

# THE DETERMINANTS OF INDUSTRIAL LOCATION IN SPAIN, 1856-1929.

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**Abstract.** During the 19<sup>th</sup> century, the Spanish economy went through the first stages of the industrialization process. This process developed in parallel to the growing market integration of goods and factors as a result of the liberal reforms in the 19<sup>th</sup> century and the construction of the railway network, with the subsequent fall in transport costs. In that period, there were major changes in the pattern of industrial location across Spain, with an increasing concentration in space of the industrial activities between 1860 and 1930 and a deeper regional specialization. Which were the forces behind these changes? On the theoretical side, the Heckscher-Ohlin model suggests that the distribution of economic activity in space is determined by comparative advantage according to factor endowments. In turn, NEG models show the existence of a bell-shaped relationship between the process of market integration and the degree of concentration of industrial activity in the territory. This paper examines empirically the determinants of industrial location in Spain estimating the model proposed by Midelfart-Knarvik *et al.* (2000, 2002). This model nests both Heckscher-Ohlin and NEG factors allowing for testing the relative strength of these arguments, since they are not mutually exclusive and might be at work simultaneously. The analysis of the different interactions for the Spanish case shows that both, comparative advantage and NEG forces were determinant factors of industrial location in Spain.

## 1. Introduction

Economic activity is unevenly distributed across space both at international level and within countries. In Europe, many countries have experienced in the last decades strong economic growth leading to a process of convergence in the level of income per capita across states. However, spatial inequalities within countries are still remarkable (Puga, 2002). When did these disparities begin? What has been their long-term evolution until the present regional distribution of output has been conformed? According to Combes *et al.* (2008a), such spatial inequalities are the result of a long-term evolution that can be traced back to the Industrial Revolution. This view of the process illustrates two noteworthy elements. On the one hand, the interest of long-term historical studies in order to analyze the main trends and dynamics of inequality since changes in the spatial distribution of human activity are fairly slow. On the other hand, this view stresses the relevance of the industrialization process in shaping regional disparities. It is in the manufacturing sector that monopolistic competition and economies of scale, key elements in the so-called 'New Economic Geography' tend to operate.

The aim of this paper is to study the patterns in industrial location and its determinants in Spain throughout the first stages of industrialization (1860-1930). From a spatial point of view, one of the major changes during the process of industrialization was the fall in transport costs. In the Spanish case, the construction of the railway network and technological improvements in sea transport triggered an important reduction in transport costs favouring the integration of the domestic market. Likewise, this increasing market integration was also encouraged by the liberal reforms implemented by successive Spanish governments in the 19<sup>th</sup> century in parallel to the process of industrialization.

Paluzie *et al.* (2004) and Tirado *et al.* (2006) have analyzed the evolution of the long run trends in the geographical concentration of manufacturing across Spanish regions and the patterns of regional specialization. The evidence found by these authors shows that the integration of the Spanish market generated profound changes in the location of manufacturing activities in Spain throughout the second half of the 19<sup>th</sup> century and the first decades of the 20<sup>th</sup> century. In that period, the spatial concentration of manufacturing experienced a remarkable increase and regional specialization augmented as well, at least in the second half of the 19<sup>th</sup> century. Then, with such

evidence available, the next question to answer is: what were the forces that determined the location of different industries across regions?

On the theoretical side, the classical trade theory represented by the Heckscher-Ohlin model suggests that the distribution of economic activity in space is determined by comparative advantage according to factor endowments. In this model, there are two production factors (capital and labour). Assuming absence of transport costs, commodities being produced under constant returns to scale and considering markets operating under perfect competition, the theorem predicts that the distribution of economic activity is determined by the availability of factor endowments in a location relative to the endowments available at alternative locations. Therefore, a capital-abundant location will specialize in the production of capital-intensive goods whereas a labour-abundant location will produce labour-intensive goods. However, disparities in natural resources or factor endowments, especially within a country, may not be enough to explain the high degree of the existing concentration of economic activity. New Economic Geography models suggest that the interaction between transport costs, increasing returns to scale and the size of market under a monopolistic competition framework can lead to the spatial agglomeration of economic activity. In this context, the distribution of economic activity in space is shaped by the existence of two types of forces operating in different directions: *agglomeration* or *centripetal forces*, and *dispersion* or *centrifugal forces*.

As shown by Krugman (1991), the concentration of economic activity is a result of the interaction of two centripetal forces. First, in order to save in transport costs, firms tend to agglomerate near the locations with better access to markets where a large number of customers and suppliers are located. As a result, this increase in the market size generates a more than proportional increase in the share of firms in that location<sup>1</sup>, pushing upward nominal wages. The increase in the number of firms allows for a greater variety of local goods and consumption can benefit from lower transport costs. Consequently, the lower local price index and the resulting increase in real wages attract new workers to the urban centres<sup>2</sup>. Hence, access to markets, or market potential, has a positive influence in the decisions of location by firms and workers, inducing factor mobility (capital and labour, respectively). The interaction of these forces leads to a cumulative process, where agglomeration is reinforced once it has started.

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<sup>1</sup> This property is known as the '*home-market effect*'. Helpman and Krugman (1985).

<sup>2</sup> An alternative process for agglomeration in Krugman and Venables (1995).

However, studies like Puga (1999) show that the relationship between the process of regional integration and the degree of concentration in the economic activity can describe a non-monotonic evolution. When transport costs are high, industry is dispersed across space. When transport costs fall to an ‘intermediate’ level, *centripetal forces* intensify agglomeration when workers are mobile. For low transport costs, a new tendency towards dispersion can emerge. Congestion costs, wage differentials, fragmentation of firms, or non-economic motivations affecting the decision to migrate (amenities), act as *centrifugal forces* favouring the dispersion of economic activity. Therefore, NEG models show the existence of a bell shaped relationship between the process of market integration and the degree of concentration of industrial activity in the territory.

Some studies have analyzed the long run trends in the concentration of manufacturing activities in space and regional specialization. In the case of the United States, Kim (1995) showed that the geographical concentration of manufacturing increased between 1860 and 1927. From that moment onwards, the trend was reversed and a new pattern of continuous reduction in the geographical concentration until 1987 made manufacturing more spatially dispersed across the United States<sup>3</sup>. At the same time, regional specialization increased from 1860 to WWI (in spite of the decrease in 1880 and 1890), flattened out in the interwar years and then decreased since the end of WWII until 1987<sup>4</sup>. Therefore, from 1860 to 1930, a period when regional economies in the United States were becoming an integrated national economy, industry became more localized as regions became more specialized.

In a recent working paper, Combes *et al.* (2008b) tested empirically the theoretical prediction in NEG models of a non-monotonic evolution in the spatial distribution of economic activities in the long run. As in the case of the United States, evidence confirmed the existence of a bell-shaped evolution in the geographical concentration of manufacturing. The analysis, focused on the French *Départements*, showed that spatial concentration increased considerably from 1860 to 1930 both for manufacturing employment and manufacturing Gross Value Added, and then decreased in 2000, being the level of dispersion in this last year higher than in 1860.

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<sup>3</sup> Hoover’s coefficient of localization for U.S. states had a value of 0.273 in 1860, reached a peak of 0.316 in 1927 and then decreased to 0.197 in 1987. Thus, in this last year, the level of geographical concentration of manufacturing was lower than in 1860.

<sup>4</sup> Again, the evolution of the Krugman specialization index shows that U.S. states were less specialized in 1987 (0.43) than they were in 1860 (0.69).

