characteristics.

This new database is partly available in the annexes. One of its most relevant uses relates to the literature that examines how the diffusion of infrastructure alters the urban hierarchy of cities. Our data show that railway connections have tended to reinforce the urban hierarchy favouring political capitals and the most dynamic cities, and the centre-periphery model (Krugman

1992).[48] Knowing the location of the points of access within the network (stations and stops) at which trans-shipments took place between companies would make it possible to measure, with a good degree of accuracy, the quality of both urban and rural inter-modality, which is a key element for understanding the magnitude the effects of railways (Mimeur et al. 2018)

The second contribution derives from the proposed analysis of this data. It confirmed that knowing the expansion and business concentration process of the railway companies, and linking them to the territory, is necessary if we are to understand the development of the network (as is clearly highlighted in the cases of the Sevilla-Cordoba or Valladolid-Ariza lines).[49]. Indeed, we showed that companies' strategies conditioned the sequence of the railway expansion, as our results point to the fact that the network was mainly established following economic and business criteria, with most companies expanding their networks in, and first linking together, the most populous and economically active nodes in the country. It was only after these routes had been established that initiatives for line development in other areas began. These results contribute to ongoing debates, like those that focus on the factors that explain network expansion in Spain (Cordero and Menéndez 1978; Comín et al. 1998). In this regard, although some authors (Bel 2011) have pointed out that the development of railways was not driven by the requirements of economic activity, our conclusions resemble those reached by the recent study of Muñoz Rubio and Ortúñez Goicolea (2022). Rather than political, administrative or military reasons, economic activity and expected profits seem to be the crucial variables for explaining the development of the Spanish railway network.

Finally, and with a view to the future, we should point out that this work is part of a preliminary approach, as we seek to identify and (if possible) quantify the relevance of all of the factors behind the expansion of this infrastructure in a more systematic way. In this regard, we expect to incorporate variables such as the locations of military barracks, pre-railway overland transport flows, or the influence of local politics, etc. In the same note, we think that it is also necessary to refer back to Crafts et al. (2008). They demonstrated that the performance of British companies at the beginning of the twentieth cen-

48. In the case of Spain, this has been verified by Barquín et al. (2012) who calculated that cities with railway access experienced greater population growth than unconnected ones. Mojica and Martí-Henneberg (2011) came to similar conclusions. There have also been several international studies of this phenomenon; some of the most relevant have analysed the cases of France (Mimeur 2016), England (Bogart et al. 2021) or Finland (Alvarez-Palau and Martí-Henneberg 2020).

49. One aspect which we have not addressed (given the "macro" nature of the study), but which constitutes a future line to explore, is the interaction between the companies and the local authorities. In this respect, we can highlight the work of Pascual (1999), who studies this relationship in Catalonia.

tury was heterogeneous, and attributed part of the differences to their business management strategies. Thus, understanding how and why the Spanish rail network expanded and operated is the necessary first step towards being able to analyse whether the performance of Spanish companies was diverse, and if these differences could have led to railways having varying spatial effects.

Author contribution statement

Guillermo Esteban-Oliver: framework, writing, formal analysis, investigation, dataset, visualization and supervision.

Jordi Martí-Henneberg: framework, writing, investigation and supervision.

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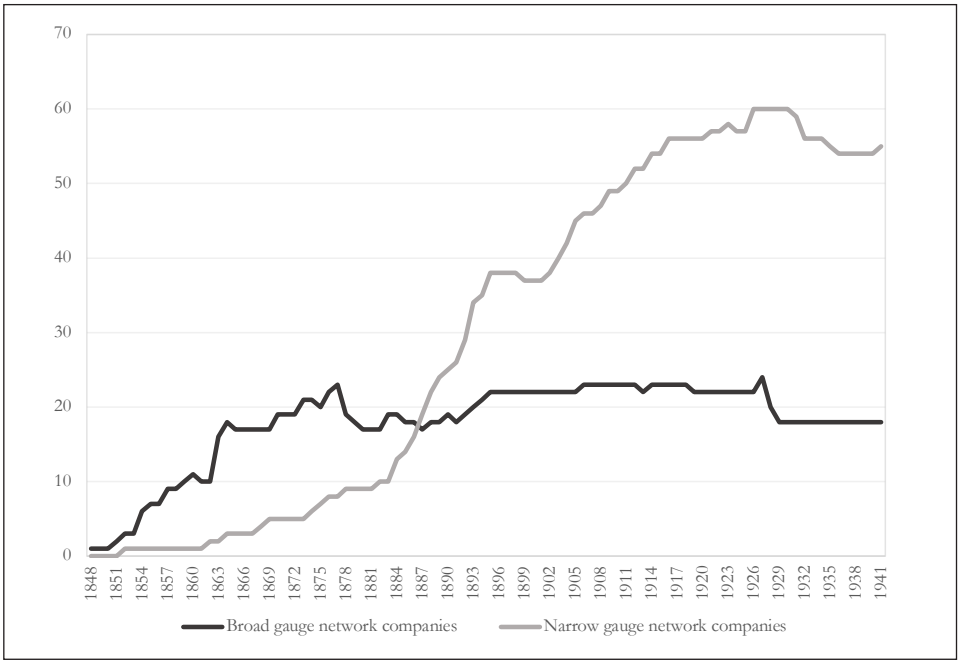
Annex A

FIGURE A.1 ▪ *Number of companies operating railway lines in Spain (1848–1941)*



Sources: García-Raya (2006), Eloizola (2005) and Cuellar (Unpublished).

Notes: The Figure shows the total number of companies operating lines in Spain (*x* coordinates) in each year of the period (*y* coordinates).

