Industrial agglomerations and wage gradients:
the Spanish economy in the interwar period[*]

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Abstract:

This paper gives new evidence on the relationship between integration and industrial agglomeration in the presence of scale economies, by testing directly one of the predictions that can be derived from Krugman (1991), that is, the existence of regional nominal wage gradients and its transformation following changes in trade regimes. Our case study analyzes the effects of the substitution of an open economy by a closed economy regime, exactly the opposite process studied by Hanson (1996, 1997). In Spain, during the interwar period, protectionist policies would have favored the loss of centrality of the coastal location (Barcelona) and the relative rise of central locations (such as Madrid). Our results indicate the existence of a wage gradient centered in Barcelona during the interwar period (1914-1930) and its weakening after 1925.

1. Introduction

The geographical distribution of Spanish industry shows today two interesting features. On the one hand, a high concentration, higher than what we can find in the majority of European countries (Hallet, 2002). On the other hand, the coexistence of two industrial cities: Madrid and Barcelona. The purpose of this paper is to give a reasoned explanation to these facts, by using a theoretical framework that seems to be specially designed to give an answer to this kind of questions, i.e. "the new economic geography" and by analyzing new evidence on the first phase of Spanish industrial development, the period that goes from the mid 19th century to the Civil War.

In the last decade, a considerable number of theoretical models has considered the existence of a relationship between economic integration, scale economies and the geographical concentration of industries. As Neary (2001) highlights, the key contribution of this "new economic geography" literature is to give a rational-decision theoretical basis for the propensity to agglomerate. Nevertheless, economic historians had many years ago shared some of the concerns of this strand. Williamsom (1965) had already stated that a country's regional economic disparities will widen during the initial phase of industrialization and then diminish, thus anticipating the Ù-shaped relationship between market integration and industrial agglomeration in the long term that we encounter in a majority of "new economic geography" models. Accordingly, both the current levels of geographical concentration of production and the particular location of large industrial centers in Europe, could be related to the changes registered during the first phases of modern economic development.

In this respect, Paluzie et al. (2002) in a descriptive analysis of the evolution of the geographical concentration of industries in Spain in the last 150 years, show that the larger increases in the levels of concentration are to be found during the long period that goes from the middle of the 19th century to the Civil War (1936-1939), a period that represents a first stage in Spanish industrial development. That's why we will focus on that period in our current analysis.

As for the geographical location of large industrial centers, the second half of the 19th century was dominated by the rise of Barcelona as the main center of industrial production in Spain. In those years, Barcelona got to concentrate a third of Spanish industrial output. However, the turning of the century marks a halt in this process, and Madrid begins then to increase its share of Spanish manufacturing, filling the gap gradually with the Catalan city.

Economic historians have given some explanations to these facts. On the one hand, Madrid's growth has been explained by the overcoming of some ties like water and industrial soil supplies and by the reduction in transport costs. Without undervaluing these arguments, we think they apply to the 1860's (water piping is constructed in 1858, the Ensanche, the city's expansion is dated in 1868 and Madrid becomes Spain's railway hub in the second half of the 19th century). On the other, historians have also used arguments such as coal's substitution by electricity and public expenditure. But public expenditure was not quantitatively important and electricity generalization occurs later on, in the 1920's.

However, we think that the evolution in the geographical location of industrial centers in Spain since the turn of the 19th century could also be related to changes in the trade policy regime, an hypothesis not considered by economic historians. In fact, the "new economic geography" has also been concerned by the question of the effects of trade policies on regional inequalities within countries. Krugman and Livas (1996) explain the existence of large metropolis in developing countries as a by-product of protectionist policies followed after WWII. These policies would have favored capital cities located in the geographical centers of countries, from which transportation costs to domestic consumers can be minimized. On the contrary, trade liberalization could modify the initial pattern of industrial location by changing the reference market for domestic firms. Hanson (1996, 1997, 1998) has analyzed in depth these effects in the case of the Mexican economy and has shown how trade reform has weakened the industrial belt around Mexico city, giving rise to new industrial centers in the north of the country, in the U.S. border.

In this paper we suggest two explanatory hypotheses. On the one hand, we believe that the increase in the geographical concentration of Spanish industries along the period 1850-

1935 is linked to the existence of scale economies in a context of increasing domestic market integration. On the other hand, we think that the initial development of Barcelona as the Spanish industrial capital and its subsequent loss of punch in front of other locations like Madrid, both the capital-city of the country and its geographical center, could be related, though not exclusively, to the changes in Spanish trade policy at the end of the 19th century. At this point in time, the nationalistic reaction to what has been called the "crisis finisecular" after the loss of the remaining colonies, supposes the abandon of a liberal regime, characterized by a relative openness, and the adoption of a nationalistic model of development that breaks the former dynamics and imposes harsh restrictions in the international trade of goods and raw materials.

Besides this basic motivation, the study pretends also to provide new evidence on the relationship between integration and industrial agglomeration in the presence of scale economies, by testing directly one of the predictions that can be derived from new economic geography models, that is, the existence of regional nominal wage gradients and its transformation following changes in trade regimes. In this respect, in a recent survey on the empirics of agglomeration, Head and Mayer (2003) emphasize that while the main ideas of the new economic geography have already been synthesized into a coherent collection of closely linked models, the empirical literature remains unsettled in both methodology and results. Like recent empirical research, we will try to discern if the data supports some of the underlying mechanisms at work in this kind of models. Furthermore, our case study analyzes the effects of the substitution of an open economy by a closed economy regime, exactly the opposite process studied by previous work in the field.

The article is organized as follows. Section 2 provides the analytical framework by discussing the theoretical models and the previous empirical work in which we sustain our investigation. Section 3 analyzes the historical evolution of the key variables signaled by the theory. This evidence will suggest us the hypotheses to test. Section 4 is devoted to the presentation of our empirical analysis strategy, a strategy indebted to Hanson's recent work on the Mexican economy (Hanson, 1996, 1997); and to the discussion of the results

obtained. In the last section, we give the main conclusions and we suggest some directions for further research.

2. The analytical framework

The last decades have seen a revival of the interest in economic geography. The phenomena of globalization and the appearance of regional blocks have contributed to this resurgence by intensifying the fears of radical changes in the localization of economic activities. In fact, industries are geographically more agglomerated than what suggests the location of resources. The existence of internal scale economies forces firms to concentrate their production in a relatively small number of centers. On the contrary, if firms want to minimize the costs of supplying consumers, the presence of high transport costs acts as a force in favor of industry's dispersion. So, in principle, the reduction in transport costs should weaken this dispersion force and reinforce the agglomeration tendencies. That's why economic integration generates fears.

From a theoretical point of view, the location of final demand and that of input's supply is not exogenous but there would be some cumulative causation mechanisms that tend to reinforce industrial agglomerations already in place. These mechanisms are of two kinds: on the one hand, the home market effect, which highlights the importance of market access, and on the other, vertical linkages between firms, that generate an interdependence in the location decisions of firms belonging to different levels of the production chain. (See Fujita et al. (1999) for a formalization of the different possible agglomeration forces).

