Social Networks of Innovation in the European Periphery: Exploring Independent versus Corporate Patents in Spain circa 1820-1939

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Abstract: »*Soziale Netzwerke der Innovation in der Europäischen Peripherie. Erforschung unabhängiger vs. Firmenpatente in Spanien ca. 1820-1939*«. There is a widespread idea that corporations have completely taken over invention and innovation processes throughout the twentieth century, thus becoming the main users of patent systems. However, recent studies suggest that, in spite of corporate expansion, independent invention is still economically significant nowadays, and that individuals outside the boundaries of the firm were actually the principal source of innovation before World War II. This article analyzes the history of corporate and independent patents in Spain in the long-term, in order to confirm that independents were also very relevant to promoting innovation and technology transfer in latecomers with high rates of technological dependence. Employing a new method of work with patent files, we also offer new historical evidence of the structure, effectiveness and scope of emerging international social networks of innovation. After introducing the research framework, Section Two briefly summarizes the characteristics of the Spanish patent system, and compares corporate and independent patents taken out between 1820 and 1939. Section Three studies the duration and strength of independent patents and the structure of the communities of innovation, and the conclusions make up Section Four.

Keywords: patents, innovation, Spain.

1. Introduction

According to most economic and historical literature related to invention activity and innovation processes, firms and corporations have become lead actors in technological shifts and economic development. A fairly widespread impression is that from the so-called 'second industrial revolution', beginning in the late nineteenth and early twentieth century, large-scale enterprises and multinationals have taken over from independent inventors and individual

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entrepreneurs as the main source of creativity and inventiveness. Progressively, in-house R&D laboratories replaced workshops and garrets as places of investigation, experimentation and testing. Likewise, multinationals increasingly gained control of patent ownership and management, taking over the exploitation and commercialization of new technologies and spreading international technology transfer and innovations (Fisk 2009). The results were, and continue to be, technological and economic globalization. There seemed to be no intelligent life outside the multinational and multidivisional firms. Only some very powerful industrial districts, small knowledge-based enterprises and a few ingenious inventors might compete with those giants in certain areas from time to time, without calling corporate innovation into question.

This perception arose from the writings of J. A. Schumpeter (1942), who, in the decade of the 1940s claimed and complained that large firms would eventually displace the entrepreneur, the hero of free capitalism and innovation, thus provoking unintended consequences for the entire society. Notwithstanding, strong economic growth and technological progress during the 'golden age' after World War II, which was especially based on the expansion of large American, European and Japanese corporations, set aside Schumpeter's predictions up until the international crisis of the 1970s and early 1980s (Hannah 1976; Chandler 1977). The new corporate economy had come into existence, and during the 1990s the process of globalization occupied the front pages of both specialized newspapers and academic books, as business schools and economic faculties taught and reflected on the new dynamics of capitalism (Chandler 1990). Corporate innovation and international patenting, more and more complex and industrially interrelated, appears to have become the main engine of technological change and of the springboard of entire new scientifically-based sectors (Andersen 2001, chap. 7-8).This 'neo-Schumpeterianism' has definitively placed the corporation in the center of the map as the genuine object of study, eliminating any remaining independent inventors or entrepreneurs outside the in-house laboratories and the managerial structure.

Thus, although there are thousands of historical and current studies focused on the innovation and enterprise, in any country and sector, there is a lack of research related to the beginning of this story; that is, the role of independent invention in world technological development. Only very recently some scholars have begun to be concerned with and analyze the phenomenon in pioneer countries as to its economic and social consequences. Z. Khan and K. Sokoloff (2004) reflected on the significant historical contribution of great individual inventors to the progress of technology. Studying the US patent system between 1790 and 1930 and the education level of individual patentees, the authors outline how invention rapidly turned in a 'democratic' activity as patent institutions guaranteed effective protection to anyone independently of their social origins or status (see also Khan 2005). N. Lamoreaux and K. Sokoloff (2005) have continued that work, demonstrating how the decline of independ-

ent invention during the first half of the twentieth century was the cause of the decrease in total US patents per capita, as corporations progressively absorbed these talented individuals by means of acquiring their patent rights throughout long-term contracts or directly employing them in their R&D labs. From another point of view, C. Macleod (2007) has demonstrated how independent inventors were glorified in Britain before World War I as the new heroes of the British economic empire, something that declined during the interwar period onwards, precisely when corporate invention expanded and the social role of scientists arose.