As regards Spain, evidence on a bell shaped curve was also found in the period between 1856 and 1995 Paluzie *et al.* (2004). In this case, a remarkable increase in geographical concentration of economic activity occurred from mid-19<sup>th</sup> century. Different empirical studies have tried to explain the determinants of industrial location during the second half of the 19<sup>th</sup> century. Rosés (2003) argued that the industrialization of the Spanish regions in mid-19<sup>th</sup> century was the result of a combination of comparative advantage and increasing returns. Following Davis and Weinstein (1999, 2003), this author tested the existence of a ‘home market effect’ concluding that new modern manufacturing industries characterized by increasing returns to scale tended to be concentrated in regions in which the home-market effects were larger. Therefore, regions such as Catalonia where new industries showing increasing returns were established reinforced its initial comparative advantage in terms of human capital endowments.

In turn, Tirado *et al.* (2002) tried to explain the increase in the geographical concentration in manufacturing during the second half of the 19<sup>th</sup> century. To this aim, these authors compared two points in time: 1856 and 1893. They found that in 1856 human capital endowment was not significant in explaining the relative industrial intensity of Spanish provinces. Conversely, in 1893 this variable became significant, possibly capturing the importance of technological skills. NEG effects were also relevant. First, the provinces specialized in sectors where economies of scale were important showed a relatively higher industrial intensity. Moreover, the impact of economies of scale increased as the Spanish market became more integrated. Finally, market size was a relevant factor for regional specialization in 1856 but at the end of the century access to markets turned out to be more important.

The aim of this paper is to examine empirically the determinants of industrial location in Spain from 1860 to 1930 estimating an empirical specification derived structurally from a NEG model. The standard model developed by Midelfart-Knarvik *et al.* (2000, 2002) nests both Heckscher-Ohlin and NEG factors allowing for testing the relative strength of these arguments, since they are not mutually exclusive and might be at work simultaneously. This strategy allows us to identify the forces driving industrial location and to assess whether these forces changed during the period under study as market integration progressed.

Some studies have carried out a similar exercise for different European countries and historical periods. Wolf (2007) made use of this model in order to explain the relocation of industry in interwar Poland after the reunification in 1918. He found that both, Heckscher-Ohlin factor endowments and NEG mechanisms were economically relevant. Particularly, the most important factor for industrial location was skilled labour endowment, with the availability of innovative activities proxied by patent announcements being also significant. As regards NEG forces, there was evidence of a forward linkage. Likewise, Crafts and Mulatu (2005, 2006) also explored the determinants of industrial location in Britain estimating an equation based on Midelfart-Knarvik *et al.* (2002). Again, Heckscher-Ohlin and NEG arguments played a relevant role in explaining the location of industry within Britain in the last decades of the 19<sup>th</sup> century and the beginning of the 20<sup>th</sup> century. The results confirmed the significance of factor endowment variables, and the influence of market potential and economies of scale on location decisions in a period of intense fall in transport costs, although this interaction weakened throughout time and in 1931 was no longer significant.

Within this framework, the aim of this paper is to analyze the determinants of industrial location in Spain from mid-19<sup>th</sup> century until the outbreak of the Spanish Civil War (1936-1939). The exercise considers 43 Spanish provinces<sup>5</sup> (NUTSIII according to the Eurostat territorial division) in four benchmark years: 1856, 1893, 1913 and 1929. The paper is organized as follows. In the next section, some historical background on the integration of the Spanish market is reviewed. Furthermore, the effects of market integration on the concentration of industry, regional specialization and market potential are examined. In section 3, the empirical strategy, the database employed and the estimation results are presented. The main results are discussed in section 4. Finally, section 5 concludes.

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<sup>5</sup> Limitation in the availability of statistical information is responsible for the exclusion of the three Basque's provinces, Navarre, the Balearic Islands and the two provinces within the Canary Islands (see data description in section 3 for details).

## **2. Market integration and industrial location: Background and evidence.**

During the second half of the 19<sup>th</sup> century the Spanish market became increasingly integrated. The construction of the railway network and its progressive expansion played a key role in the integration of the different regional economies. Traditionally, transports in Spain had to face serious difficulties derived from the geography of the country. Compared to its European neighbours Spain is a mountainous country with an average altitude above sea level around 660 m., ranking third in Europe after Switzerland (1.300 m.) and Austria (910 m.), and more than doubling the European average (297 m.)<sup>6</sup>. Apart from the ruggedness of the land, the rivers are characterized by its poor and irregular flow and inland navigation has traditionally been very limited. Therefore, prior to the construction of the railway, there were important obstacles to the development of a modern transport system which did not favour the integration of the Spanish market. The road network was narrow, badly designed and in a poor state of conservation, and inland navigation, the cheapest mean of transport before the railway era, was almost non-existent. The limits imposed by geography to these transport means were, however, partially counterbalanced by the availability of coastal navigation. Located in the Iberian Peninsula, the total length of the Spanish coastline is around 8.000 km.

In this context, the expansion of the railway network brought about important changes that favoured the process of market integration. The Railway Acts of 1848 and 1855 established the legal framework for the construction of railways and its radial structure around Madrid. The first line was finished in 1848 and within the next decades the basic network was completed. The expansion of the railway network is shown in Figure 1 in the Appendix. The first wave in the construction of the railway, going from 1855 to 1873, connected the main economic centres in Spain. At a second stage, between 1873 and 1896, the network arrived to the rest of the territories (Herranz, 2005). Therefore, in the second half of the 19<sup>th</sup> century the basic network had been finished becoming a crucial element for the integration of the Spanish economy.

The major effect of the new infrastructures was the decrease in transport costs. Actually, one of the main features in the world economy during the First Globalization period was the fall in transport costs (Williamson and O'Rourke, 1999). As regards the Spanish economy, according to the calculations of Herranz (2005), the ratio between the

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<sup>6</sup> Small states like Andorra (1.995 m.) and Liechtenstein (1.100 m.) are also among the most mountainous countries.

unit price of railway transport for commodities and the alternative mean of transport was in 1878 around 0.14% meaning that there was a reduction up to an 86% in transport prices as a result of the introduction of railways. Coastal shipping was also seriously affected in this period by technological innovations and improvements in the port infrastructures leading to a sharp reduction in freights<sup>7</sup>. Table 1 shows the reduction of costs in railway and coastal shipping transport. In both cases, there was an important decrease in the price of transport being more intense in sea transport<sup>8</sup>.

**Table 1. Real transport costs, 1867-1930.**

	<b>Railways</b>	<b>Coastal shipping</b>	<b>Railways</b>	<b>Coastal shipping</b>
	<b>pts/Tm/1000kms</b>	<b>pts/Tm/1000kms</b>	<b>1867=100</b>	<b>1867=100</b>
<b>1867</b>	107,02	15,32	100	100
<b>1900</b>	85,12	8,28	79,54	54,03
<b>1914</b>	79,80	7,69	74,57	50,22
<b>1930</b>	62,14	3,96	58,07	25,84

*Source: Martínez-Galarraga (2008).*

As a result, falling transport costs led to a higher integration of the domestic market for goods. In parallel to this process, capital and labour markets also were becoming more and more integrated. In the capital market, the reduction in transaction costs was linked to a number of institutional changes in the money and banking sectors. The monetary system was unified around the peseta in 1869. A few years later, in 1874, the Bank of Spain became the only issuing bank (Tortella, 1994). In 1855, a network of branches was established in all provincial capitals and a new transfer system between these branches was launched by the central bank allowing for capital movements along cities and a further integration of the financial market (Castañeda and Tafunell, 1993). As regards the integration of the labour market, Rosés and Sánchez-Alonso (2004) have found a convergence in regional real wages from 1860 to 1930 with the only exception of the WWI years.

<sup>7</sup> “The introduction of iron in the construction of ships and the substitution of steam for sailing ships helped to decrease waterborne freight rates [...] At the same time, improvements in harbours such as the Ría de Bilbao, Gijón and Barcelona enabled ships of higher tonnage to dock, which decreased further the fixed shipping costs”, Gómez Mendoza (1981), p. 57. See also Herranz (2004), pp. 61-62.