In Krugman (1991) seminal paper, the combination of the home market effect and labor mobility generates endogenously center-periphery patterns. Firms want to locate close to demand to save in transport costs and, hence, industrial activities characterized by scale economies concentrate disproportionately in the locations with a good market access. In these locations, the disproportionate concentration of industry induces either an increase in wages or the attraction of workers who migrate from other regions. Both phenomena tend to increase further the share of income and expenditure in the region initially favored.

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Another relevant question that has been posed in the literature is what are going to be the main industrial centers inside a domestic market and what might be the effects of trade liberalization policies on the internal geography of countries. Krugman and Livas (1996) analyze the impact of trade liberalization in the distribution of activities inside a country and conclude that a country that opens up to external trade will experience a geographic dispersal of its economic activity. This model, in which there are three regions, two domestic and one external and where the centrifugal force is a congestion cost in urban agglomerations, would explain the rise of large metropolis in developing countries and its progressive loss of importance after the implementation of trade liberalization policies.

However, Paluzie (2001) obtains the opposite result in another model of three regions, two domestic and one external but using as a centrifugal force the same as Krugman (1991), i.e., the attraction of a dispersed rural market, instead of the congestion cost used by Krugman and Livas (1996). In this model, external trade liberalization increases regional inequalities in the country that opens up to trade. Crozet and Koenig-Soubeyran (2002a,2002b) evaluate carefully the origins of the differences in outcomes and extend the model by introducing the possibility of an asymmetry between the two domestic regions: one of them has a pronounced advantage in terms of its access to international markets. In this case, trade liberalization moves domestic firms to the regions closer to the external market.

Empirical tests, following a line of research opened by Kim (1995), have been centered mainly in the analysis of industrial specialization and geographical concentration of industries and in that of the determinants of the patterns of specialization and location such as scale economies, input-output linkages and relative factor endowments. However, the estimations derived from this kind of studies lack sufficiently solid theoretical foundations. As Neary (2001) highlights, the papers that test directly the empirical implications of the new economic geography models are still insufficient. Among the exceptions, we have Davis and Weinstein (1999, 2003) that nest an increasing returns model of economic geography featuring home effects inside a Heckscher-Ohlin framework. Their empirical

specification is derived directly from a general equilibrium perspective and they are able to identify precise null and alternative hypothesis. They find evidence of the existence of a home market effect in the productive structure of OCDE countries and Japan.

Another interesting approach is that of Gordon Hanson, who has focused on a prediction derived in Krugman (1991) seminal paper that has been relatively neglected: the existence of wage gradients. In Krugman's model, firms can afford to pay higher wages if they have a good access to the larger market. The nominal wage in a region tends to be higher if incomes in other regions with low transport costs from this region are high. Hence the wage equation in the model exhibits a kind of demand linkage or "backward linkage": in the regions that concentrate a higher proportion of industry, wages are higher, this in turn attracts more workers and so income and expenditure increases further in these regions. In Krugman and Livas (1996) agglomeration creates congestion costs or increases land rents so firms in agglomerated regions must compensate workers by paying them high wages.

In all these models, when the equilibrium outcome is full concentration of industry in one region, a higher real wage is sustained in the core region. On the contrary, when a symmetric equilibrium is reached, regional real wages are equalized. But in any case, differences in nominal wages persist between the different regions. Nominal wages are higher in the central region and diminish with transport costs from that region. Hence, in the real world we should observe a regional wage gradient with nominal wages decreasing with transport costs from industrial centers.

Hanson (1996, 1997, 1998) uses Mexican trade liberalization in the 80's as a controlled experiment that generates an exogenous variation in market and supplier access. Hanson (1996) analyzes the relocation experienced by Mexican apparel industry. Before trade liberalization in 1985, this industry was concentrated around Mexico city, with design and marketing in the city and assembly in neighboring states. Things change dramatically after the reform. On the one hand, there's substantial relocation of manufacturing activity towards the northern border states, and on the other, the nature of manufacturing activity is also transformed and Mexican apparel industry specializes in off-shore assembly for U.S.

firms. The empirical analysis shows the existence of a negative relationship between relative nominal wages and distance to Mexico city before 1988 and a partial weakening of this gradient after the reform in 1985.

Hanson (1997) extends the analysis to all Mexican manufacturing activity studying the determinants of relative regional wages for a panel of industrial sectors over the period 1965-1988. The endogenous variable is the wage in each Mexican region relative to the wage in Mexico city for the same sector. The explanatory variables are distance to capital and to the closer U.S. border, as well as the same variable interacted with post 1985-dummy variables. Industry and year fixed effects are included. The results show that distance to industrial centers has a negative influence in relative wages. An increase in 10% in the distance to Mexico city is associated with a 1,9% reduction in the relative regional wage while the same increase in the distance to the border is associated with a 1,3 % reduction. However, according to Hanson's hypothesis a weakening in the gradient to the capital and an increase in the impact of the distance to the border after liberalization were also expected. The evidence on these expected changes receives a weaker support.

Finally, Hanson (1998) analyzes the effects of trade liberalization in regional industrial employment in Mexico during the period 1980-1993. In this case, the evidence he finds on the theoretical prediction of important changes following trade reform is higher. For instance, he shows that growth in regional industrial employment is negatively related with distance to the U.S. after 1985, while prior to this date, the relationship was not significant.

Hence, the Mexican case study seems to confirm the theoretical hypothesis concerning the importance of proximity to the external market in a open economy context. The evidence on the reduction in regional disparities that should follow trade liberalization according to Krugman and Livas (1996) model is less conclusive. Let's see now if the Spanish experience can provide us with new evidence in that respect.

2. History and hypotheses

Along the second half of the 19th century and the first third of the 20th century, the Spanish economy covered a long period in its process of economic development; a period that was dominated, like in the majority of European countries, by the increase in the share of industry in production. The particularly hard road to industrialization was accompanied by an increasing domestic integration in the markets of goods and factors that favored the productive specialization of Spanish regions.

Even though domestic market integration goes back to the 18th century, we have to wait until the construction of the railway network during the second half of the 19th century to see a reduction in internal transport costs that could represent a real progress in market integration. The construction of this large transportation infrastructure is characterized by some distinctive features. The first is the intensity in the construction process. It takes off with the 1855 Railway Act and by the end of the 1880's the main internal connections were already established. The second is the network's radial design around Madrid that converted the capital city in the country's main communications' hub.

During Primo de Rivera's Dictatorship (1923-1930), there was a second impulse in railway's investment. However, in this case, most of the investment was devoted to the renovation of the fixed and mobile materials and not to an enlargement of the network. (Herranz, 2001).

In any case, the results of this investment strategy, without being spectacular, implied the integration of both the goods and the labor markets by the end of the 19th century. This fact has already been analyzed in different works that show the convergence in the prices of goods and factors (wages) between Spanish provinces along this period. (GEHR, 1985, Rosés and Sánchez-Alonso, 2002).