Finally, T. Nicholas' insight (2010, 2011) has gone more deeply into the issue, demonstrating the relevant function of independent invention in the US, Britain and Japan between 1880 and 1930. During that last year, approximately half of the patents were still granted to single applicants in each of those countries, regardless of the significant differences in the cost of the monopoly or in the legal requirements (prior technical exams etc.). Furthermore, by exploring cross-patent citations and other quality indicators, Nicholas demonstrates that the technical quality of independent innovation was as high as that originated from firm-based research in the three countries. Thus, these questions seem to have also captured the interest of present-day economists and business management scholars, who are increasingly focusing on independent invention and entrepreneurship as a source of technical and economic progress and discussing its actual economic significance. The conclusions of "the return to independent invention", as T. Åstebro (2003) called it, are not clear yet. On the one hand, it certainly seems astonishing that during the first decade of the twenty-first century approximately one third of all patents are still granted to individuals outside the boundaries of the firm in most of the developed countries (Spear 2006; IFIA 2006)[1].On the other hand, almost all experts agree in pointing out the diversity of results obtained by independents, from high-relevance innovations to inventions that are apparently worth nothing (Åstebro 2003; Dahlin, Taylor and Fichman 2004; Meyer 2005). In general, individual inventors achieve less technological impact than corporations, except when they are very specialized, are users of the technology and are somehow related to the social networks of innovation within the sector (Lettl, Rost and von Wartburg 2009).

In spite of these recent studies, further research on the role of independent invention is needed. We do not know, for instance, the extent of the contributions of individual and corporate innovation in latecomers and undeveloped

[1] According to B. Spear, who studied completed term patents, one third of successful innovations in Great Britain between 1970 and 2003 were registered by independent inventors. The International Federation of Inventor's Associations (IFIA) claims that independent patentees applied for 25% to 50% of total resident patents in many countries during 2005 (Italy, UK, France, Sweden, Finland, Austria, Belgium, Ireland or Norway). See <http://www.invention-ifia.ch/independent_inventors_statistics.htm>.

countries with high rates of technology transfer. Were independents also able to activate processes of diffusion and transfer outside their domestic boundaries or is that the business of the multinational? Were local technicians, inventors, introductors and entrepreneurs in the lacking countries also essential for technological change? Which were those historical social networks of innovation at both local and international levels, if any, and how did they work? In this article we contribute to the topic by analyzing long-term independent invention in Spain, a latecomer at the European periphery. The method of analysis is also new. During the last ten years we carried out an enormous cataloguing task of each and every one of the 150,000 patents registered in Spain from 1820 to 1939, building up a detailed database from the original files at the Spanish Patent and Trademarks Office (OEPM)[2]. Thus, we have been able to distinguish reliably between corporate and independent inventions and to cross-reference that information with some innovation qualifiers such as the patent extension, obligatory working clauses, monopoly assignments, or with the professions of independents.

Our findings suggest, first, that independent innovation was also very relevant in latecomers and requires further research. Independents completely dominated the registration of patents in Spain before 1880 and they were still involved in more than half of the applications in the 1930s. This was particularly striking among residents, where independents largely outnumbered local firms even up until the first third of the twentieth century, although when patent length and implementation are analyzed, domestic firms demonstrated more effectiveness than domestic individuals. Secondly, the study suggests that non-resident independents and corporations from leader countries also had a significant and effective role in technology transfer to Spain, which confirms the independents' technical capacities in advanced economies. Finally, the analysis demonstrates that early international social networks of innovation were developed, linking pioneering engineers and technicians with domestic entrepreneurs and industrialists at the periphery.