<sup>8</sup> In 1870, the volume of coastal trade represented 20,73% of the volume in railways and it accounted for a 15,69% in 1920 (Frax, 1981). Besides, motorized road transport was in an infant stage at this time in Spain. Indeed, the process of substitution of railways by trucks started in the 1930s. Herranz (2005).

How did the location of industry respond to the falling transport costs and the subsequent integration of the domestic market? Did industry become more geographically concentrated? Did the productive structure of Spanish regions converge? Did market potential change during this period of market integration? Several studies have focused on these questions.

Paluzie *et al.* (2004) analyzed the long-term effects of the market integration on the spatial distribution of industry across Spain. Measured through the Gini and Hirschman-Herfindhal indexes, the geographical concentration of industrial production increased from 1856 to 1929 in parallel to the deeper market integration for goods. Then, between 1955 and 1975, during the Francoist regime, an absence of significant changes is observed. From the 1980s onwards, industrial production tended to be more spatially dispersed in a framework characterized by industrial restructuring and the beginning of the process of European integration. As a result, a bell-shaped relationship between market integration and geographical concentration of industry appeared in the long run. Particularly, it was in the first stages of the industrialization process, in parallel to market integration that industrial production was increasingly concentrating in a limited number of provinces.

This fact leads us to analyze in which provinces manufacturing production concentrated. Tirado *et al.* (2006) have computed industrial intensity indices<sup>9</sup> showing that the number of provinces with an index above one, that is, provinces with industrial specialization, decreased from 1856 (14 provinces) to 1893 (9 provinces), and also from 1913 (8 provinces) to 1929 (7 provinces). In the mid-19<sup>th</sup> century traditional industry showed a high degree of dispersion in space. However, the integration of the Spanish market and the take-off of the industrialization process led to radical changes in the localization and spatial concentration of industry. During the second half of the 19<sup>th</sup> century an industrial axis in East and North-East Mediterranean provinces emerged. In the first third of the 20<sup>th</sup> century, the Mediterranean axis weakened and new locations like Saragossa appeared as industrial centres together with Catalonia, the Basque Country, Madrid and Valencia (see Figure 2 in the Appendix)<sup>10</sup>.

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<sup>9</sup> This index is calculated as the ratio (share of industrial output / share of population).

<sup>10</sup> In 1929, the 7 provinces with an industrial intensity index above one were Barcelona, Madrid, Biscay, Guipúzcoa, Valencia, Saragossa and Santander.

When individual industries are studied, evidence provided by Paluzie *et al.* (2004) shows that most of the sectors shared an increase in the geographical concentration between 1856 and 1929. The only exceptions were wood/furniture along the whole period and paper between 1856 and 1893. At the beginning of the period, the industrial sector showing a higher degree of concentration was textiles, the leading sector in the Spanish industrialization. At the end of the period, metallurgy and chemicals, two of the sectors linked to the Second Industrial Revolution, were approaching to textiles. Moreover, in these sectors, the Gini index was very close to one signalling an almost complete concentration of the activities. This is mainly the case of the textiles, which increasingly agglomerated around Barcelona. Conversely, the most dispersed industrial sector during the whole period was foodstuffs.

On the other hand, Tirado *et al.* (2006) studied the effects of the Spanish market integration on regional specialization between 1856 and 1929. They calculated a bunch of indicators in order to describe the main patterns of regional specialization for Spanish provinces, in four benchmark years (1856, 1893, 1913 and 1929) considering seven industrial sectors: foodstuffs, textile/leather, metallurgy, chemicals, paper, glass/ceramics, and wood/furniture. According to the weighted Krugman specialization index, regional specialization increased between 1856 and 1893. However, in the interwar years this trend changed and no further differences in the productive structure among regions were observed. The same conclusion had been reached in Betrán (1999)<sup>11</sup>. Therefore, the integration of the Spanish market came along with a higher degree in the geographical concentration of industrial activities, and also an increase in regional specialization although for the latter there seems to be no further deepening in the interwar years.

Another aspect to be taken into consideration is the impact of market integration in changing the relative accessibility of regions. Did the reduction in transport costs change the market potential of Spanish provinces? Following the work by Crafts (2005b) a new database for the provincial market potential in Spain between 1867 and 1930 has been constructed (Martínez-Galarraga, 2008)<sup>12</sup>. Changes in market potential can be caused by a shift in the spatial distribution of GDP, in relative transport costs, or

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<sup>11</sup> This trend is different from the one observed in the British case. Crafts and Mulatu (2006), showed that regional specialization changed little from 1841, with an index of 0.63, to 1871 (0.66) and 1911 (0.61). Therefore, the Spanish pattern in regional specialization in this period is quite similar to the one obtained by Kim (1995) in his the long term study of the US manufacturing.

<sup>12</sup> The methodology is detailed in section 3.

both. In that respect, 1867 is a crucial year in the calculations. At that moment, when the first wave in the construction of the railway network had almost finished, 32 out of the 47 continental provinces in Spain had been connected.

Moreover, during the second half of the 19<sup>th</sup> century, as shown previously in Table 1, the decrease in sea transport costs was higher than the experienced in the rail freight. As a result, provinces with good access to the sea increased their relative market potential when compared to inland provinces. Nevertheless, some provinces, most of them from the interior of Spain, showed a remarkable increase in their market potential. These provinces were not connected to the railway network in 1867. Thus, the reason for their relative increase was the arrival of the railway favouring a substantial relative increase in the market potential of these provinces.

Overall, important changes in the spatial distribution of market potential can be observed during the second half of the 19<sup>th</sup> century (Figure 3 in the Appendix). In 1867, the geographical structure of the market potential was characterized by a more stratified distribution across space with three different groups of provinces: coastal provinces, inland provinces with connection to the railway network, and inland provinces with no access to the railway network. In 1900, the picture had changed remarkably, shifting to a more polarized situation. A first group included coastal provinces with a higher relative market potential (including also Madrid) and a second group of inland provinces with a lower relative market potential. Once established, this structure showed a persistent pattern in the first three decades of the 20<sup>th</sup> century. The basic railway network had been finished by the year 1896 and from that moment the expansion of the railway lines was very limited. Thus, the major changes in the market potential of Spanish provinces occurred during the second half of the 19<sup>th</sup> century when the Spanish market was integrating, the basic railway network was constructed, and transport costs were falling more intensely.

From a theoretical point of view, market integration can affect the location of industry in different ways as a result of a reallocation of production factors, a shift in the comparative advantage of the provinces, changes in the accessibility of regions, or a reinforcement of the process of regional specialization inducing a process of structural change. These aspects are treated in the empirical strategy developed in the following section.

### 3. Empirical strategy.

In the previous section, the main trends in industrial concentration, market accessibility and regional specialization in Spain between mid-19th century and 1930 have been broadly described. However, the location of industry and regional specialization are the result of the interaction of regional endowments and industry characteristics. Regions, or provinces as in the Spanish case, differ in factor endowments. Hence, some provinces are relatively abundant in land; others are relatively abundant in labour. In addition, the geographical position may give some locations an advantage in terms of access to markets. As mentioned above, Spanish's coastal provinces are characterized by a higher market potential. On the other hand, industries show different features as well. For example, some industries are more prone to develop plants of a larger size (metallurgy, paper, chemicals). In such a case, firms can exploit economies of scale and increasing returns. Industries can also differ in their intensity in the use of factors (agricultural inputs in foodstuffs and labour in wood/furniture), the share of intermediate inputs (foodstuffs and textiles), or the proportion of sales to other industrial producers (glass/ceramics).