TABLE A.1 ▪ *Railway companies and their acronyms (broad-gauge network)*

Acronym	Full name of the company
AGL	Compañía del Ferrocarril de Asturias, Galicia y León
AGR	The Algeciras (Gibraltar) Railway
AND	Compañía de los Ferrocarril Andaluces
AVT	Sociedad de los Ferrocarriles de Almansa a Valencia y Tarragona
BAM	Ferrocarril de Barcelona a Arenys de Mar
BFF	Caminos de Hierro de Barcelona a Francia y Figueras
BGG	Ferrocarril de Barcelona a Granollers y Gerona
BGR	The Granada Railway (Baza-Guadix)
BMG	Ferrocarril de Barcelona a Mataró y Gerona

(Continued on next page)

Acronym	Full name of the company
CRB	Compañía de los Ferrocarriles de Ciudad Real a Badajoz y de Almorchón a Bélmez
CBG	Caminos de Hierro de Barcelona Gerona
CCA	Compañía de los Ferrocarriles Carboníferos de Aragón
CCT	Compañía del Ferrocarril de Cinco Casas a Tomelloso
CEB	Compañía del Ferrocarril de Córdoba a Belmez
CFC	Compañía del Compostelano
CFO	Compañía de los Ferrocarriles del Oeste de España
CFT	Compañía Ferrocarril del Tajo
CHC	Caminos de Hierro del centro
CHG	Compañía de los Caminos de Hierro de Granada
CMF	Ferrocarriles a Cáceres a Malpartida y la Frontera con Portugal
CSE	Compañía de los Caminos de Hierro del Sur de España
CSP	The Coruna, Santiago and Peninsular Railway
CVA	Compañía Belga de los Caminos de Hierro Vecinales de Andalucía
EAC	Sociedad para la explotación y construcción de Aranjuez a Cuenca
ESTADO	(Administración estatal pre-RENFE)
FAL	Ferrocarril de Alcantarilla a Lorca
FAS	Nueva Compañía del Ferrocarril de Alar a Santander
FBG	Ferrocarril de Barcelona a Granollers
FBMA	Ferrocarril Barcelona Mataró Arenys de Mar
FBP	Compañía de los Ferrocarriles de Bilbao a Portugalete
FCA	Ferrocarril Central de Aragón
FCM	Sociedad del Ferrocarril de Córdoba a Málaga
FCS	Compañía del Ferrocarril de Córdoba a Sevilla
FCVT	Ferrocarril de Vinyalta a Tarragona
FEE	Compañía de los Ferrocarriles del Este de España
FMA	Ferrocarril de Madrid a Aranjuez
FMS	Compañía del Ferrocarril de Medina a Salamanca
FMT	Ferrocarril Minero de Triano
FNE	Compañía de los Ferrocarriles del Noroeste de España
FSF	Compañía de los Ferrocarriles de Salamanca a la frontera portuguesa
FSM	Compañía del Ferrocarril Santander Mediterráneo
FSN	Ferrocarril Soria Navarra
FTB	Ferrocarril de Bilbao a Tudela por Miranda
FTV	Compañía de Ferrocarriles y Tranvías de Valencia
FZB	Compañía del Ferrocarril de Zaragoza a Barcelona

(Continued on next page)

Acronym	Full name of the company
FZH	Compañía del Ferrocarril de Zafra a Huelva
FZME	Ferrocarril Zaragoza Mediterráneo
FZP	Compañía del Ferrocarril de Zaragoza a Pamplona
GCE	Gran Central Español
HBM	Caminos del Hierro de Barcelona a Mataró
HEB	Caminos del Hierro del este de Barcelona
LBA	The Great Southern of Spain Railway
LRT	Compañía del Ferrocarril de Lérida a Reus y Tarragona
MB	Maciá y Brocca
MCO	Compañía de Explotación de los Ferrocarriles de Madrid a Cáceres y Portugal y del Oeste
MCP	Compañía de los Ferrocarriles de Madrid a Cáceres y Portugal
MDP	The Madrid and Portugal Direct Railway
MRS	Compañía del Ferrocarril de Mérida a Sevilla
MZA	Compañía de los Ferrocarriles de Madrid Zaragoza Alicante
MZV	Compañía de los Ferrocarriles de Medina a Zamora y Orense a Vigo
NOR	Compañía de los Caminos de Hierro del Norte de España
OES	Compañía Nacional de los Ferrocarriles del Oeste
PSS	Compañía del Camino del Hierro de el Puerto de Santa María a San Lúcar
SAC	Compañía del Ferrocarril de Sevilla a Alcalá y Carmona
SBB	Ferrocarril de Selgua a Barbastro
SCF	Sociedad General de Ferrocarriles Vasco-Asturiana
SCGF	Sociedad de Crédito General de Ferrocarriles
SJC	Compañía de los Ferrocarriles de Sevilla a Jerez y Puerto Real a Cádiz
SJP	Sociedad del Ferrocarril en Jérez, Puerto de Santa María y Cádiz
TBA	Compañía de los Ferrocarriles de Tarragona a Barcelona y Francia
TBF	Nueva Compañía de los Ferrocarriles de Tarragona a Barcelona y Francia
TMB	Ferrocarriles de Tarragona a Martorell y Barcelona
UMR	The Utrera and Moron Railway
VQO	Compañía del Ferrocarril de Villacañas a Quintanar de la Orden
VSM	Ferrocarril de Villalba a Soria y Medina del Campo
WGR	The West Galicia Railway
YII	Empresa del Ferrocarril de Isabel II
ZPB	Compañía de los Ferrocarriles de Zaragoza a Pamplona y Barcelona
ZEV	Compañía de Zaragoza a Escatrón y de Val de Zafán a las minas de Gargallo a Utrillas

Sources: "Cronología básica del Ferrocarril Español de Vía Ancha", García-Raya (2006) and Cuellar (Unpublished).