The process was reinforced by the impulse in capital market's integration with the unification of the monetary system (1869) and the expansion of the branches of the Central

Bank, the *Banco de España*, since the first years of the Monarchic Restoration (1874). In this respect, Castañeda (2001) points out that, from 1885 on, the central bank established a free system of transfers between its branches that favored capital market integration in Spain.

Finally, from 1869, this context of internal market integration was accompanied by a progressive economic openness towards neighboring countries (Tena, 1999). On the one hand, as can be observed in Figure 1, the reduction in tariff protection levels reaches its maximum at the end of the 1880's, when Spain signs several trade treaties with its main trading partners. On the other, during the last decades of the 19th century, as O'Rourke and Williamson (1999) have recently highlighted, a considerable reduction in international transport costs, due to the technological innovations in maritime and earth transports leads to an increasing integration of national economies in the international markets, favoring international trade in goods and factors.
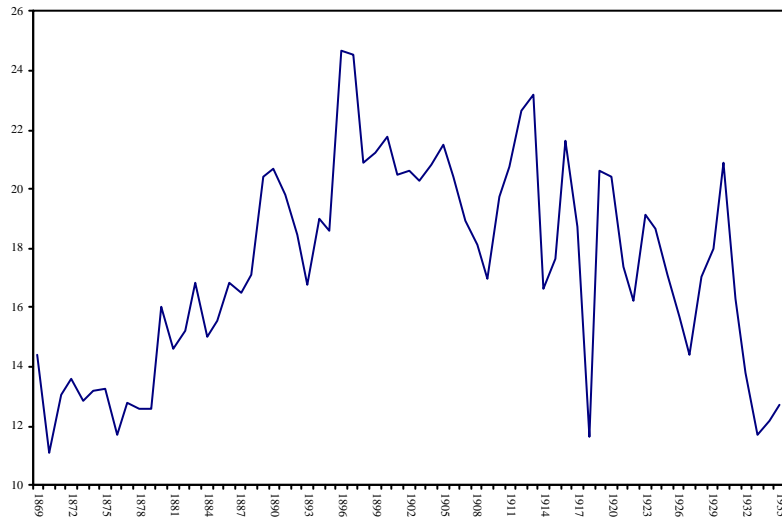
All this generated an upsurge of international trade. In fact, the openness rate reached by Spain at the beginning of the 1890's represented an historical maximum until the 1970's. (Figure 2).

Figure 1
Nominal protection rates (%)
**Spain 1877-1926**
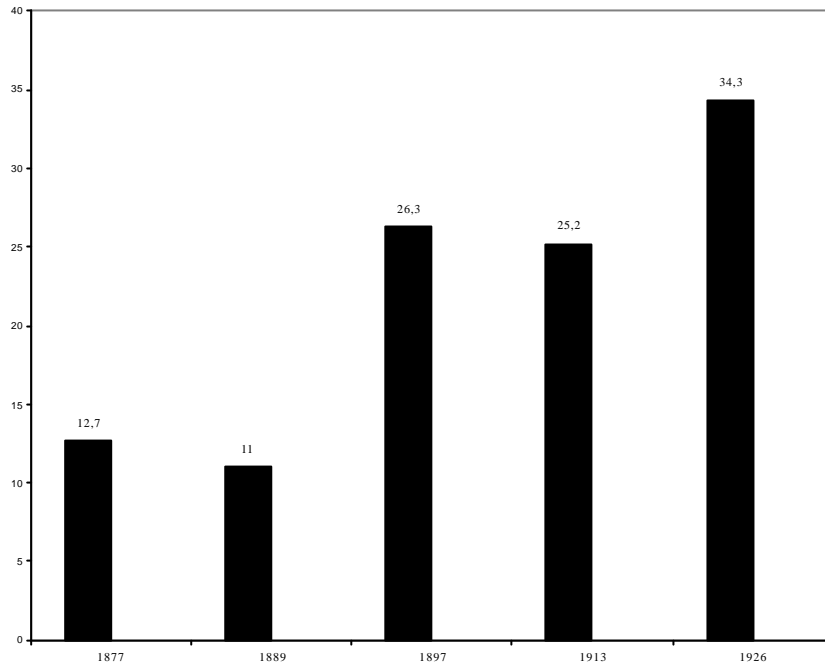
Source.- Tena (1999).

Figure 2
Openess rates (%)
Spain, 1869-1935

Source- Serrano Sanz (1997).

In these circumstances, the Spanish economy underwent a deep transformation of its regional production distribution. Figure 3 gives some evidence on this process through the

analysis of the aggregate levels in the geographical concentration of the industry during this period, measured through a synthetic indicator, the Gini location coefficient. There was a substantial increase in the geographical concentration of Spanish industry. As we can observe in Table 1, these changes not only occurred at the aggregate level but also in almost all the industrial sectors in which we can disaggregate industrial production.

Figure 3
**Indexes of geographical concentration of industry. Spain 1856-1929**
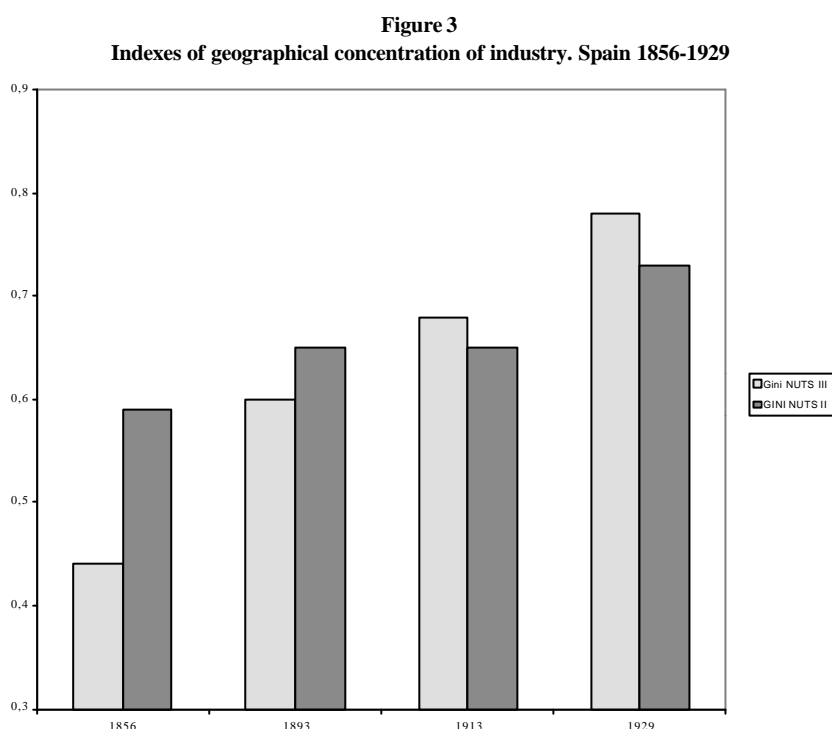
Source.- Paluzie et al. (2002)

Table 1.
Gini indexes of geographical concentration by sector

NUTSIII	1856	1893	1907	1913	1929
Alimentary	0.34	0.43	0.45	0.55	0.65
Textiles Leather	0.73	0.87	0.88	0.91	0.94
Metallurgy	0.71	0.79	0.78	0.83	0.89
Chemistry	0.61	0.66	0.69	0.73	0.87
Paper	0.76	0.70	0.69	0.75	0.85
Glass and Ceramics	0.48	0.54	0.58	0.66	0.78
Wood	0.86	0.72	0.67	0.67	0.65

Source.- Paluzie et al. (2002).