In our case, the analysis of the determinants of industrial location in Spain between 1856 and 1929 is based on the province and industries characteristics displayed in Table 2. The first two variables in the column including regional characteristics capture relative endowments according to the Heckscher-Ohlin model. The variable agricultural production as a percentage of GDP is taken as a measure of 'agriculture abundance', that is, the relative abundance in the endowment of factor land across provinces. In this sense, the North Western provinces stand out as the more agrarian, and therefore, the more relatively land abundant territories in Spain (Orense, Lugo), together with some Castilian provinces (Cuenca and León). On the contrary, Madrid, Barcelona and Western Andalusia are among the less agrarian provinces. The second Heckscher-Ohlin variable refers to the abundance of labour in each province measured by total active population per square kilometre<sup>13</sup>. In this case, the three main areas along the period are Madrid, the Mediterranean coast (Barcelona, Valencia and Alicante) and the North Western coastal provinces (now Coruña and Pontevedra).

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<sup>13</sup> Capital is not included based on the assumption of a high degree of capital mobility across regions. Midelfart-Knarvik *et al.* (2000), Crafts and Mulatu (2005).

The third regional characteristic, market potential, is a NEG variable that captures the advantage of a province in terms of its proximity to markets. In spite of the changes over time quoted in the previous section, throughout the whole period Barcelona and the North-North Western provinces showed a higher market potential. In the case of Barcelona, sea access and the dimension of its own market could explain its predominant position. For the Atlantic coast, the reason could be sea access and proximity to the main European markets. Opposite to this, the provinces with a lower market potential are inland locations in Castile (Cuenca and Soria), Extremadura (Cáceres and Badajoz) and Granada.

**Table 2. Regional and industry characteristics.**

<i>Regional characteristics (provinces)</i>	<i>Industry characteristics</i>
Agricultural production % GDP	Agricultural input, % total costs
Total active population per land	Labour input, % of Gross Value Added
Market potential	Size of establishment
	Intermediate goods, % of output
	Sales to industry, % of output

The second column in Table 2 includes industry characteristics. In this case, according to trade theory the first two variables pick up factor intensities and the last three are NEG variables. Having this information, five interaction variables are examined.

First, the interactions *agricultural abundance x agricultural input intensity* and *labour abundance x labour intensity* are based on comparative advantage theory. In this sense, the Heckscher-Ohlin model predicts that industries using intensively a factor of production (agricultural inputs and labour) will tend to be located in provinces abundantly endowed with that factor. Therefore, these two first interaction variables are based on the Heckscher-Ohlin factor endowments model. The next three interactions take into account NEG-type mechanisms.

The interaction between *market potential x size of establishment* captures the idea that industries with higher economies of scale or increasing returns tend to concentrate in regions with a good access to markets. When transport costs are sufficiently low (reaching ‘intermediate’ levels) firms with a large scale production are induced to locate near big markets and then supply from these central areas. The sign of

this interaction is expected to be positive. If transport costs were either, very high or very low, the pull of market potential would be weakened.

The interaction market potential  $\times$  intermediate goods captures ‘forward linkages’. Firms buy inputs from other producers as intermediate goods. Therefore, in order to minimize transport costs, firms that are highly dependent on intermediate goods will tend to locate near central areas where it is more likely that a higher number of suppliers will be concentrated. In this case, a bigger market implies a better access to supply, and again, a positive sign is expected for this term.

Finally, the interaction *market potential  $\times$  sales to industry* is capturing the ‘backward linkages’. Firms may also produce goods for other industrial users. Thus, firms prefer to be close to their customers in order to minimize transport costs. And customers will usually be located in central locations. However, it is not clear, a priori, the sign of this interaction. The backward linkages induce firms to be near the customers, but firms may want to be located near final consumers as well.

The model constructed by Midelfart-Knarvik *et al.* (2000, 2002) nests within it both factor endowments and NEG elements taking into account the interaction between regional and industry characteristics. Actually, the model considers these interactions as determinants for industrial location. The specification derived by these authors is:

$$\ln(s_i^k) = \alpha \ln(pop_i) + \ln(man_i) + \sum_j \beta[j](y[j]_i - \gamma[j])(z[j]^k - \kappa[j]) \quad (1)$$

were  $s_i^k$  is the share of industry  $k$  in province  $i$  (see data section);  $pop_i$  is the share of Spain’s population living in province  $i$ ;  $man_i$  is the share of total Spain’s manufacturing located in province  $i$ ;  $y[j]_i$  is the level of the  $j$ th regional characteristic in region  $i$ ;  $z[j]^k$  is the industry  $k$  value of industry characteristic paired with region characteristic  $j$ ;  $\alpha$ ,  $\beta$ ,  $\beta[j]$ ,  $\gamma[j]$  and  $\kappa[j]$  are coefficients. Equation (1) cannot be estimated in that form. Expanding the relationship gives the equation to be estimated:

$$\ln(s_i^k) = c + \alpha \ln(pop_i) + \beta \ln(man_i) + \sum_j (\beta[j]y[j]_i z[j]^k - \beta[j]\gamma[j]z[j]^k - \beta[j]\kappa[j]y[j]_i) \quad (2)$$

As stated by Midelfart-Knarvik *et al.* (2000, 2002), the first two variables ( $pop_i, man_i$ ) capture regional size effects. All else equal, we would expect larger countries to have a larger industrial share in any given industry (coefficients  $\alpha$  and  $\beta$ , respectively). First, the estimated coefficients on regional characteristics,  $y[j]$ , are estimates of  $-\beta[j]\kappa[j]$ . Secondly, the estimated coefficients on industrial intensities,  $z[j]$ , are estimates of  $-\beta[j]\gamma[j]$ . If we divide these estimates by  $\beta[j]$ , we get an estimate of the cut-off point defining high and low abundance and intensity. However, the most relevant information comes from the interaction variables between region and industry characteristics since these interactions determine industrial location. For that reason, we concentrate on the study of the parameters  $\beta[j]$ .

### Data

In this paper the analysis is focused on 43 Spanish provinces (NUTS3)<sup>14</sup>, seven industrial sectors, and four years: 1856, 1893, 1913 and 1929. In order to explain the patterns of industrial location, the endogenous variable considered, ( $s_i^k$ ), is the share of a certain industry  $k$  in the total manufacturing activity of region  $i$ , defined as:

$$s_i^k(t) = \frac{x_i^k(t)}{\sum_k x_i^k(t)},$$

where  $x_i^k(t)$  is the level of industrial activity  $k$  at location  $i$  and time  $t$ . This indicator is constructed based on the fiscal information provided by the main source used: *Estadística Administrativa de la Contribución Industrial y de Comercio (EACI)*. This publication compiles a tax paid on the industrial activity established in 1845 and consisting of “a system of fixed rates per active unit of the main production means in each of the branches or productive processes established by the legislator<sup>15</sup>”. The share that represents a certain industry in each province is calculated through the sectoral aggregation of tax paid in that sector over the total amount paid in the province. Information for the years 1856 and 1893 has been collected from this source.

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<sup>14</sup> Seven provinces are excluded of the sample. The three Basque’s provinces and Navarra are absent due to the lack of the fiscal information used to construct  $s_i^k$ . The two provinces within the Canary Islands and Baleares are not included since estimates of the market potential are not available for these island territories.

<sup>15</sup> Nadal and Tafunell (1992), p. 256. Own translation.

The treatment of the data provided in the EACI faces two main problems: first, the exclusion of the Basque Country and Navarre, exempt from the payment of the tax for they had a special fiscal regime. Second, this tax suffered important changes in 1907<sup>16</sup>. Therefore, for the last two years in this study, 1913 and 1929, after the change of legislation, the EACI is not a satisfactory source. This problem has been dealt with and overcome by Betrán (1995, 1999) in her study on the industrial localization in Spain during the first decades of the 20<sup>th</sup> century. She reconstructed the industrial taxes paid in each province in 1913 and 1929, based on the two taxes existing at that time: *Estadística Administrativa de la Contribución Industrial y de Comercio (EACI)* and *Estadística de la Contribución de Utilidades (ECU)*. Hence, data for 1913 and 1929 comes from Betrán (1995, 1999).