2. Independent and Corporate Patenting in Spain

From the beginning, as seen in 1811, 1820 and 1826, the Spanish patent system was conceived in a rather hybrid manner. The legislation assured a basic normative framework in order to protect national invention activity as well as to attract foreign investors and entrepreneurs, individuals or firms, who wanted to

[2] See <http://historico.oepm.es> for further information. More than 70 people (graduated students, scholars and technicians) have been involved in the Collaboration Agreement between the OEPM and the Universidad Autónoma de Madrid (UAM) for cataloguing and studying the historical patent and trademark files.

extend their rights in Spain, but limiting that protection if it did not turn into actual innovation and industrial growth within the borders. This was implemented by two major means: regulating patents of introduction and, at the same time, establishing compulsory working clauses. The former could be used to protect foreign third-person technologies without their authorization in order to implement them locally, providing they were not already established in Spain. The latter required nationals and foreigners to put into practice, within national territory and over a period of one, two or three years, depending on the law, the inventions granted by any patent, otherwise declaring an expiration date and therefore making that technical knowledge public and of free usage. Although many countries used similar strategies during the nineteenth century, most abandoned them as they reached technological competence and international competitiveness. In Spain those characteristics remained until 1986, upon joining the European Union, and if we add the traditional judiciary weakness in prosecuting fraud against industrial property[3], it seems that the Spanish patent system has been rather weak until recent times. This was compatible with international agreements for the protection of industrial property, signed from 1883-1884 on, as Spain guaranteed the same treatment to foreign and domestic resident patentees, being six months before 1900, and one year of priority rights after that date[4].

Non-resident patentees have always had a strong presence in the Spanish innovation system, representing approximately 50% of the total patents in the second half of the nineteenth century and the first half of the twentieth, more than 70% after 1960, and more than 90% after entering the European Union in 1986, when the European Patent applications with reference to Spain went into effect (Sáiz 2005). Indeed, the presence of foreign technology in the patent system has been higher than the previous percentages, as many residents applied for 'patents of introduction' just to bring unimplemented technologies from abroad (that is, in order to manufacture them within Spain, as this kind of patent cannot block importations). If we add non-resident applications to resident patents of introduction, we obtain a figure of 65 and 70% of foreign technology presence between 1820 to 1939 (see Sáiz 2002, sec. 3). Thus, Spain has always experienced a considerable technological dependence and very high rates of technology transfer from abroad.

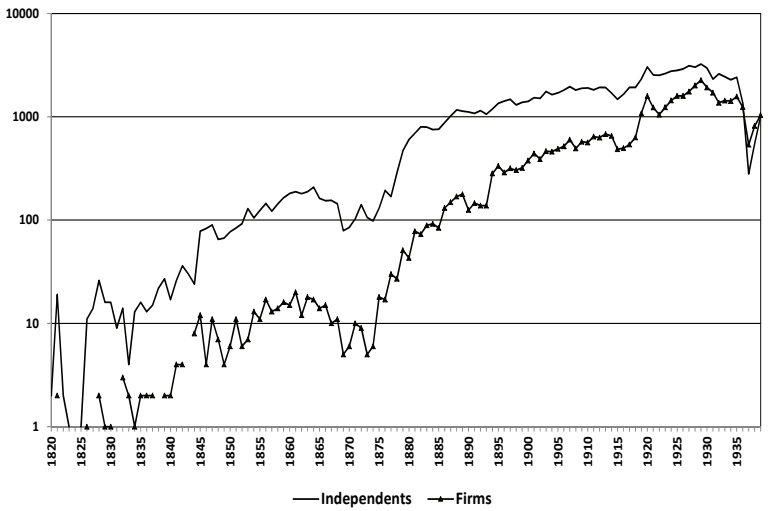
It is well known that during the nineteenth and twentieth centuries patent systems everywhere went through a progressive shift from being mainly used by independent inventors, skilled artisans, small-scale industrialists and entre-

[3] The first courts specialized in and focused on mercantile issues, including patents, trademarks and industrial design, do not come into operation in Spain until 2004 (Organic Law 8/2003, of the 9th of July).