TABLE A.2 ▪ *Year of start and end of operations, and the evolution of the total length of lines (km) under the management of railway companies*

Company	1855	1860	1866	1870	1877	1887	1900	1910	1927	1941	First	Last	Maximum mileage (km)
AGR							178	178			1890	1912	178.2
AGL											1880	1884	744.7
AND					160	793	1067	1083	1305	1646	1877	1941	1570
AVT	57	57	287	330	330	330					1852	1890	329.6
BAM											1856	1858	28.46
CRB			367.4	431.1							1863	1879	431.1
BFF			128	128							1864	1874	127.56
BGG		69									1857	1860	69.3
BGR								53			1906	1917	52.6
BMG		28									1859	1860	69.3
CRB			367	431	431						1861	1863	127.56
CBG											1878	1880	46.3
CCT									6	6	1914	1941	6.3
CEB				28	71						1870	1879	71
CFC					41						1873	1885	41
CFO											1893	1894	55.7
CFT					169						1876	1879	231
CHC	18										1854	1859	19
CHG									53	53	1918	1941	52.6
CMF						9					1880	1889	9
CSE							253	318	318		1895	1928	333.9
CSP						41					1886	1895	41
CVA							37	37			1895	1918	36.9
EAC											1883	1883	151
ESTADO							32	32	149	367	1889	1941	367
FAL							56	56	56	56	1900	1941	55.5
FAS											1871	1873	138.6
FBG	30										1854	1856	29.5
FBMA											1857	1859	28
FBP							12	12	21	21	1888	1941	21.2
FCA							119	294	294	414	1898	1941	413.9
FCB											1863	1864	127.9
FCM			261	280	307						1863	1878	307.1

(Continued on next page)

Company	1855	1860	1866	1870	1877	1887	1900	1910	1927	1941	First	Last	Maximum mileage (km)
FCS		130	130	130							1859	1879	129.9
FCVT											1882	1883	41.6
FEE						88					1885	1891	87.7
FMA	279										1851	1855	278.7
FMS					57	77	77	77	77		1875	1927	76.9
FMT			7	7	7	7	12	12	12	12	1865	1941	11.8
FNE			175	254	452						1863	1879	452
FSF						202	202	202	202		1886	1928	202.4
FSM									257	353	1927	1941	353.1
FSN									94	94	1920	1941	93.8
FTB			249	249	249						1863	1877	249.1
FTV							29	29	29	29	1889	1941	29.1
FZB	17	176									1855	1864	483.2
FZH						67	180	180	180	226	1886	1941	226.2
FZME											1895	1898	32
FZP		60									1860	1864	187.2
GCE							94	94			1892	1919	93.8
HBM											1848	1853	28.5
HEB	28										1854	1855	28.5
LBA							145	145	145	145	1890	1941	145.1
LRT			39	39	62						1863	1885	86.8
MB					40						1876	1886	76.2
MCO							651	651	651		1895	1927	650.9
MCP						316					1880	1894	324.9
MDP							40	40	107		1894	1927	106.9
MRS				31	61						1870	1879	126.2
MZA		609	1296	1428	1559	2672	3656	3656	3670	3655	1856	1941	3659
MZB											1881	1884	173.1
MZV			90	90	90	279	281	281	281		1864	1927	281.4
NOR			723	723	882	1781	3405	3656	3681	3803	1860	1941	3639
OES										1410	1928	1941	1409.7
PSS											1892	1894	28.8
SAC					39	51	51	51	51	51	1873	1941	50.6
SBB						19					1880	1888	19
SCGF						56					1885	1899	55.5

(Continued on next page)

Company	1855	1860	1866	1870	1877	1887	1900	1910	1927	1941	First	Last	Maximum mileage (km)
SJP	15	132	160	160	160						1854	1877	159.8
TBA					262						1875	1885	288.76
TBF						462					1885	1897	628.43
TMB		19	93	93							1860	1874	92.7
UMR			35	43	74						1864	1877	74
VQO									25	25	1927	1941	24.9
VSM											1884	1884	92.3
WGR							73	73	73		1896	1927	73
YII		105	139	139							1857	1870	138.6
ZPB			701	701	701						1865	1877	701
ZEV					31						1874	1877	30.5

Sources: Own research, based on García-Raya (2006) and Morillas-Torné (2012) and Cuellar (unpublished).

TABLE A.3 ▪ *Year and company connecting the provincial capitals on the Iberian Peninsula*

Provincial capital	Year of first connection	Year of connection with Madrid	Company that established the first connection	Broad-gauge companies with connections in 1941
Barcelona	1848	1863	HBM	NOR, MZA
Madrid	1851	x	FMA	MZA, NOR, OES
Valencia	1852	1857	AVT	NOR, FCA, FTV
Tarragona	1856	1865	LRT	MZA, NOR
Albacete	1857	1857	MZA	MZA
Alacant/Alicante	1858	1858	MZA	MZA, AND
Santander	1858	1866	YII	NOR
Córdoba	1859	1865	FCS	MZA, AND
Guadalajara	1859	1859	MZA	MZA
Sevilla	1859	1865	FCS	MZA, AND, SAC
Burgos	1860	1863	NOR	NOR, FSM
Lleida	1860	1863	NOR	NOR, Estado
Palencia	1860	1863	NOR	NOR
Pamplona/Iruña	1860	1863	ZBP	NOR
Valladolid	1860	1863	NOR	NOR, MZA
Cádiz	1861	1865	SJP	AND

(Continued on next page)

Provincial capital	Year of first connection	Year of connection with Madrid	Company that established the first connection	Broad-gauge companies with connections in 1941
Ciudad Real	1861	1861	MZA	MZA
Zaragoza	1861	1863	MZA	NOR, MZA
Castellón de la Plana	1862	1862	AVT	AVT
Girona	1862	1863	MZA	MZA
Vitoria-Gasteiz	1862	1863	NOR	NOR
Ávila	1863	1863	NOR	NOR, OES
Bilbao	1863	1863	FTB	NOR, FBP, FMT
León	1863	1863	FNE	NOR
Logroño	1863	1863	FTB	NOR
Málaga	1863	1865	FMC	AND
Murcia	1863	1865	MZA	MZA, AND, FAL, Estado
Badajoz	1864	1866	MZA	MZA
Huesca	1864	1864	ZBP	NOR
San Sebastián/ Donostia	1864	1864	NOR	NOR
Zamora	1864	1864	MZV	OES
Granada	1866	1873	FCM	AND
Oviedo	1870	1881	FNE	FNE
Coruña, A	1875	1885	FNE	NOR
Lugo	1875	1885	FNE	NOR
Toledo	1876 (1939)	1876 (1939)*	CFT	OES
Salamanca	1877	1877	FMS	OES
Huelva	1880	1880	MZA	MZA, FZH, Estado
Cáceres	1881	1881	MCP	OES, MZA
Jaén	1881	1881	AND	AND
Ourense	1881	1885	MZV	OES
Cuenca	1883	1883	MZA	MZA
Pontevedra	1884	1885	MZV	OES
Segovia	1884	1884	NOR	NOR
Soria	1892	1892	GCE	FSN, FSM
Almería	1895	1899	SUR	AND
Teruel	1901	1901	FCA	FCA

Sources: See Table A.2.