As for the geographical localization of this increasingly concentrated manufacturing production, Figure 4 proves the appropriateness of the phrase used by economic historians: Catalonia became Spain's factory. In the Principality of Catalonia, a meteoric growth in industrial production entailed a considerable increase of the share of Catalan output in overall Spanish industrial production. In 30 years, Catalonia's contribution to Spanish industrial output rises from 25% to 40%.

Figure 4
IPICAT vs. IPIES (%)
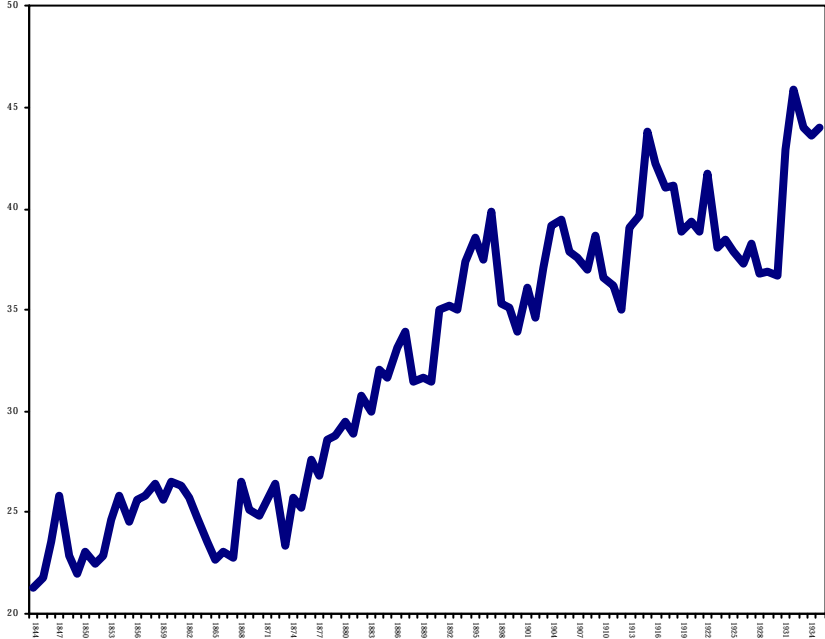
Source.- Own elaboration.

Among Catalan regions, it was the area around Barcelona, the historical capital-city, that concentrated the majority of this spectacular growth. According to data coming from fiscal sources, the coastal province of Barcelona, which had a long history of trade and

manufacture, increased its share in Spanish industrial output from 18,56% in 1856 to 33% in 1893.[1]

Previously, in Tirado et al. (2002), we tried to explain this evidence for the period 1856-1893. Particularly, we sought to analyze the determinants of the industrial specialization of Spanish provinces and its changes along that period. From the analysis, we deduced the importance of two kind of variables. On the one hand, the relative endowment variables, specially human capital. On the other, those variables linked to the existence of scale economies, captured through average firm size and the market potential of each province. Finally, the comparative analysis of the determinants in industrial specialization in two points of time, 1856 and 1893, showed that, as economic integration progressed, the explanatory power of the scale economies variables was increased. In this paper, we will try to look deeply into this topic.

Nevertheless, here we also pretend to extend the analysis temporarily. This forces us to explain a series of changes in the institutional framework described that had possible implications in the location of Spanish industry. Thus the last decade of the century sees a radical change in terms of Spanish economy integration in the external markets. On the one hand, in 1883, the gold convertibility of the peseta is abandoned, thus debilitating Spanish place in the international capital markets. On the other, from 1892 on, the return to protectionism documented in Figure 1, poses a serious threat to external integration. The results of this new turn in the tariff regime can be noted soon. From 1895, the openness rate of the Spanish economy follows a new tendency, this time a decreasing one. (Figure 2).

In fact, those are the first signs of what has been called "the nationalistic road in Spanish capitalism": a policy that encouraged domestic production through protectionism and an

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[1] The variable used to compute these percentages is the quota paid by the province of Barcelona in the tax payments corresponding to the *Contribución Industrial y de Comercio, Tarifa 3ª* (Industrial and Commercial Contribution, third tariff). In this respect, we have to point out that Spanish total tax payments do not include the Basque Country and Navarre (with its own fiscal regime these regions were exempt from the payment of this tax). Hence, the indicator overestimates Barcelona's share in Spanish industrial output. This is not the case of the series plotted in Figure 4, calculated from estimates of Catalan and Spanish output. However, these estimates do not allow to distinguish Barcelona's production from the overall Catalan production. In any case, both indicators reflect a considerable rise of Barcelona in Spanish industrial map.

increasing public intervention in favor of industrial production. The instruments employed to these aims have been analyzed in detail by historians. For instance, Maluquer (1987) and Comín (1996) have highlighted the promotion of incentives for industrial development through market regulation and the direct intervention of the State in the industrial sector through public expenditure, though at a reduced scale.

The most important expressions of this new model of development are to be found in the interwar years. At this moment, the response to the overproduction crisis that follows the special situation caused by Spain's neutrality in WWI, was a further increase in tariffs in order to protect Spanish industry (Cambó's tariff, 1922) and the implementation of infrastructure projects of investment that not only reinforced internal market integration but also increased demand for some domestic industrial sectors (Palafox, 1992).

Summarizing, during the period 1892-1931, the integration of the domestic markets of goods and factors was reinforced, but now in a context of relative closeness. In this context, the geographical concentration of industries continued to follow an increasing tendency. So, in Figure 3 we can observe further increases in the geographical concentration of industries in 1913 and 1929, dates for which these kind of data are available. This tendency is also verified at a higher level of disaggregation. As we can see in Table 1, five out of seven sectors increased its levels of concentration during those years.[2]

In addition, during this period some relevant changes in the geographical location of industry start to show up. As can be observed in Figure 4, Catalonia's weight in Spanish industry, aside from some exceptional situations like WWI or the first years of the 2nd Republic, reaches a standstill at the end of the 19th century.[3] As for Barcelona, 1913 and 1929 data show that its weight in Spanish industry stabilizes: in 1913, this province's

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[2] In 1913 and 1929 the indexes are constructed using the information elaborated by Betrán (1995).

[3] In this respect, historians have documented the transitory expansion of several sectors in Catalonia due to the extraordinary demand from countries engaged in WWI. This would be the case of sectors like leather tanning and wool textiles. As for the growth in Catalonia's weight during the first years of the Republic, Palafox (1992) attributes it to the crisis in the sector of basic goods and the change in expectations generated by the new regime but not to a progress in the production of the sectors located in Catalonia.

contribution to Spanish industrial production was 27,63%; in 1929 it was 28,55%. Its relative growth, quite remarkable during the period 1856-1893, had stopped.