[4] Further information on the historical characteristics, origins and evolution of the Spanish patent system can be found in Sáiz (2002).

preneurs themselves to being increasingly acquired by firms and corporations. By the second half of the twentieth century the vast majority of patents and new technologies protected in western economies were already owned by firms, which then employed inventors and scientists in their research departments. Apparently, the period between 1880 and 1939 was crucial in reversing patent ownership, especially in countries such as the US, Germany, the UK or France (Inkster 1991, 160-6; Cantwell and Andersen 1996; Andersen 2001, 28-34). Eventually, lagging economies followed the same pattern, as this first technological globalization took place and corporations from the North Atlantic extended their influence. Indeed, that seems the case of Spain, in which firms progressively increased their presence after 1875-80 and mainly during the final years of the nineteenth century and the 1920s, which was a decade of exacerbated protectionism and heavy industrialization under Primo de Rivera's dictatorship, when many foreign corporations arrived in Spain. Notwithstanding, inconsistent with that view is that approximately 50% of the patents were still granted to independent inventors in pioneer countries throughout the decade of the 1930s (Nicholas 2010, 57-8, 2011, 997) as also occurred in Spain and more than likely in other economies, which means that the predominant historiography has neglected half of this story.

Graph 1: Independent and Corporate Patents in Spain, 1820-1939



Source: *Archivo Histórico Nacional* y *Gaceta de Madrid* between 1820 and 1826. From 1826 to 1939: Original patent files at the OEPM. Independents: Patents applied for by one or more individuals; Firms: Patents applied for by firms alone or together with other individuals.

Table 1: Percentages of Independent and Corporate Patents. Spain, 1880-1939

	Individuals, %	Firms, %	Patents, n.
1820-1849	90.8	9.2	834
1850-1879	91.5	8.5	5,041
1880-1889	88.8	11.2	9,681
1890-1899	83.9	16.1	14,913
1900-1909	78.0	22.0	21,811
1910-1919	74.4	25.6	24,965
1920-1929	64.5	35.5	44,338
1930-1939	58.3	41.7	31,284

Source: See Graph 1.

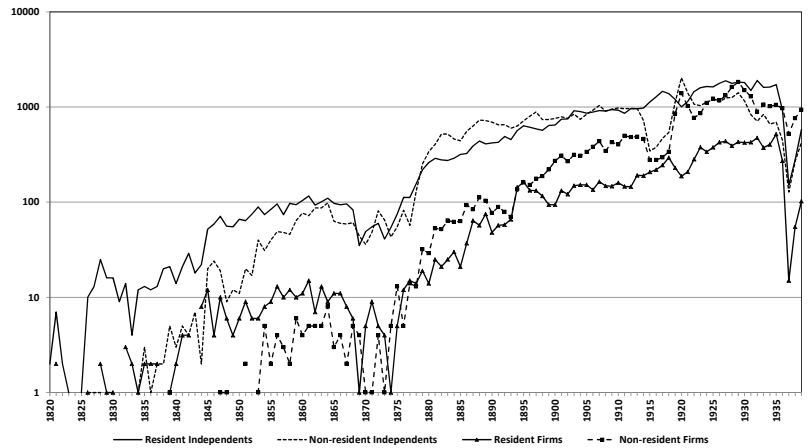
Graph 1 establishes the long-term evolution of patents applied for by independents and firms in Spain. The corporations' catching-up process is noteworthy, particularly after the 1880s, which has mainly attracted the interest of research scholars, but firms never outnumbered total independent patents. From 1880 to 1930, the Spanish economy improved and expanded under intense protectionism and governmental support for 'national' industrial production, meaning domestic and especially foreign firms installing factories within national territory. Spain strongly benefitted from World War I, first because of the increase in value of direct industrial and services exports during the conflict, which yielded enormous profits for firms and entrepreneurs, secondly because of the import-substitution phenomena in times of war, and finally because Spain's neutrality also attracted capital, bank branches, firms and skilled human capital from abroad. These foreign investments, together with national accumulated capital, would play a significant economic role in the industrial expansion (especially of heavy industry) of the 1920s, the decade in which corporate patents rapidly increased.