Notes: On the first date, the closest station to Toledo was 13 km from its centre, while in 1939, a branch line was constructed that directly connected the city to the network.

TABLE A.4 ▪ *Year and company connecting the ports with customs to the railway network in the period 1848–1941*

Port	Year of connection	Company	Notes
Alicante	1858	MZA	
Altea	1914	Estrecha	
Benidorm	1914	Estrecha	
Dénia	1884	Estrecha	No branch line to the port
Jávea	1915	Estrecha	No branch line to the port
Santa Pola	-		
Torrevieja	1884	AND	
Villajoyosa	1914	Estrecha	
Adra	-		
Almería	1895	SUR	
La Garrucha	-		
San Miguel de Cabo de Gata	-		
Arenys de Mar	1859	MZA	
Badalona	1848	HBM	
Barcelona	1848	HBM	
Malgrat	1859	MZA	
Masnou	1848	HBM	
Mataró	1848	HBM	
Sitges	1882	TBF	
Villanueva y Geltrú	1882	TBF	
Algeciras	1890	AGR	
Bonanza	1898	CVA	
Cádiz	1861	SJP	
Chipiona	1892	CVA	
La Línea	-		
Puente Mayorga-San Roque	-		
Puerto de Sta. María	1856	SJP	
Rota	1892	CVA	
San Fernando	1861	SJP	
San Lucar de Barrameda	1877	AND	
Tarifa	-		
Vejer de la Frontera	-		
Benicarló	1865	AVT	

(Continued on next page)

Port	Year of connection	Company	Notes
Burriana	1907	Estrecha	
Cap y Corp	1865	AVT	No branch line to port
Castellón	1888	Estrecha	
Vinaroz	1865	AVT	
Ares	1913	Estado	
Betanzos	1913	Estado	
Camariñas	-		
Cedeira	-		
Corcubión	-		
Coruña	1875	FNE	
Ferrol	1913	Estado	
Muros	-		
Noya	-		
Ortigueira	1966	Estrecha	
Padrón	1873	CFC	
Puebla del Deán	-		
Puente-ceso	-		
Puentedeume	1913	State	
Riveira	-		
Santa Eugenia-Riveiro	-		
Blanes	-		
Cadaqués	-		
La Escala	-		
Lloret de Mar	-		
Palafrugell	1887	Estrecha	
Palamós	1887	Estrecha	
Rosas	-		
San Feliu de Guixols	1892	Estrecha	
Selva de Mar	-		
Tossa	-		
Albuñol	-		
Almuñecar	-		
Motril-Calahonda	-		
Salobreña	-		
Deva	1893	Estrecha	

(Continued on next page)

Port	Year of connection	Company	Notes
Fuenterrabía	1913	Estrecha	
Pasajes	1864	NOR	
San Sebastián	1864	NOR	
Zumaya	1901	NOR	
Ayamonte	1935	Estado	
Huelva	1880	MZA	Connection via a narrow-gauge line in 1868
Isla Cristina	1935	Estado	
Lepe	1935	Estado	
Moguer	1875	Estrecha	
Sanlúcar de Guadiana	-		
Puebla de San Ciprián	1968	Estrecha	
Rivadeo	1968	Estrecha	
Santiago de Foz	1968	Estrecha	
Vivero	1968	Estrecha	
Estepona	-		
Fuengirola	1916	Estrecha	
Málaga	1863	FCM	
Marbella	-		
Nerja	-		
Torre del Mar	1908	Estrecha	
Torrox	-		
Vélez-Málaga	-		
Águilas	1890	LBA	
Cartagena	1863	MZA	
Mazarrón	1886	Estrecha	
Portman	1874	Estrecha	Not connected to the rest of the network
San Pedro del Pinatar	-		
Avilés	1894	NOR	
Castropol	1968	Estrecha	
Colombres	1905	Estrecha	
Cudillero	1962	Estrecha	
Gijón	1874	FNE	
Lastres	-		
Llanes	1905	Estrecha	

(Continued on next page)

Port	Year of connection	Company	Notes
Luanco	1910	Estrecha	
Luarca	1972	Estrecha	No branch line to the port
Pravia	1972	Estrecha	
Rivadesella	1905	Estrecha	
San Esteban	1904	Estrecha	
Tapia	1972	Estrecha	
Vega de Ribadeu	1968	Estrecha	
Villaviciosa	-		
Bayona	1926	Estrecha	
Camposancos	-		
Carril	1873	CFC	
La Guardia	-		
Marín	1884	MZV	
Pontevedra	1884	MZV	
Puente Cesures-Padrón	1873	CFC	
Ramallosa	1926	Estrecha	
Vigo	1898	MZV	
Villagarcía	1873	CFC	
Castrourdiales	1899	Estrecha	
Requejada	1895	Estrecha	
San Vicente de la Barquera	1905	Estrecha	
Santander	1858	YII	
Santoña	1896	Estrecha	
Sevilla	1860	SJP	
Suances	-		
Cambrils	1865	AVT	
Salou	1865	AVT	
San Carlos de la Rapita	1865	AVT	
Tarragona	1865	AVT	Connection via the Canal del Ebro
Torredembarra	1865	AVT	
Tortosa	1868	AVT	
Vendrell	1865	TMB	
Cullera	1878	Estrecha	
Gandía	1864	Estrecha	