On the contrary, a new group of territories begins moving forward in Spanish industrial structure: the Basque provinces of Guipuzkoa and Biscay, Saragossa and Madrid, the capital city and geographical center of the Spanish state. (Betrán, 1999).

To have a more complete picture of the changes in industrial geography that occur in the interwar period, we construct another index of industrial location: the industrial intensity index. This index is calculated as the ratio between the proportion of industrial activity that takes place in each territorial unit and the proportion of total population living in this unit.

$$INTENS_i = (C_i/\Sigma C_i) / (POP_i/\Sigma POP_i)$$

where C_i is the province's industrial production and POP_i is province i's total population. Hence, an index larger than one indicates that the province is specialized in industry, i.e., the relative weight of industrial activity is larger than that of the population. In contrast, an index of less than one would indicate that the province is not specialized in industry.

In Figure 5 we plot the geographical distribution of this index in 1856, 1893, 1913 and 1929. We observe an interesting evolution of this index. First, the number of provinces that show industrial specialization diminished considerably between 1856 and 1893, from 14 to 9 and in 1893, with the exception of Madrid and Sevile, they all belong to the coastal periphery and 3 out of 4 Catalan provinces show industrial specialization. In 1913 there is a further reduction in the number of provinces specialized in industry (8) but now it is the periphery that looses weight in the benefit of Madrid and the Basque Country (that was excluded from the sample before). Finally, in 1929, the number of provinces specialized in industry is only 7, the periphery continues to loose weight, Barcelona is the only Catalan province still showing industrial specialization and Saragossa, a more central territory, shows industrial specialization for the first time.
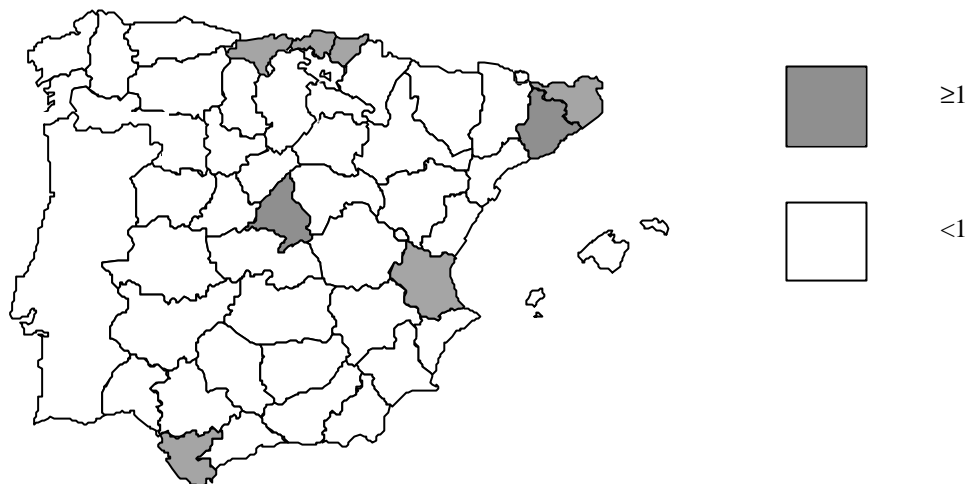
Figure 5

5.a) Industrial intensity indices in 1856
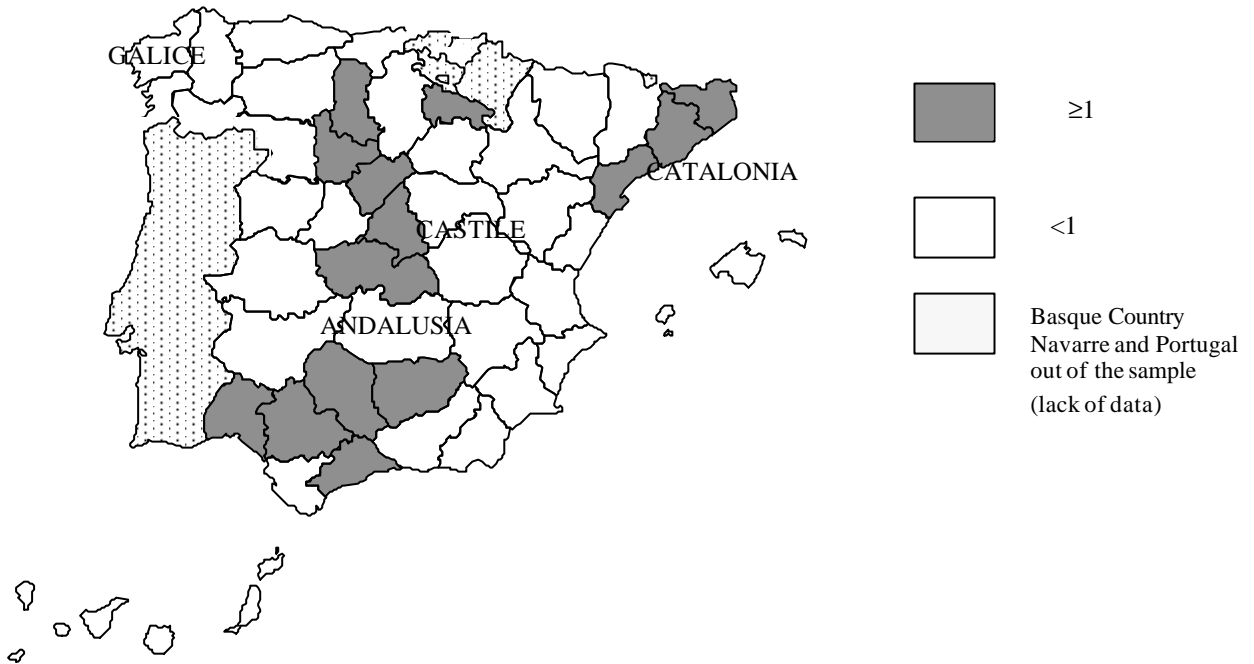
5.b) Industrial intensity indices in 1893
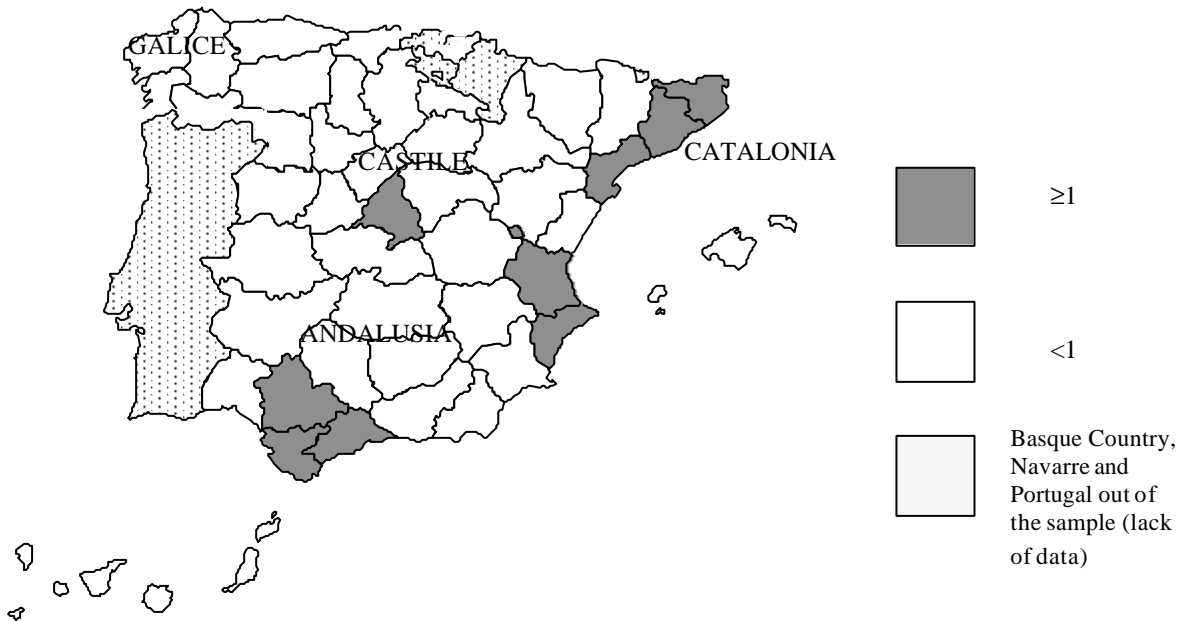
5.c) Industrial intensity indices in 1913