With respect to the size variables, the share of Spain's population living in province  $i$ , is obtained from the Census of Population (1860, 1900, 1910, 1930). The share of total Spain's manufacturing located in province  $i$ , comes from the database constructed in Martínez-Galarraga (2007). In that paper, new regional GDP estimates were constructed based on the Geary and Stark's (2002) methodology<sup>17</sup>. This database covers NUTS3 provinces and three economic sectors: agriculture, industry and services.

Industry characteristics include agricultural input as a percentage of total costs, labour input as a percentage of GVA, intermediate goods and sales to industry as a percentage of output, and size of establishment as reported in Table 2. Unfortunately, we do not have information for the first four industry characteristics contained in this study over the period 1860-1930. The first input-output table for the Spanish economy was published in 1958. Therefore, using this source to elaborate industry characteristics and then apply them in retrospective implies the assumption that the industry features in 1958 are a good proxy for the previous period considered in this paper (1860-1930). This assumption is present in relevant studies in Spanish economic history. The

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<sup>16</sup> “The act of 03-08-1907 represents a break in the history of the taxation on manufacturer or industrial activities, since it establishes that joint stock companies and limited partnership by shares devoted to the production may pay the tax ‘Impuesto de Utilidades’, a tax on property passed in 1900. From 1921 this prescription was extended to every mercantile society [...]. The nature of this latter tax is much more different from the previous one: it rests on the (net) profits of societies, and it does not take into account the means of production nor the supposed income generated by them. This fact arises a serious problem because from the year 1907 onwards the information contained in the industrial contribution books presents an incomplete image of industrial activities. And, what is absent constitutes an important part of the biggest companies. Besides, it is a growing part of companies because of the conversion of many societies in joint stock companies in order to benefit from the benevolent tax treatment offered by the ‘Impuesto de Sociedades’ (Corporate Income Tax)”, Nadal and Tafunell (1992), p. 259. Own translation.

<sup>17</sup> See also Crafts (2005a).

construction of the industrial production index in historical perspective (Carreras, 1983, 1984) is based on the unitary added values generated in different industrial sectors and then extrapolated backwards according to the evolution of industrial prices. Thus, the information in the input-output table for 1958 was used to weight the industrial index for the period 1850-1958. Furthermore, the series of industrial output constructed by Carreras have been used by Prados de la Escosura (2003) in the reconstruction of historical series for Spanish GDP.

Finally, in the case of the size of establishment, the source used is again the fiscal information in EACI. This publication includes the tax quota paid at one particular industry and the total number of contributors. Data is offered for 1856 and 1893, and it is used as a proxy of economies of scale<sup>18</sup>.

Regional characteristics, which are time varying, include agricultural endowments, labour abundance and market potential. The first one, captured by the agricultural production as a percentage of GDP in each province, is taken from the same source as the size variable for manufacturing (Martínez-Galarraga, 2007). In this case, data on Gross Value Added at factor cost in agriculture is used. The abundance of labour in each province is measured through total active population per square kilometre. Information on the total active population by province has been compiled from the Census of Population and the area in square kilometres of each province can be found in *Instituto Nacional de Estadística*.

Finally, estimates of the market potential for the Spanish continental provinces come from Martínez-Galarraga (2008). In that paper, regional accessibility is measured using the Harris market potential equation, which can be defined as:

$$MP_i = \sum_{j=1}^{j=n} \frac{M_j}{d_{ij}}$$

where  $M_j$  is a measure of the size of province  $j$  (usually GDP) and  $d_{ij}$  is the distance, or as in this case, bilateral transport costs between  $i$  and  $j$ . Following this expression, market potential has been calculated for the Spanish case based on the study by Crafts

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<sup>18</sup> This is the only partially time varying industry characteristic. However, the values for 1893 are used for the years 1913 and 1929.

(2005b) for Britain from 1871 to 1931<sup>19</sup>. Market potential can be divided into two main components: internal and external market potential. First, the internal market potential includes Spanish provinces, considering the *self-potential* of province  $i$ , where the internal distance is calculated according to the expression:

$$d_{ii} = 0.333 \sqrt{\frac{(\text{area of province}_i)}{\pi}}$$

The size of the provincial markets is measured by the aggregate income. Data on GDP at a NUTSIII levels are obtained from Martínez-Galarraga (2007). For  $d_{ij}$ , transport costs are considered. In such a case, data on distances and average transport rates for commodities are needed. Internal transport is assumed to be by railway and coastal shipping. For railway distances, the sources are Ministerio de Obras Públicas (1902), and Wais (1987). For distances between ports, electronic atlases provide information on the length of sea journeys<sup>20</sup>. As regards transport costs, data on railway rates come from Herranz (2005)<sup>21</sup> and coastal shipping rates in 1865 have been obtained from Nadal (1975). In order to consider the reduction in sea transport costs, the data have been corrected with the freight rate indices calculated by Mohammed and Williamson (2004). However, in the first benchmark year, in 1867, only 32 out of the continental 47 provinces considered were connected to the railway network. For that reason, road transport was also included in the internal market potential estimates at that time<sup>22</sup>. Distances by road were taken from Dirección General de Obras Públicas (1861). For road transport prices, the information in Barquín (1999) has been used. Finally, the relative weight of each transport mode in the coastal provinces is obtained from Frax (1981).

Second, foreign markets have to be added to the internal market potential<sup>23</sup>. The construction of the external market potential is based on the gravity equation for international trade estimated by Estevadeordal *et al.* (2003). The elasticities obtained for

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<sup>19</sup> See also Keeble *et al.* (1982). For a historical exercise, see Schulze (2007). In the case of Wolf (2007), estimates of both MA (market access) and SA (supplier access) for the Polish regions in the interwar period were calculated, following Redding and Venables (2004), using data on regional bilateral flows. Unfortunately, such information is not available for the Spanish case.

<sup>20</sup> [www.dataloy.com](http://www.dataloy.com) and [www.distances.com](http://www.distances.com).

<sup>21</sup> Data kindly provided by the author.

<sup>22</sup> On the contrary, in 1930 motorized road transport was not still playing an important role, and therefore, it has not been considered. Herranz (2005).

<sup>23</sup> Differences with the work by Crafts (2005b) are explained in Martínez-Galarraga (2008).

distance and tariffs are used to reduce the size of foreign markets. GDP of the main trading partners for Spain is obtained from Crafts (2005b) based on the estimates of Prados de la Escosura (2000). Prevailing exchange rates have been applied to convert GDP figures from pounds to pesetas. Maritime distances are once again obtained from an electronic atlas and finally, tariffs come from O'Rourke (2000) and Mitchell (1998a, 1998b).

### Estimation results

The results from the estimation of equation 2 are reported in Table 3. Equation (2) is estimated by OLS, with heteroskedasticity-corrected standard errors using White's method, pooling across the seven industries considered for the years 1856, 1893, 1913 and 1929. The total number of observations is, depending on the year, around 300. The goodness of the fit in terms of the adjusted-R<sup>2</sup> is acceptable going from 0.56 to 0.62<sup>24</sup>.

Table 3 shows the estimation results, including the constant term, the two size variables ( $pop_i, man_i$ ), the three regional characteristics,  $y[j]$ , the five industry characteristics,  $z[j]$ , and the five interaction variables,  $\beta[j]$ . As mentioned above, the important coefficients are those of the interaction variables. These coefficients capture the combined effect of regional and industry characteristics in the location of industry.