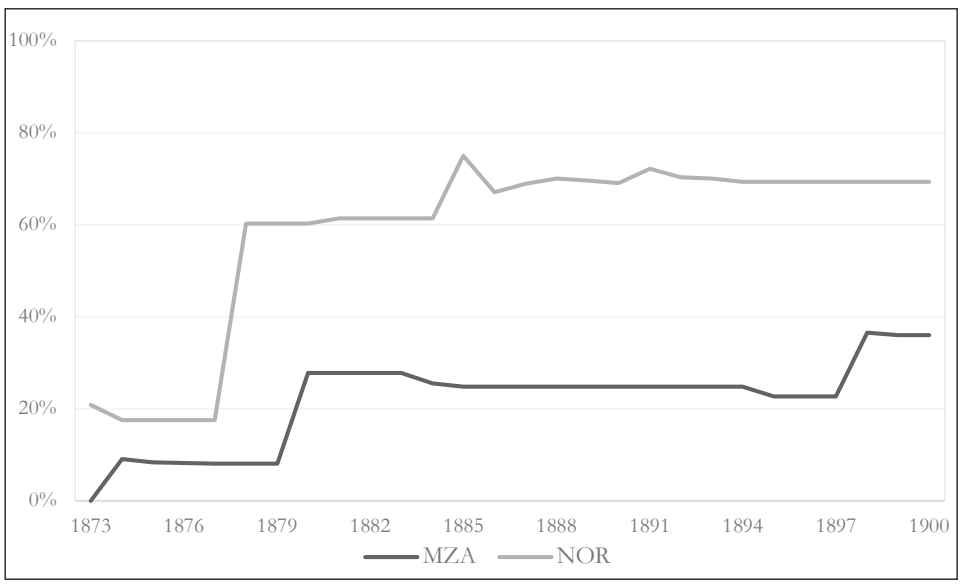
(Continued on next page)

Port	Year of connection	Company	Notes
Valencia	1852	AVT	
Murviedro	1862	AVT	
Sagunto	1862	AVT	
Bermeo	1955	Estrecha	
Bilbao	1863	FTB	
Lequeito	-		
Plencia	1893	Estrecha	
Poveña	1926	FBP	
Santurce	1926	FBP	

Sources: Port inventory: Estadísticas del comercio exterior de España y Estadísticas del Comercio de Cabotaje de España (1850-1930). Location of ports: National topographic map 1:50.000. Location of tracks: Morillas-Torné (2012).

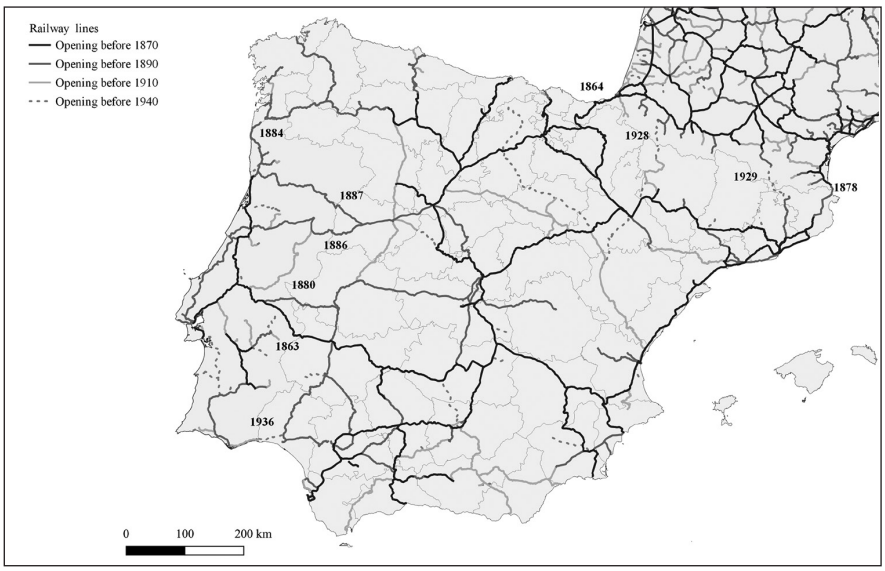
Notes: We considered that a port was connected to the network if its tracks went as far as the port infrastructure.

FIGURE A.2 ▪ *Percentage of the km of lines belonging to MZA and Norte which came from the acquisition of other companies (1873-1900)*



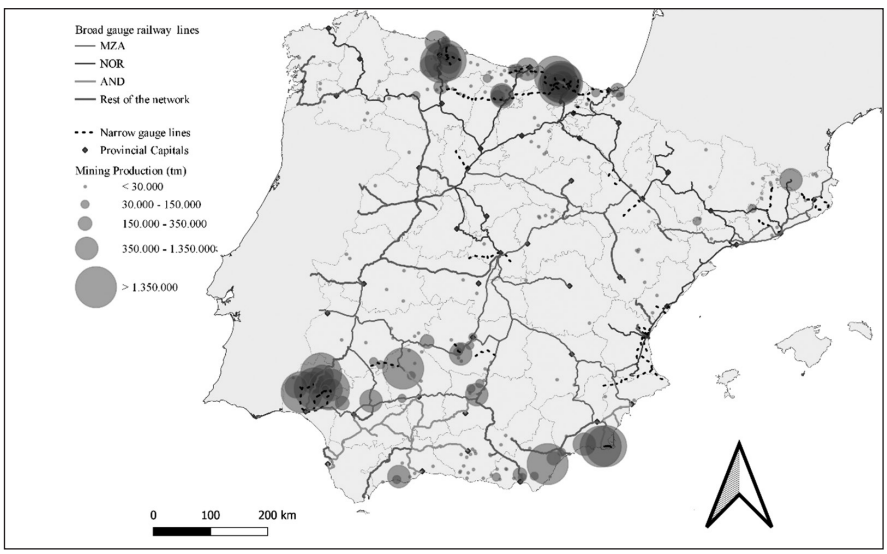
Sources: See Figure A.1.

MAP A.1 ▪ *The development of railways in Spain, Portugal and south of France, and the opening year of borders crossings prior to 1941*



Sources: García-Raya (2006) and own research.