However, the unforeseen and neglected side of the coin is that individual patentees always stood out during the entire period studied. Independents completely predominated before 1880, with an average of 90.1% patents, compared to only 9.9% applied for by firms, the majority of the latter being small family companies with limited partners and only a few eventually being incorporated (see Sáiz 1999, 163-9). Thus, most of the nineteenth-century innovation businesses-based less on domestic invention activity than on foreign technology transfer-related to the first Spanish industrialization and modernization process were mainly developed by independents. Furthermore, albeit their proportion constantly decreased from 1890 to World War I and during the 1920s, it still remains true that independents applied for the majority of patents before World War II (see Table 1). As we already know, the same phenomenon was occurring in the US, UK and Japan, and more than likely in other countries. We would certainly not be mistaken if we point out that even during the second industrial revolution, among the 'visible hand' and the research labs, an enor-

mous share of the innovation processes were still achieved in small workshops and in-house basements.

Although the general trends of the Spanish patent system have been widely analyzed in previous studies (Sáiz 2002), it is necessary to point out here the repercussion of the financial crisis of 1864-1868 and the economic changes brought about by the Restoration of the Monarchy after 1876 (see Graphs 1 and 2). We must especially refer to the patent law of 1878, which introduced a system of progressive annual quotas that, in practice, provided an enormous savings in patent rights, since only first-year fees were required to make it effective. Likewise, the 1883 international agreement on industrial property must be mentioned, as it reinforced protection for foreign patents. Thus, from that time on, there was a continuous increase in applications and grants, both domestic and, even more so, foreign, in response to legal and socio-economic improvements and to the general increase of inventions and patents in the world. There were critical periods, during the general crisis of the end of the nineteenth century or during World War I, but patent growth slowed down noticeably in Spain at the end of the 1920s, caused in part by the decline of the international economic panorama after the crisis of 1929 and the 1930s recession, which influenced foreign patentees, but mostly by a sharp domestic deterioration in political and social conditions that led to Franco's military coup and to the Spanish Civil War (1936-1939), which entailed a rapid economic collapse, while patent series dropped off.[5]

Graph 2: Independent and Corporate Patents in Spain by Residence, 1820-1939



Source: See Graph 1.

[5] For the strong influence of wars on patent series, see Diebolt and Pellier 2012.

In Graph 2 we disaggregate independent and corporate patent data by applicant's residence. As is demonstrated, Spanish resident independents dominated resident firms by and large during the whole period studied, apparently being the main source of domestic patent activity and technology transfer. Nevertheless, among non-residents the bias was slightly different. Although foreign independents also played a key role after 1850, and particularly between the decade of 1880 and 1914, foreign companies constantly climbed up the patent registry from the middle of the 1890s onwards, and remarkably after World War I, when they outnumbered foreign independent patents. Therefore, the data confirm, firstly, that individual patenting, both domestic and foreign, deserves more attention than we have currently paid to it in order to understand the processes of innovation at the European periphery. The actual role of those social networks of technicians, businessmen and small entrepreneurs in the modernization process, as well as their international connections and agents, should be included in the specialized scholars' research agenda. Secondly, the series also corroborates that foreign rather than domestic corporations also made a relevant contribution to the process of technological diffusion and technology transfer to Spain after 1890, especially in the 1920s and 1930s. Although this has been much more deeply considered by historiography, we still lack studies as to how that corporate action took place and which patent and business strategies were followed, especially within latecomers and underdeveloped countries.