5.d) Industrial intensity indices in 1929

Figure 6 plots the comparison between Madrid and Barcelona's industrial production. During the second half of the 19th century, Madrid's weight relative to Barcelona decreases from 22% to 15%. The change in this tendency starts at the turning of the century. However, Madrid's most important advance occurs in the period between WWI and the Great Depression.[4]

Figure 6
Madrid vs. Barcelona (%)
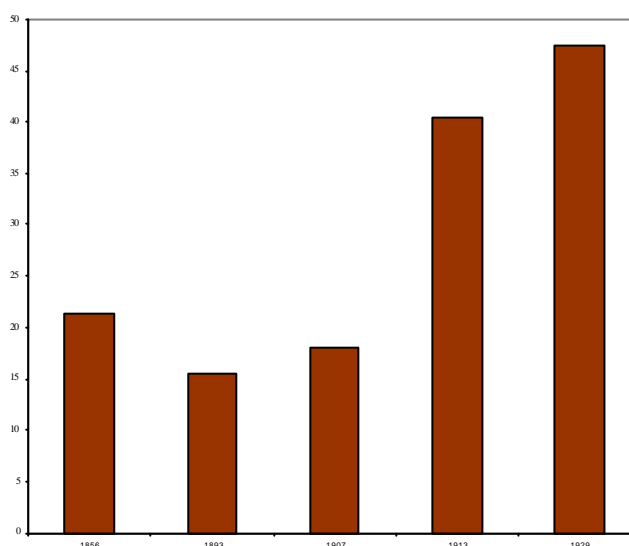
Source.- Own elaboration.

The situation described reflects accurately some of the "new economic geography" theoretical predictions presented in the previous section. This will allow us to establish some explanatory hypothesis about the determinants of this evidence.

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[4] Figure 6 plots Madrid's relative weight to Barcelona in Spanish industrial output estimated from fiscal sources. In this respect, 1856, 1893 and 1907 data are constructed from the *Contribución Industrial y de Comercio, tarifa 3ª*. However, 1913 and 1929 data add a new tax, the *Contribución de Utilidades*, a compulsory new tax on industrial corporations introduced in 1909 (Betrán, 1995). Given this difference in the sources used we have to be cautious in the interpretation of the evolution between 1907 and 1913. However, what we want to analyze in our paper is the beginning of a catching-up between Madrid and Barcelona from the end of the 19th century. This tendency is maintained independently of the bond in levels caused by the change in the source.

In particular, our paper poses two explanatory hypotheses. First, we claim that a growing integration of the domestic market and the existence of increasing returns in industrial production, in conjunction with demand linkages (home market effect) and supplier linkages (specially in raw materials), favored the growth of productive agglomeration during the second half of the 19th century and the first third of the 20th century.

Second, we propose a new explanation for the evolution in the location of this increasingly concentrated industry. Barcelona became the first industrial pole thanks to domestic market integration in a context of increasing openness. However, the nationalistic reaction to the turn-of-the-century crisis reinforces domestic market integration but this time in a context of high tariff barriers. Under this new policy, growth in concentration is linked to the appearance of new productive locations. In particular, those better placed to serve the internal market both for good sales and for the supply of raw materials. These circumstances explain the continuous growth in industrial concentration and the beginning of a change in its location. Barcelona continued to be the country's main industrial center, but we observe the relative growth of other locations such as the Basque Country, Saragossa and Madrid, and a relative decline of the regions located in the Mediterranean periphery.

In what follows, we discuss the validity of this hypothesis through the analysis of one of the structural implications of the models previously described: i.e. the existence of a wage gradient centered in the main productive center and its evolution along the process.

4. Empirical analysis

Previously, in Tirado et al. (2002), we tried to test the importance of market size in the making of an industrial cluster around Barcelona in the second half of the 19th century. We concluded that Barcelona's rising as the main industrial center in Spain was linked to the existence of some initial comparative advantages that made the Catalan city a privileged location for the industrial processes characteristic of the first technological revolution. These initial advantages, in the presence of scale economies, favored the genesis of an

industrial agglomeration around Barcelona in a scale much larger than what purely endowment considerations would have suggested.

Yet the methodology used in that study shared the problems highlighted in recent surveys of the empirical new economic geography (Overman et al. (2002), Combes and Overman (2003), Head and Mayer (2003)): this kind of regressions lack sufficiently solid theoretical foundations. Here we want to ease this problem by focusing more directly in one of the structural implications of this kind of models, i.e. the generation of a gradient in the geographical structure of nominal wages centered in Barcelona, the main industrial center in Spain during this period.

These critiques could also be applied to some recent studies on the importance of scale economies in explaining the geographical concentration of the industry, written by historians. Among them, two stand out: that of Broadberry and Marrison (2002) on the British cotton textiles and its high concentration in the Lancashire and that of A'Hearn (1998) on the factors that explain regional inequalities in industrial location in Italy. In the Spanish case, one stands out: that of Betrán (1999) on the role of scale economies in explaining inequalities in the growth of the industry in the Spanish provinces during the period 1913-1929.

What distinguishes our approach from these recent economic history studies is a more close link with the new economic geography theories both in the kind of analysis used (the test of the existence of nominal wage gradients) and in the interpretation of the descriptive evidence we have.

In addition, we also discuss the changes in geographical location due to the increase in tariff protection from the end of the 19th century. From the models discussed in Section 2 we would expect the rise of new productive centers and the weakening in the wage gradient centered in Barcelona.