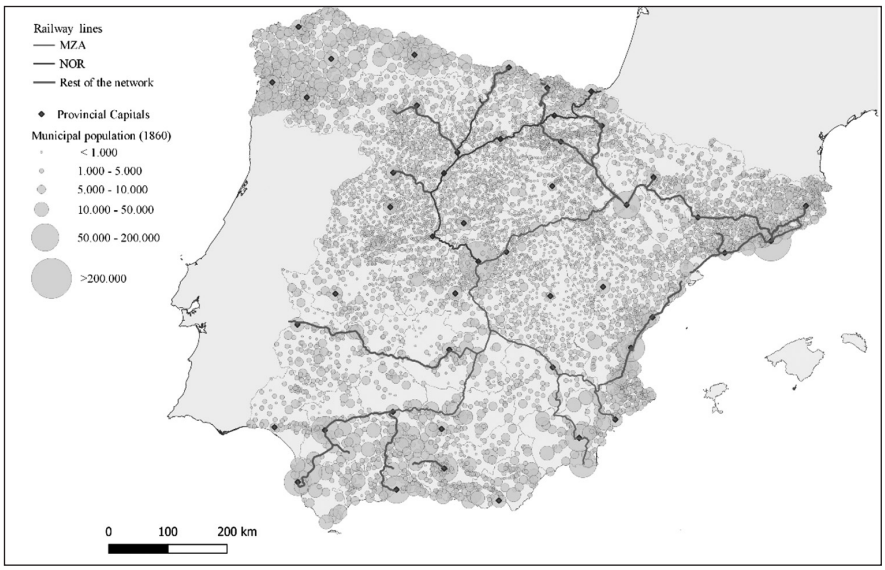
MAP A.2 ▪ *Mining Production (1890) and broad and narrow-gauge track (1900)*



Sources: Mining production, Palacios-Mateo (2021); Railway lines, Morillas-Torne (2012).

Notes: The grey dots represent the total mining production obtained within the borders of a given municipality in 1890.

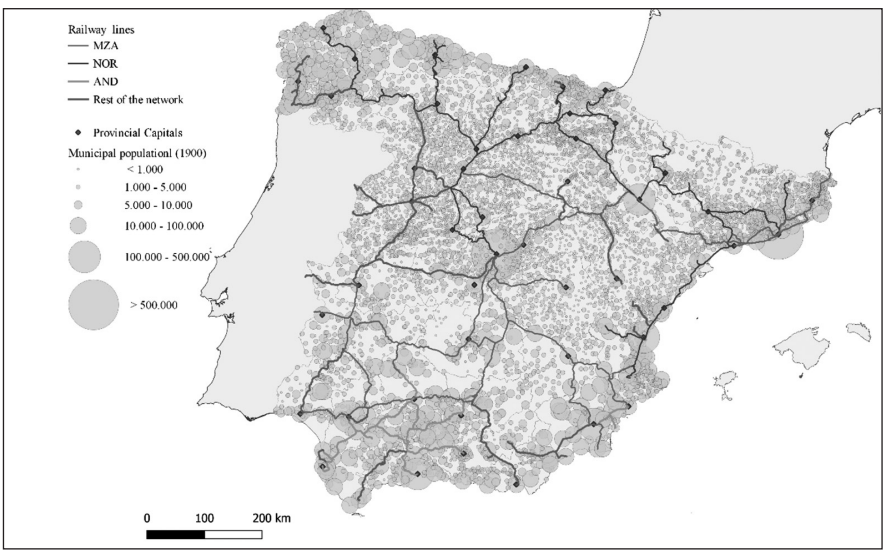
MAP A.3 ▪ *Municipal population of Spain (1860) and railway lines (1866)*



Sources: Population, Beltrán et al. (2019); Railway lines; see Map A.1.

Notes: The points locate in the municipal centres and their sizes represents their population.

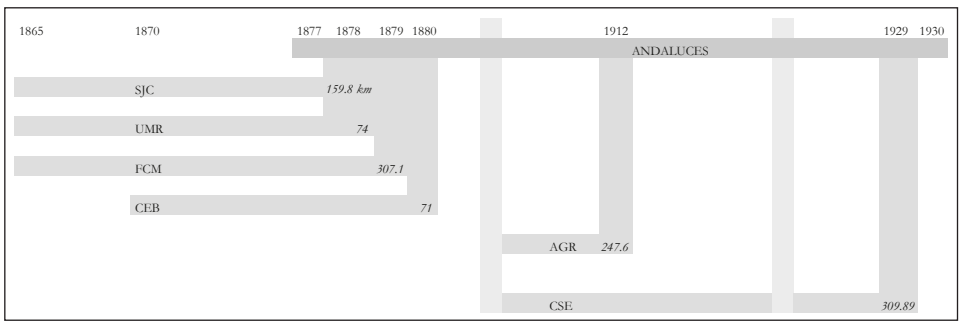
MAP A.4 ▪ *Municipal population of Spain (1900) and railway lines (1900)*



Sources and notes: See Map A.2.

Annex B

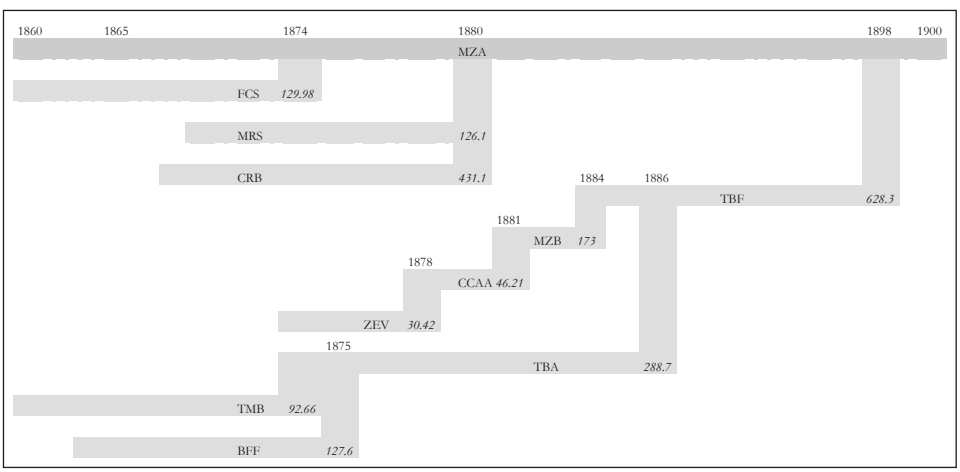
FIGURE B.1 ▪ *Chronology of fusions and take overs by the Compañía de los Ferrocarriles Andaluces (1877–1930)*



Sources: Chronology of the Fusions and Take Overs of Railway Companies in Spain, Cuellar (unpublished); km of track, García-Raya (2006) and Morillas-Torné (2012).