The first two interactions are based on Heckscher-Ohlin effects. The coefficient for the interaction relating *agricultural abundance* and *agricultural input use* has the right positive sign, but it is only statistically significant in the first and the last year of study. This result shows that, on those particular dates, manufacturing industries with an intensive use of agricultural inputs were located in regions with relatively good endowments for agricultural production. The second Heckscher-Ohlin interaction refers to *labour abundance*. In this case, the coefficient is significantly different from zero in 1893 and 1913, showing a positive sign as expected. Those regions with a relatively larger abundance of labour attracted industries which intensively relied on this production factor. However, in 1856 and 1929, this effect vanishes since this interaction is not significant. Overall, there seems to be evidence in favour of traditional factor endowment variables affecting the location of industry in Spain throughout the period considered, although these forces changed in different years.

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<sup>24</sup> In this case, the adjusted-R<sup>2</sup> is similar to the one obtained by Crafts and Mulatu (2005, 2006) for the British case.

**Table 3. Regression results.**

	<b>1856</b>	<b>1893</b>	<b>1913</b>	<b>1929</b>
<i>Constant</i>	30.985 (118.384)	-288.983 (184.083)	-172.488 (189.132)	188.587 (166.015)
<i>Population</i>	-0.032 (0.499)	-0.285 (0.327)	0.068 (0.339)	0.409 (0.422)
<i>Manufacturing</i>	-0.0117 (0.399)	0.089 (0.239)	0.111 (0.280)	-0.136 (0.284)
<i>Share of agricultural GVA</i>	-0.613 (0.473)	0.090 (0.340)	0.620 (0.405)	-0.154 (0.342)
<i>Labour abundance</i>	1.543 (1.702)	-2.076** (1.013)	-3.125** (0.959)	-0.405 (0.898)
<i>Market potential</i>	4.181 (22.352)	14.091 (30.543)	27.119 (29.003)	-15.141 (23.241)
<i>Agricultural input use</i>	-0.808** (0.301)	-1.049** (0.198)	-0.404* (0.218)	-0.367** (0.151)
<i>Share of labour in GVA</i>	1.284 (1.172)	-5.918** (0.892)	-3.758** (0.815)	-0.364 (0.749)
<i>Size of establishment</i>	-1.377 (1.045)	-7.016** (1.188)	-6.207** (1.135)	-1.982** (0.993)
<i>Intermediate input use</i>	-1.649 (19.210)	57.675* (30.563)	35.222 (31.516)	-26.377 (27.566)
<i>Sales to industry</i>	-4.995 (10.22)	27.934* (15.981)	18.083 (16.134)	-16.895 (14.108)
<i>Share of agricultural GVA * Agricultural input use</i>	0.192** (0.084)	0.068 (0.044)	0.077 (0.052)	0.121** (0.034)
<i>Labour abundance * Share of labour in GVA</i>	-0.273 (0.428)	0.585** (0.279)	0.900** (0.256)	0.055 (0.244)
<i>Market potential * Size of establishment</i>	-0.022 (0.188)	0.602** (0.181)	0.785** (0.161)	0.216* (0.192)
<i>Market potential * Intermediate input use</i>	-0.757 (3.651)	-2.581 (5.061)	-4.812 (4.812)	2.189 (3.847)
<i>Market potential * Sales to industry</i>	-0.318 (1.936)	-1.590 (2.632)	-2.814 (2.464)	1.306 (1.967)
<i>Number of observations</i>	261	295	300	301
<i>Adjusted R<sup>2</sup></i>	0.56	0.62	0.56	0.56

Note: White heteroskedasticity-robust standard error in brackets. \* significant at 10%. \*\* significant at 5%.

Let's turn now to the three 'New Economic Geography' interactions. The variable that relates *market potential* and the *size of establishment* is insignificant in 1856 and does not have the expected positive sign in that year. However, from 1893 to 1929, this interaction becomes significant and exhibits a positive sign. Thus, at that time industries with increasing returns to scale tended to be located near the central areas in terms of high market potential. On the contrary, there is no evidence of linkage effects. The interaction between *market potential* and *intermediate input* (forward linkage) and the interaction between *market potential* and *sales to industry* (backward linkage), both have the wrong sign in most of the cases (negative) and, most importantly, are always insignificant. Therefore, market potential NEG effects appear to be important for the interaction that captures the relevance of economies of scale, and only from 1893 onwards.

#### **4. Discussion.**

The regression results indicate that both Heckscher-Ohlin and NEG factors were driving industrial location patterns in the first stages of industrialization in Spain. In 1856, the interaction relating regional agricultural abundance and agricultural input use is the only significant interaction variable. This result shows that traditional factor endowments theory was relevant in the sense that manufacturing industries that used intensively agricultural inputs were located in the provinces with good endowment of land and agricultural production. Instead, no evidence of significant effects in the NEG interaction variables is found at that time. In mid-19<sup>th</sup> century the Spanish domestic market was not fully integrated and, in addition, the industrialization process was at an infant stage. With the major exception of textiles in Catalonia the structure of manufacturing production was mainly dominated by foodstuffs<sup>25</sup>.

At the end of the century, factor endowments appear to be still important, but in this case, through the interaction considering labour abundance. Then, labour intensive industries were attracted to regions where the factor labour was relatively abundant. Throughout the second half of the 19<sup>th</sup> century the process of industrialization in Spain

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<sup>25</sup> According to the data provided by Prados de la Escosura (2003), in 1856 foodstuffs accounted for 48.7% of the GVA in total Spanish manufacturing.

had progressed and Spanish manufacturing was mostly oriented towards the production of consumption goods, which are generally labour intensive products<sup>26</sup>.

Most importantly, in 1893, NEG effects became significant determinants in explaining the location of industry in Spain as captured by the interaction between market potential and economies of scale. Theory predicts that the forces pulling increasing returns industries into central locations are strongest at ‘intermediate’ levels of transport costs (Puga, 1999). In this sense, the expansion of the railway network in the second half of the 19<sup>th</sup> century may have played a key role in the process. The first great impulse in the construction of railway started after the Railway Act of 1855 was passed and lasted until the 1870s (Herranz, 2005). By 1893, the main economic centres and a large number of provincial capitals were connected to the network. The result was an important decrease in transport costs in a country where geographical conditions had traditionally imposed heavy costs on communications. And falling transport costs favoured deeper market integration. At the same time, as the industrialization proceeded during the second half of the 19<sup>th</sup> century, economies of scale activities achieved a higher development within the industrial sector.

Therefore, it is possible to hypothesize that, as stated by NEG models, the interaction of increasing returns, transport costs and the size of market may have favoured the emergence of agglomeration forces and eventually, favoured the gradual concentration of industry in a limited number of provinces<sup>27</sup> (Figure 2 in the Appendix). This result is in line with the one obtained in the exercise carried out by Tirado *et al.* (2002). These authors found that in 1893 the NEG variable capturing economies of scale gained explanatory power as a determinant of regional specialization when compared to 1856. Therefore, they concluded that domestic market integration had stimulated the cumulative effects of production scale. Nevertheless, they also found that this element was already important in 1856 although the impact was weaker. Similarly, Rosés (2003) had found evidence of a ‘*home market effect*’ around 1860.

The significant effects found in 1893 for both, the factor endowment interaction considering labour abundance and the NEG interaction between market potential and economies of scale increased in magnitude in 1913. This fact indicates a strengthening

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<sup>26</sup> It is worth reminding that the production of capital goods (iron and metal industry) developed specially in the Basque Country, but unfortunately this region is absent from the data due to statistical restrictions.