Hence, we are following a line of research opened by Hanson (1996, 1997) that has focused on the Mexican industry. Hanson analyzes the effects of trade liberalization on industrial location in Mexico. In particular, he shows how trade reform has implied a weakening in the role of the central metropolis, Mexico City and the rise of some locations closer to the U.S. border. The Spanish case in the interwar period could give us evidence on a similar but inverse process. The closeness of the Spanish economy would favor the loss of centrality of the coastal location (Barcelona) and the relative rise of central locations (Madrid).

To perform this analysis we have nominal wage data for 47 Spanish provinces in 1914, 1920, 1925 and 1930 from the *Estadística de Salarios y Jornadas de Trabajo* published by the Ministry of Labor and Prevision (Ministerio de Trabajo y Previsión) in 1931 (from now on ESJT). This source, used in other economic history studies (Rosés and Sánchez-Alonso, 2002, Silvestre, 2001), gives provincial data on hourly wages for different workers categories coming from surveys.

Figure 7 plots the geographical distribution of the average nominal wage for manufacturing non-skilled workers in 1914 and 1930. In 1914, we observe a wage gradient centered on Barcelona in the Mediterranean axis (Catalonia, Valencia and Balearic Islands). In 1930, the Mediterranean wage gradient is considerably weakened. We observe also the growth in the wages of other areas such as the north (Basque Country and Asturias) and the Ebro Valley (Aragon and Navarre).

Figure 7

Nominal wages, non-skilled manufacturing workers, 1914

■	$w > a + \sigma$
▨	$a \quad w \quad a + \sigma$
□	$w < a$
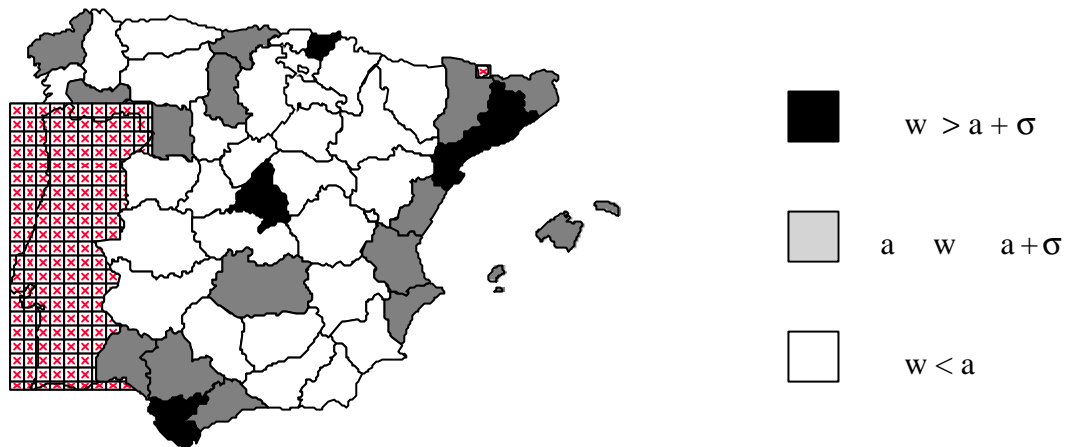
Nominal wages, non-skilled manufacturing workers, 1930

■	$w > a + \sigma$
▨	$a \quad w \quad a + \sigma$
□	$w < a$
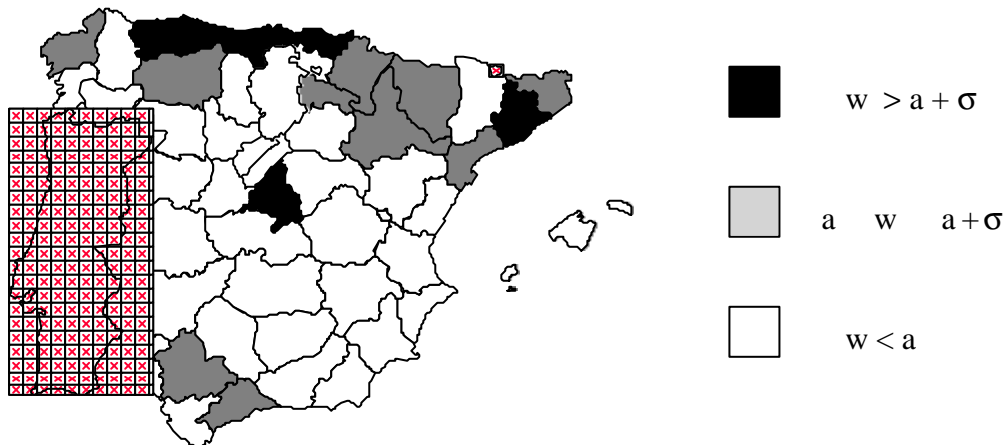
Note: w is the nominal wage in each province for non-skilled manufacturing workers, a is the Spanish average wage for non-skilled manufacturing workers and σ is the standard deviation

In the empirical analysis, the functional form proposed allows us to test the hypothesis posed in Section 3. We specify the existence of a log-linear relationship between the structure of nominal wages and the transport cost between each location and the main industrial center, Barcelona. Thus, following Hanson (1996), we have:

$$\log (w_{ijt}/w_{cjt}) = \beta_0 + \beta_{1t} \log (d_i) + \mu_{ijt} \tag{1}$$

where w_{ijt} is the nominal wage for sector j, in region i, at time t, w_{cjt} is the central region (Barcelona) wage for sector j at time t, d_i is unit transport costs from region i to Barcelona, and μ_{ijt} is the error term.

The theoretical predictions are that $\beta_{1t} < 0$ and that over time, Barcelona's centrality being weakened, the absolute value of this parameter will be reduced so that $|\beta_{1t-1}| > |\beta_{1t}|$.

We will use the wages of skilled manufacturing workers in 8 manufacturing sectors (Metallurgy, Chemistry, Textiles, Electricity, Apparel, Wood, Transports and Furniture), 4 points in time (1914, 1920, 1925 and 1930) and a number of provinces that on average represents 35% of Spanish geography. From this information, we have estimated the sectoral wage for the provinces for which we don't have direct data using the existing sectoral data and the data on average provincial wage for skilled manufacturing workers that the source also gives. Thus, the data base used in the analysis is composed of observations on 4 years, 8 manufacturing sectors and 47 provinces.

As for transport costs, the available information only allows us to proxy them with distance variables. Thus, in the exercise we use the distance by railway between the province's capitals in the period analyzed.

In relation with the strategy followed in estimating equation (1), we have to signal the existence of a problem linked to the existence of idiosyncratic components in the error term. Following Hanson (1997), we assume the error term has the following form:

$$\mu_{ijt} = \varepsilon_i + \omega_j + \phi_t + \eta_{ijt} \tag{2}$$

where ε_i is the fixed effect for region i, related to the specific characteristics of the region, ω_j the fixed effect for industry j, ϕ_t is the fixed effect for year t, and η_{ijt} is an i.i.d. term with mean zero and variance σ.