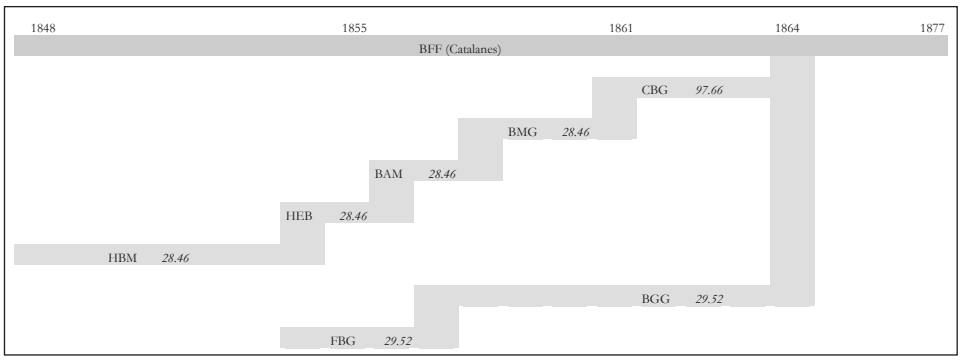
Notes: the numbers (in italics) next to the acronyms of the companies indicate the number of km of track that were in service at the time that they were taken over. The numbers that appear above the chronology of the companies refer to years. The grey columns indicate a jump in time in the graph scale.

FIGURE B.2 ▪ *Chronology of fusions and take overs by MZA (1860–1900)*



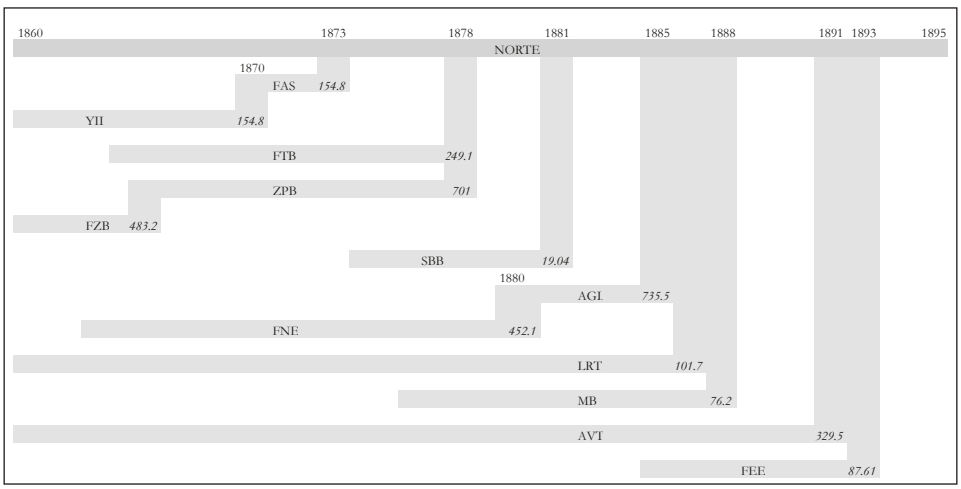
Sources and notes: See Figure B.1. We did not consider the Aranjuez-Cuenca to have been absorbed on account of the fact that it was directly sold to MZA by the constructor (EAC), barely a month after it was completed. For more details about this, see p. 66, Tedde (1978).

FIGURE B.3 ▪ *Chronology of fusions and take overs in the Catalan railway network, Compañía Barcelona-Francia (1848–1877)*



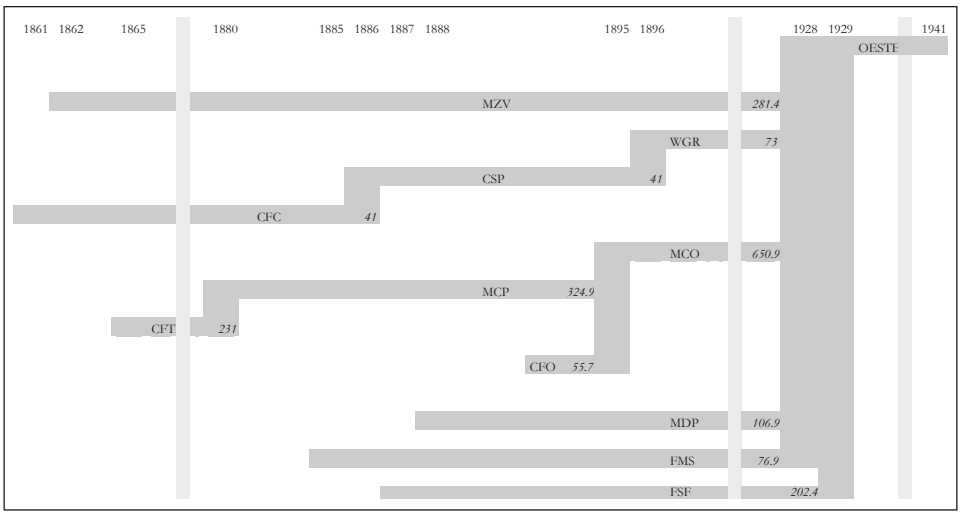
Sources and notes: See Figure B.1.

FIGURE B.4 ▪ *Chronology of fusions and take overs by Norte (1860–1895)*



Sources and notes: See Figure B.1.

FIGURA B.5 ▪ Chronology of fusions and take overs in the railway network of the Compañía del Oeste de España (1861≠1941)



Sources and notes: See Figure B.1.