<sup>27</sup> NEG models show that when transport costs are high, agglomeration forces are low and firms tend to be dispersed across space in order to save transport costs. When transport costs are intermediate, *centripetal forces* intensify agglomeration when workers are mobile.

of the main determinants of the industrial location patterns up to the First World War, in a period characterized by a deeper geographical concentration of industry in Spain. Thus, the results resemble the US experience described by Kim (1995). In that case, both, economies of scale and resource endowments explained the increase in regional specialization and geographical concentration of manufacturing industry as transport costs decreased between 1860 and WWI.

However, in 1930, the abundance of labour is no longer significant. A possible explanation for this finding might be that during the interwar years, capital intensive industries like chemicals, or metal and machinery, experienced an important expansion in Spain (Betrán, 1999). Instead, agricultural abundance turns out to be relevant for industrial location again, as in 1856. It is not straightforward to interpret this result. The significance of the interaction between agricultural abundance and the intensity in the use of agricultural inputs could be related to the changes that took place in the agricultural sector in the first decades of the 20<sup>th</sup> century. Agricultural specialization has traditionally differed across Spanish regions (Jiménez Blanco, 1986). Moreover, these patterns of specialization intensified between 1900 and 1930 and those regions that achieved a deeper specialization in their agricultural sector experienced a higher increase in productivity (Simpson, 1997).

Finally, as in the British case (Crafts and Mulatu, 2005, 2006), although the results show that the reduction in transport costs experienced in Spain in the 19<sup>th</sup> century encouraged industries with economies of scale to move to locations with high market potential at the end of the century, transport costs were not low enough to exert a pull of centrality on industries with linkage effects. Backward linkages were not important determinants of industrial location over this period, i.e., industries which sell a large share of their output to industry did not tend to locate in provinces with a high market potential. The same result is obtained for forward linkages. Industries which are heavily dependent on intermediate goods did not tend to locate in high market potential provinces with good access to intermediate inputs.

## **5. Concluding remarks.**

In this paper, the determinants of industrial location in Spain in the first stages of the process of industrialization are analyzed. The gradual integration of the domestic market was favoured by the fall in transport costs derived from the construction of the railway network. In turn, market integration in Spain led to an increase in the concentration of manufacturing industries across space. At the same time, regional specialization increased, although in the interwar period no further increase in the differences in the productive structure among regions is observed.

Once the main trends in the geographical concentration of industry and regional specialization within Spain are reviewed, the focus of the paper is placed on analyzing the determinants of such industrial location between 1856 and 1929. To this aim, the standard model developed by Midelfart-Knarvik *et al.* (2000, 2002) in order to study the location of industry in the European Union is applied. This approach has proved to be very useful to explore the determinants of industrial location in different historical cases (Crafts and Mulatu, 2005, 2006; Wolf, 2007). The interesting aspect of this model lies in its capacity to combine within it both Heckscher-Ohlin factor endowments' theory and NEG-type mechanisms. The relative relevance of these forces is captured by a series of interactions regarding regional and industry characteristics.

In this paper, the analysis is focused on Spanish NUTSIII provinces, considering seven industrial sectors in four years: 1856, 1893, 1913 and 1929. The results show that both Heckscher-Ohlin and NEG effects were driving the location of industry along this period. Factor endowments' elements are important throughout the whole period. In some cases it is proximity to agricultural inputs the relevant aspect and in other years it is labour abundance. A role for NEG effects is also found in 1893 and in the following years. The interaction between economies of scale and market access in a context of substantial fall in transport costs is significant. The expansion and completion of the basic railway network and the development achieved by activities with economies of scale within the Spanish industrial sector determined the increasing concentration of industry and regional specialization from the second half of the 19<sup>th</sup> century onwards. However, it seems that transport costs were not low enough to exert a pull of centrality on industries with linkage effects.

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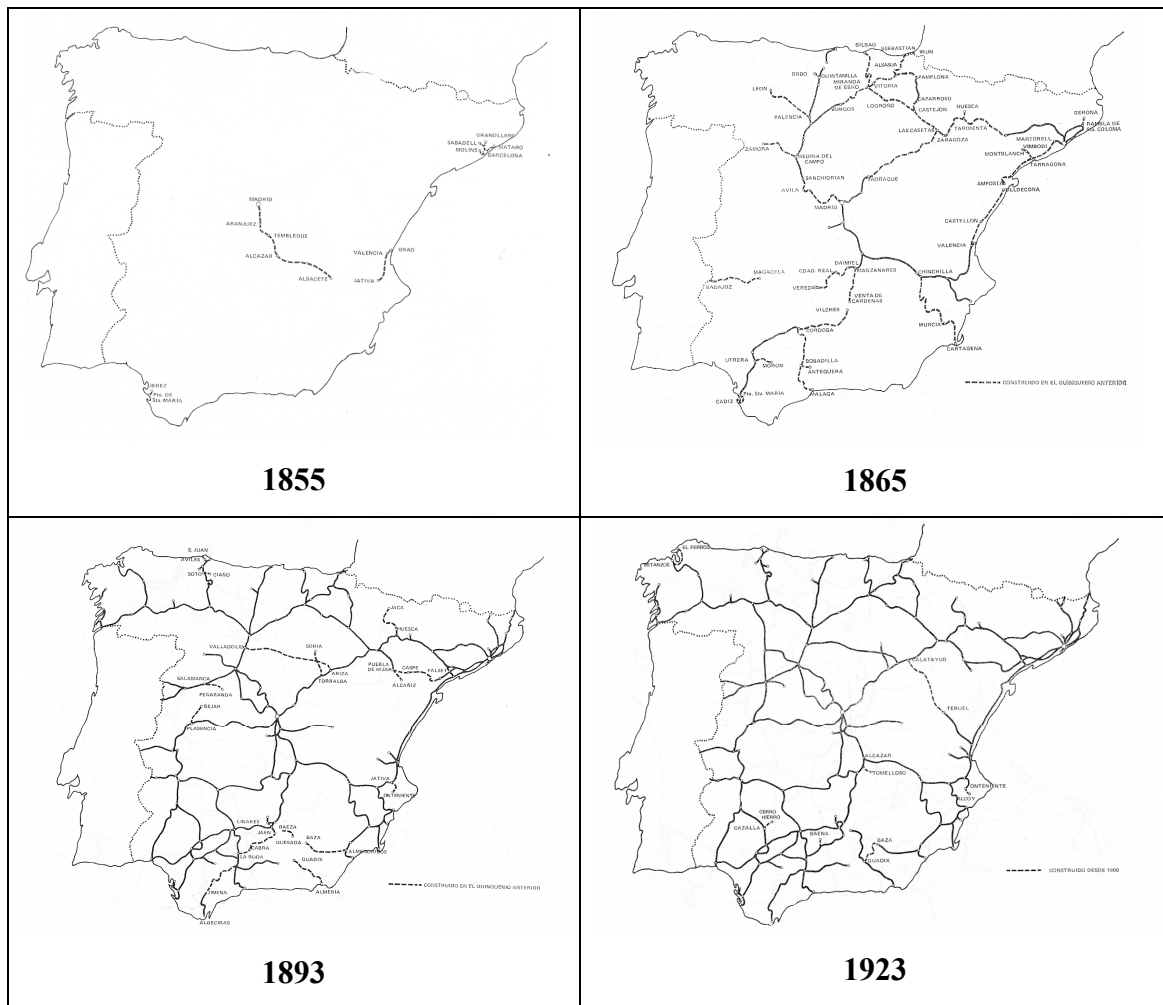
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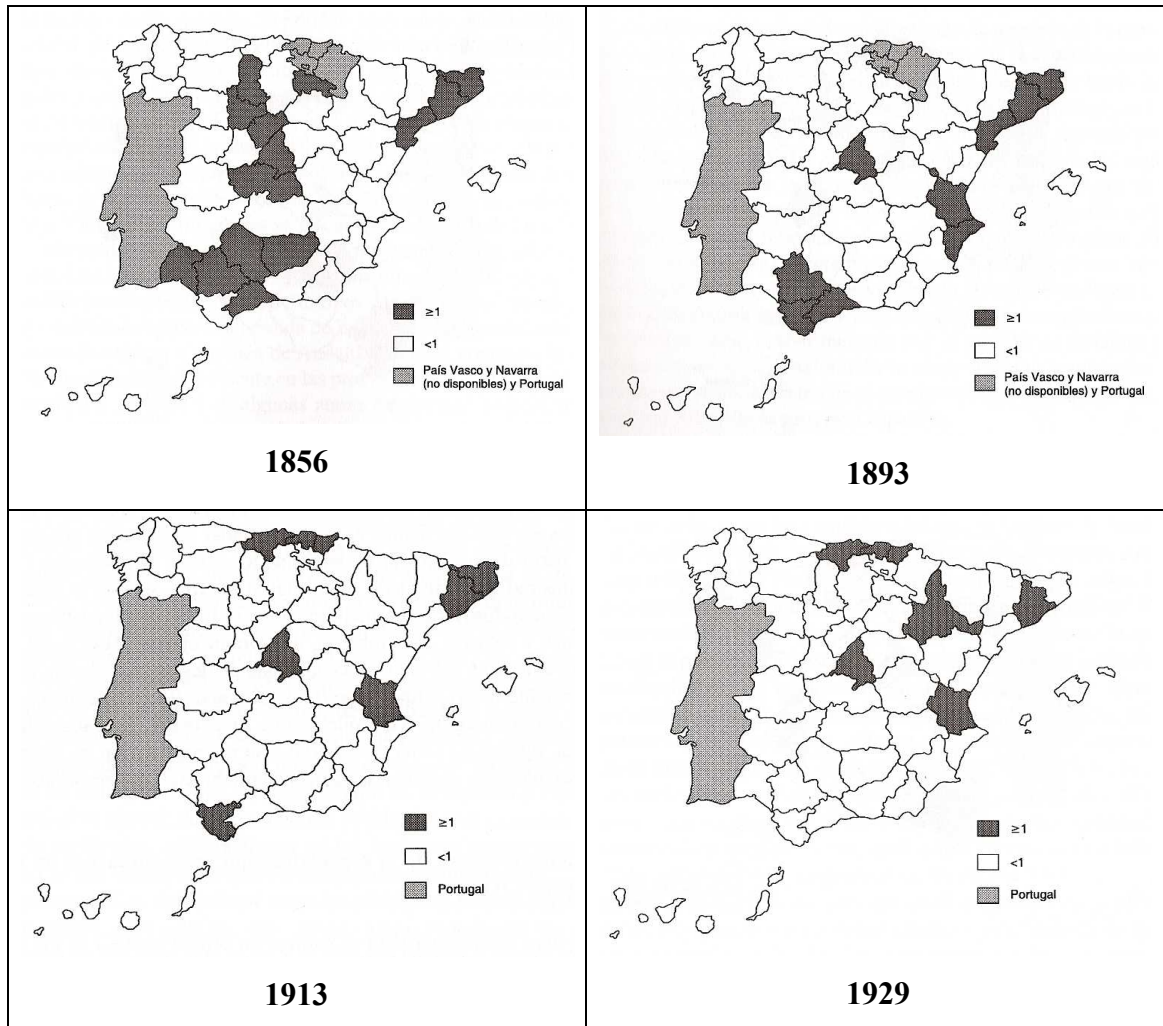
## Appendix