With the available information we can estimate equation (1) with industry and year dummies in the regression, so as to exclude them from the error term. From this functional form, we will test the existence and structural stability of the parameter that defines the wage gradient centered in Barcelona. Table 2 gives estimation results.

In all regressions we verify the existence of a wage gradient centered in the main industrial center, Barcelona. The estimated parameter of the variable DistBarcelona is significant and negative. Its quantitative value indicates that a 10% increase in the distance to Barcelona leads to a reduction in the relative nominal wage comprised between 0.27 and 0.35%.

Table 2

Regression results for relative nominal wages by sectors

Variable	1	2
log (DistBarcelona)	-0.026 (0.000)	-0.035 (0.000)
log (DistBarcelona)*D2530		0.018 (0.085)
Adjusted R^2	0.388	0.391
N	1472	1472

Note.- All regressions include year and industry dummies. We do not report their estimated values. In parenthesis we indicate the level of significance for which we reject the hypothesis null of a parameter equal to zero. Standard errors estimated by White's heteroskedasticity consistent method.

In column 2 we include a multiplying dummy that interacts distance to Barcelona with the observations corresponding to 1925 and 1930 (DistBarcelona*D2530). The inclusion of this variable allows us to test the existence of a structural break in the estimated values of the parameter on the distance to Barcelona. The estimated parameter is positive and significant at the 10%. This is evidence of a weakening in the wage gradient centered in Barcelona over that period. The values associated to 1914 and 1920 observations are significantly higher, in absolute terms, to 1925 and 1930 values. [5]

To check the robustness of the regressions results to the regional fixed effects described in equation (2), we reestimate equation (1) replacing the distance variable with province dummy variables. The explanatory power of the model increases considerably (adjusted R^2 increases to 0.711). This indicates the existence of other specific characteristics of the provinces that matter for relative wages. So, in order to test the importance of distance in explaining these specific characteristics of the regions, we regress the estimated province dummies on the distances vector. The results are as follows:

$$\omega_i^{fe} = 0.374 - 0.025 \log (DistBarcelona)$$
$$\quad (0.044) \quad (0.037)$$

R^2 adj.= 0.495

N= 46

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[5] We also tested the possible genesis of a wage gradient centred in Madrid. The results were not conclusive. The estimated parameter on distance to Madrid was positive and significant. So we could conclude that industrial agglomeration did not benefit from geographical centrality during this period. However, we expected a change in this situation over time due to the closeness policy. We tried to capture this through the inclusion in the model of a multiplying dummy: DistMadrid*D2530. We verified that this variable parameter has the expected sign, negative, though it was not significant.

where ω_i^{fe}, is the estimated province effect for province i and DistBarcelona is the distance variable. In parenthesis we indicate the significance level for which we reject the null hypothesis of a parameter equal to zero.

We verify that the distance variable explains a high percentage of the variance in fixed province effects, thus suggesting that transport costs, as measured by distance, are an important characteristic of provinces to explain the geographical structure of relative nominal wages.

The importance of exogenous characteristics of regions, such as its endowment of natural resources, in explaining the geographical structure of nominal wages does not have to be undermined. However, in the case of Spain, this cannot be an explanatory factor for the existence of a gradient centered in Barcelona because this region lacked natural resources. On the contrary, it is an important explanatory factor for the growth of nominal wages in the northern region (Basque Country and Asturias) because this region had natural resources such as coal. The increase in trade costs (and moreover the prohibition of imports of some intermediate goods and raw materials) would had lead firms to locate near the natural-resource concentration in order to serve the market created by the agglomeration of natural-resource intensive industries (steel in the Basque Country).

Another source of regional wage differentials might be government policy. If there is a concentration of government activities in a city or region, local wages will increase and a regional wage gradient will emerge. In the case of Spain this could explain the emergence of a wage gradient centered in Madrid, the capital, but not that of Barcelona, the wage gradient whose existence is verified in our empirical analysis.

Overall, the empirical analysis supports the hypothesis of the existence of a wage gradient, centered in the province of Barcelona, explained by the existence of transport costs, and of its weakening over time along the period 1914-1930.

5. Conclusions

This paper has shown how the geographical location of Spanish industry underwent relevant changes in the years comprised between the mid 19th century and the *Guerra Civil* (Spanish War). On the one hand, we observe a continuous growth in its geographical concentration along the period. On the other, we can distinguish two stages in the location of the main industrial clusters. The second half of the 19th century sees Barcelona's consolidation as the main industrial center in Spain. However, by the turn-of-the-century, the central role of the Catalan capital was eroded in relative terms because of the progress of new industrial poles, like Guipuzkoa, Biscay, Saragosse and Madrid. In addition, this paper has tested the existence of a gradient in the geographical structure of nominal wages in Spain in the interwar period centered in the main manufacturing cluster, Barcelona. We have also verified a weakening in this gradient over time.

From this evidence and the implications of some of the new economic geography models, it is possible to give an interpretation on the determinants in the evolution of geographical concentration and location of the Spanish industry during those years. A high industrial concentration around Barcelona was the result of both some initial advantages and a cumulative causation process linked to the increasing role of scale economies in production. Furthermore, we observe that the abandon of a liberal trade policy at the end of the 19th century and especially along the interwar period, implied a weakening of Barcelona's role and the relative growth of other locations.

Thus, this paper brings new insights in order to explain Madrid's rise as an important industrial center in Spain. Historians have pointed out to some irrefutable facts such as its being the capital-city and the main communications hub. Yet they have not been able to explain why the relative rise of Madrid begins with the turn of the century and not before or afterwards. On this timing we have suggested a new explanatory hypothesis, though the evidence found is not conclusive yet. The progressive closeness of the Spanish economy tended to weaken the privileged position of the coastal regions and favor the rise of central

regions. If we consider this change in the trade policy regime, we are able to explain the precise chronology of Madrid's relative rise.

As for the theoretical debate, the Spanish case in the first industrialization wave illustrates the effects of the closing of an economy to international trade, precisely the opposite trade policy change that has been analyzed recently by the literature. We observe that the new scenario did not imply a reduction in the geographical concentration of production as measured by the Gini indices. However, we have also observed a higher dispersion in the industrial centers that concentrate the industry. Our analysis is not conclusive in shading light in the theoretical debate generated by Krugman and Livas (1996) hypothesis of protectionism as a promoter of regional inequalities. However, the most important changes that occurred during this period are the changes in the location of the main industrial agglomerations. The new trade regime favored a weakening in the leading role of the coastal region, Barcelona, that had concentrated an increasing share of Spanish industrial output during the period of greatest opening to foreign trade; thus we verify Crozet and Koenig-Soubeyran (2002*a*, 2002*b*) recent hypothesis on the effects of trade policy changes when one of the regions has a pronounced advantage in terms of its access to international markets.

Finally, we would like to point out that, in our further research, we have to confirm our hypothesis, by analyzing Spanish recent experience in the second half of the 20th century of a trade liberalization reform.

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