If we focus now exclusively on corporate patenting (Table 2), we are able to verify that the presence of Spanish firms was proportionally diminishing from approximately 70% before 1880 to just 22.6% between 1920 and 1939, as also occurred with French companies taking out patents in Spain. France dominated foreign investment in Spanish IPRs until 1900 (20-23%), but dropped quickly during the first decades of the 20th century as German, USA, British and even Swiss and Dutch corporations occupied its place, corroborating their increasing international technological expansion during the second industrial revolution. Approximately 50% of all corporate patents in Spain between 1820 and 1939 were taken out by firms from those five countries (65%, if we add France). Notwithstanding, only comparing these figures with those of independent patents (see Table 3) allows the whole picture to emerge. First, we cannot forget that independents registered 2.5 times as many patents as corporations during the total period studied. Second, the majority of the patentees were Spanish residents (an average of 55%) with an outstanding presence of French residents (12.2%). Finally, although there were also independents from the rest of the countries considered (i.e. Germany, UK, USA, Switzerland, Netherlands and others) they were proportionally less represented than firms (just 23% of independent patents from those five countries mentioned).

Table 2: Percentage of Corporate patents in Spain by Firm's Country of Residence, 1820-1939

FIRMS	1820-1939 %	1820-1879 %	1880-1899 %	1900-1919 %	1920-1939 %
Spain	26.5	68.0	40.1	30.6	22.6
Germany	21.8	3.6	16.1	20.8	23.2
France	14.5	23.1	20.7	15.2	13.3
USA	10.7	0.4	5.6	9.5	11.9
UK	10.0	2.0	6.6	10.3	10.5
Switzerland	4.8	1.0	2.6	3.4	5.7
Netherlands	2.8	0.0	0.3	0.6	4.0
Italy	2.5	1.0	1.4	2.3	2.7
Belgium	1.7	0.4	3.9	2.2	1.3
Sweden	1.2	0.0	0.3	1.0	1.3
Austria	0.8	0.0	0.9	1.2	0.6
Rest	2.7	0.6	1.4	2.8	2.9
Total Patents	43,912	506	3,440	11,179	28,787

Source: See Graph 1.

Table 3: Percentage of Independent Patents in Spain by Applicant's Country of Residence, 1820-1939

INDEPENDENTS	1820-1939 %	1820-1879 %	1880-1899 %	1900-1919 %	1920-1939 %
Spain	54.5	61.6	41.1	55.1	59.3
France	12.2	22.1	16.9	11.2	9.8
Germany	8.6	1.7	9.7	8.2	9.1
UK	6.7	7.7	10.6	6.8	4.7
USA	5.7	3.3	11.1	6.2	3.2
Italy	2.4	0.8	1.4	2.3	3.2
Belgium	1.6	1.1	2.0	1.7	1.5
Switzerland	1.6	0.4	0.8	1.5	2.2
Austria	1.0	0.3	1.3	0.8	1.2
Sweden	0.7	0.1	0.7	0.8	0.7
Netherlands	0.5	0.2	0.4	0.5	0.6
Rest	4.4	0.8	4.1	4.9	4.5
Total Patents	108,792	5,330	21,093	35,564	46,805

Source: See Graph 1.

Thus, to sum up, it seems that independents, particularly residents, might have played a significant role among latecomers as Spain, economically less-developed, technologically dependent, with very few firms and corporations, but where individual entrepreneurship could have become central to the process of innovation and technology transfer from abroad. In this context, geographical proximity matters more for individuals than for firms. Spanish and French technicians and businessmen dominated the system and, although independents from Germany, UK, USA and others constantly increased their presence, they never outnumbered the former as occurred, on the contrary, with corporate patenting. Therefore, independent patenting was more than likely more closely

related to real knowledge of the Spanish businesses and market than was the case of some corporations that patented abroad as a global strategy. We should remember here that among Spanish residents there was also a remarkable percentage of qualified labor from other countries, principally France, living in and taking out patents within Spain (Sáiz 2002, 55-6). Besides market accessibility, the balance between corporate and independent patents could have depended as well on the degree of development of 'Chandlerian' firms, internationalization competences and financial capitalism in each country.