Annex C

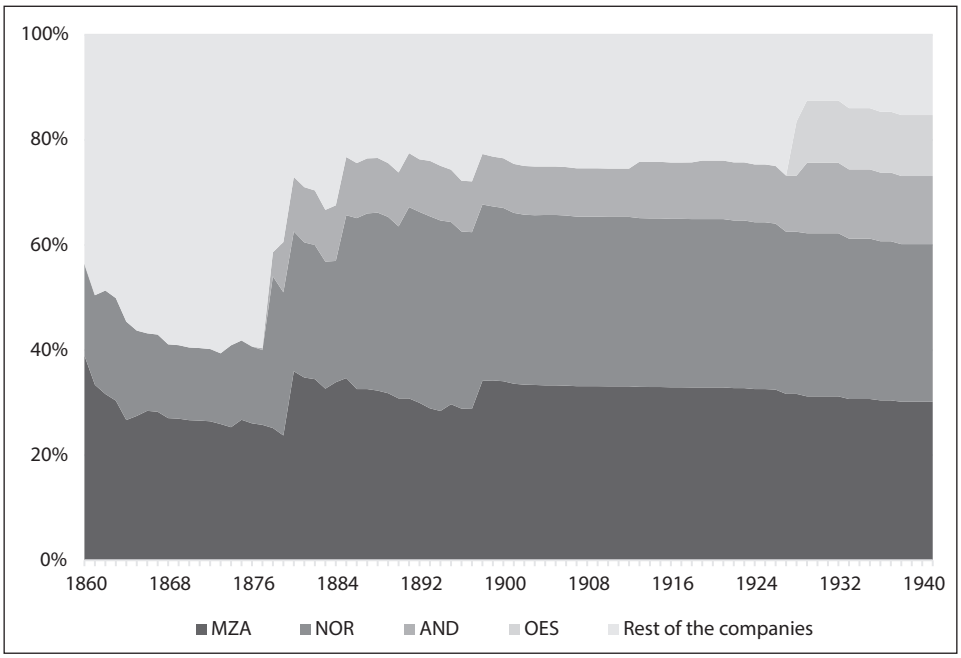
The chronology described here is also reflected in the evolution of the companies' shares of the network (Figure C.3) and that of the concentration of line ownership (Figure 3).[50] The results from the two Figures highlight various key periods. The first was from 1848 to 1877, when various companies other than MZA, Norte and Andaluces controlled the majority of the lines, holding around 50-60% of the total network. This situation is shown by a relatively low index (Figure 4). It seems that, although the financial crisis of 1866 affected their results, the increase in the concentration of line ownership was particularly notable from 1877 onwards. Thus, from this date and until 1900, the creation of Andaluces and a more asggressive policy of acquisitions by MZA, and especially by Norte, progressively led towards a situation of oligopoly. The decade between 1877 and 1887 was key with respect to this last point. This was when Andaluces was founded (1877), which included the majority of the companies that were operating in the south-west of country (SJC, UMR, FCM and CEB). Similarly, there was a multitude of operator takeovers, such as those of CBA and MRS, by MZA, and of ZBP, FTB, SBB, AGL and LRT by Norte (Annex B). On the other hand, after 1887 the market was more stable, and although AVT was absorbed by Norte (1891) and TBF by MZA (1898), there was a tendency for the situation to become more consolidated and stable, with the development of the networks of other companies (MCP, MZV) helping to reduce the coefficient. This was a situation that continued from the beginning of the twentieth century and until 1927, when the company Oeste was founded, which involved the grouping together of a large number of smaller companies and resulted in a slight increase in the concentration of the the lines.

We have noted how an oligopoloy was gradually created based on the networks of MZA, Norte, Andaluces and, subsequently, Oeste. This tendency particularly accelerated during the decade 1877–1887, became established from the beginning of the twentieth century and resulted in total integration with the creation of the RENFE network. These data also allow us to reinforce and quantify what had previously been noted by Tedde (1978), who underlined that the increases in the concentration of the share of railway ownership were particularly intense from 1876 onwards, when the expectations of profits amongst the smaller companies were not met and their financial bur-

50. Using the chronology of the market shares, we produced the first annual index of the concentration of railway line ownership in Spain (Herfindahl Index). This enabled us to see how the quotas were reflected in the concentration of line ownership. It must be emphasised that we are not referring here to market share; to reflect that, it would be necessary to consider a multitude of variables other than the coverage of the network and its stock of stations, etc. (such as the total volume of traffic and its profitability).

dens became unbearable. All of this resulted in their share values trading at minimum levels, which encouraged the largest companies to buy them.

FIGURE C.3 ▪ *Evolution of the share of the network (in km) of each company (1848-1941)*



Sources: Own research, based on Cuellar (2020) and Morillas-Torné (2012).

Notes: The result is expressed as a percentage.

■

The expansion of the Spanish railway network (1848–1941): an analysis through the evolution of its companies

Abstract

In this article, we analyse the expansion of the Spanish railway network from the perspective of the evolution of all the railway companies that operated in the period 1848–1941. To do this, we have created a new database that includes the sections of track, lines and stations, classified by company and year. We have also used GIS to link this expansion process with regional features. Our results point to the network having mainly expanded in response to criteria related to economic profit and the business objectives of the railway companies.

Keywords: railways, business strategies

JEL codes: N7, N9

■

La expansión de la red española de ferrocarriles (1848-1941): un análisis a través de la evolución de las compañías

Resumen

En este artículo analizamos la expansión de la red de ferrocarril en España a partir de la evolución de las compañías del sector durante el período 1848-1941. Para ello hemos elaborado una nueva base de datos que incluye los tramos, líneas y estaciones y apeaderos que operó cada compañía en cada uno de los años del período. Además, utilizamos GIS para vincular este proceso de expansión con el territorio y sus características. Nuestros resultados señalan que la red mayoritariamente se desarrolló siguiendo criterios económicos y de estrategias de rentabilidad empresarial de las compañías.

Palabras clave: ferrocarriles, estrategias empresariales

Códigos JEL: N7, N9

■

L'expansió de la xarxa espanyola de ferrocarrils (1848-1941): una anàlisi a través de l'evolució de les companyies

Resum

En aquest article analitzem l'expansió de la xarxa de ferrocarril a Espanya des de la perspectiva de l'evolució de les companyies del sector durant el període 1848-1941. Amb aquest objectiu hem elaborat una nova base de dades que inclou els trams, les línies, les estacions i els baixadors de ferrocarril en els quals va operar cada companyia en cadascun dels anys d'aquest període. A més, utilitzem GIS per vincular aquest procés d'expansió amb el territori i les seves característiques. Els nostres resultats assenyalen que la xarxa es va desenvolupar majoritàriament seguint el criteris econòmics i de rendibilitat empresarial de les companyies.

Paraules clau: ferrocarrils, estratègies empresarials

Codis JEL: N7, N9