Figure 1. Expansion of the railway network in Spain (1855-1923).



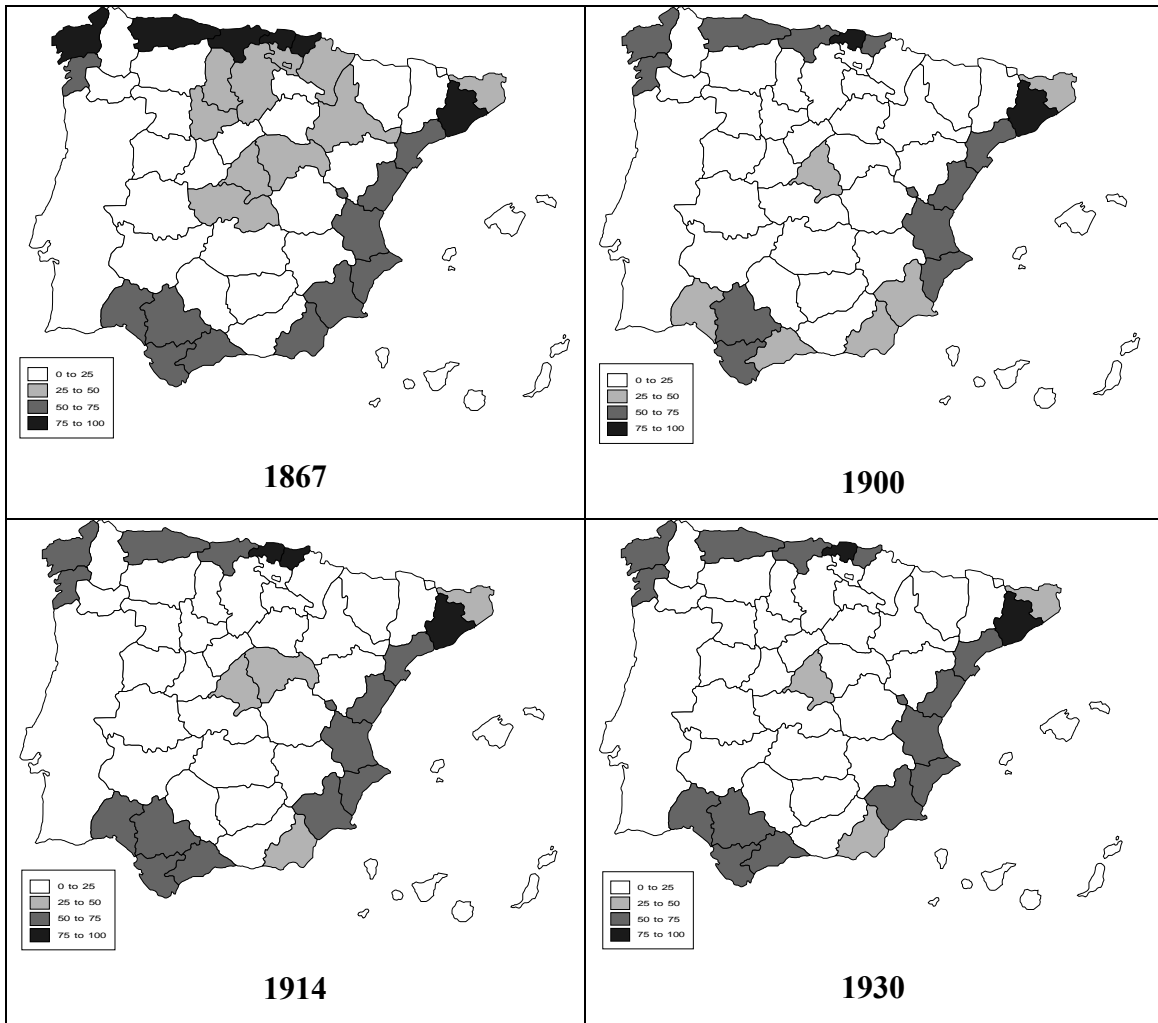
Source: Cordero and Menéndez (1978).

Figure 2. Industrial intensity index, 1856-1929.



Source: Tirado et al. (2006).

Figure 3. Market potential, 1867-1930 (Barcelona = 100).



Source: Martínez-Galarraga (2008).