Table 4: Ratio of Independent/Corporate patents in Spain by Countries, 1820-1939

	1820-1939		1820-1879		1880-1939	
	Indepen. %	Firms %	Indepen. %	Firms %	Indepen. %	Firms %
Netherlands	29.4	70.6	100.0	0.0	29.0	71.0
Switzerland	45.0	55.0	82.1	17.9	44.7	55.3
Germany	49.3	50.7	83.2	16.8	49.1	50.9
USA	57.0	43.0	98.9	1.1	56.3	43.7
Sweden	60.7	39.3	100.0	0.0	60.6	39.4
UK	62.3	37.7	97.6	2.4	61.0	39.0
Norway	66.2	33.8	100.0	0.0	66.1	33.9
CzechRepublic	66.6	33.4	100.0	0.0	66.5	33.5
France	67.7	32.3	91.0	9.0	66.0	34.0
Belgium	70.1	29.9	96.6	3.4	69.4	30.6
Italy	70.9	29.1	89.4	10.6	70.7	29.3
Hungary	73.8	26.2	100.0	0.0	73.6	26.4
Austria	77.3	22.7	100.0	0.0	77.1	22.9
Denmark	79.9	20.1	100.0	0.0	79.8	20.2
Canada	81.5	18.5	100.0	0.0	81.4	18.6
Poland	82.5	17.5	66.7	33.3	82.6	17.4
Spain	83.6	16.4	90.5	9.5	83.2	16.8
Rest	86.1	13.9	93.5	6.5	86.0	14.0
AVERAGE	71.2	28.8	91.3	8.7	70.4	29.6

Source: See Graph 1.

Table 4 presents the ratio of corporate and independent patents in Spain by countries. It clearly demonstrates that there were a few nations in which the deep economic, industrial and entrepreneurial transformations experienced during the second industrial revolution, between 1880 and 1939, led to widely extending the role of multinational corporations in foreign patenting and technology transfer. This is well-known in the German case, as we expected, but perhaps not so much when we examine the Swiss and Dutch examples. As in the case of Germany, more than half of the patents applied for in Spain from Switzerland were taken out by firms (55%), a ratio that reached 70% in the case of the Netherlands, demonstrating the necessity of further studies on Dutch corporate expansion and its role in technology transfer. Thus, in these three countries, the percentage of independents strongly dropped at the end of

the nineteenth and the beginning of the twentieth century as their firms increasingly took over the business of innovation. Another group of three countries (the UK, Sweden and the USA) also had a high percentage of firms patenting in Spain (from 37 to 43%) although independents always predominated, as occurred extensively in the rest of the countries, as demonstrated in Table 4, with 33% or fewer corporate patents. Again, the case of the host country, Spain, stands out, with the highest rank of independent patents (almost 84%) when compared to that of firms. The issue that immediately emerges is whether independents were more, less or just as efficient as corporations in facilitating innovation and technology transfer to latecomers.

3. Social Networks of Innovation in the European Periphery

Thanks to the large body of work carried out over the last decade at the Archive of the Spanish Patent and Trademark Office, by examining each and every administrative and technical patent file, we have been able to extract and analyze several qualifying indicators as to the patents' compulsory implementation, the grant extension, or the assignments and licenses registered. The obligatory working clause was an interesting administrative requisite in Spain. Within a 1 to 3-year time frame[6] independents and firms were required to demonstrate that the patented object was being implemented and manufactured within national territory, which was enforced to varying degrees depending on the period, always under penalty of expiration of the monopoly and, from 1924 on, also of a compulsory license to whoever applied.[7] Most of the patents did never pass this requirement, therefore returning to public domain within 2-4 years after being granted. Thus, we suppose that the patent's greater length and cost, both monetary and administrative, was a consequence of reasonable expectation (and materialization) of profit from the technical monopoly, which firstly led the owner to face and meet the implementation requirements, and

[6] It was one year between 1826 and 1878, two between 1878 and 1902, and three years from 1902 onwards.

[7] From the beginning of the protection system until 1849, there was hardly any control over patent implementation. The Royal Order of the 11th of January of 1849 precipitated an efficient control from 1849 to 1878, requiring notarized independent reports. Between 1878 and 1924 the implementation procedure was relaxed, a report, in some cases, by an engineer certifying that the necessary means to produce an object existed at such-and-such a factory being sufficient, but nonetheless it still was a difficult requisite to meet. In 1924 the Regulation of the 15th of January strengthened the compulsory working clauses under penalty, at first, of a forced obligatory license of the patent to whoever applied, and then, once the Law of the 26th of July of 1929 passed, including an expiration date within 3 years if nobody took the license.

secondly to pay the increasing fees year by year until it was abandoned or until the patent ended[8]. The duration of the monopoly has also been used as a measure of patent value in other historical works, as in J. Streb, J. Baten and S. Yin (2006), where only German patents surviving at least 10 years were worthy of attention.

Table 5: Independent and Corporate Patents in Spain by Implementation and Duration Percentages, 1820-1939

	Implemented %	Non-implemented %	Implemented Duration > 5 y., %	Implemented Duration >10 y., %	Patents*
Resident independents	17.8	82.2	7.8	2.9	57,379
Non-resident independents	21.0	79.0	10.9	3.9	47,641
Total independents	19.3	80.7	9.2	3.4	105,020
Resident firms	31.3	68.7	16.1	5.5	10,811
Non-resident firms	22.8	77.2	14.1	6.6	29,723
Total firms	25.1	74.9	14.6	4.9	40,534
AVERAGE	20.9	79.1	10.7	3.8	145,554*

*Calculations were made based on 95.3% of patents analyzed. It is not possible to establish whether or not the remainder were implemented.
Source: See Graph 1.

Table 5 demonstrates, first, what we have just pointed out above that is that 79% of patents taken out throughout the whole period studied never met the compulsory working clauses and expired within a few years after the concession. That means that the majority of technological information created or, more usually, transferred from abroad could be freely used in Spain after no more than five years. Secondly, that firms were always more effective in putting into practice the protected technologies than independents (25.1 to 19.3% respectively), and that the formers' monopolies obtained a longer extension than those granted to individuals when we examine the patent duration above both 5 as well as 10 years. Finally, Table 5 demonstrates the extent to which patentee's behaviors change when legal status and place of residence are crossed-referenced. Domestic firms were very active and practically doubled

[8] We obtained this information from the analysis of the initial and renovation fees met by the patentee to maintain exclusive rights, which were paid in advance between 1826 and 1878 after choosing the expiration date (5, 10 or 15 years) and annually from 1878 onwards for a maximum of 20 years. Patents of introduction only lasted a maximum of 5 years although they came under the same requirements of compulsory implementation.

the percentage of effectiveness in patent implementation (31.3%) as well as in monopoly duration (16.1% valid after 5 years) compared to the ratios shown by resident independents. Likewise, home firms went approximately ten percentage points above non-residents (corporate or independent) in exploiting patents, although those differences among foreign and resident corporations almost disappeared when we contrast the patent extension beyond 5 and 10 years. Indeed, foreign firms were the most effective in maintaining the monopoly after 10 years (6.6%). Furthermore, the variances between non-resident firms and independents in meeting the compulsory practice were minimal (22.8 and 21%) and they both outnumbered that of resident independents (17.8%), who were less effective.

Table 6: Independent and Corporate Patents in Spain by Percentage of Assignments & Licenses, 1820-1939

	Assignments & Licenses, %	Patents
Resident independents	3.8	59,326
Non-resident independents	5.5	49,466
Total independents	4.5	108,792
Residentfirms	5.6	11,648
Non-residentfirms	6.2	32,264
Total firms	6.1	43,912
Average	5.0	152,704

Source: See Graph 1.

Another complementary means of measuring the value and scope of patents is the number of assignments and licenses registered, as they could be considered an indirect proxy of technical quality of the invention protected, as well as of business interest with respect to innovation, especially in a patent system without previous technical exams. Table 6 demonstrates that only a small percentage of patents (5% on average) were officially assigned or licensed during the entire period studied, which reflects the apparent scarcity of business and the narrowness of markets of innovation in Spain. This fits well with the high percentage of patents expired within the first three to five years (almost 90%, according to Table 5), drawing a picture of free access to most technical information in the short-term, whilst a few top-quality patents concentrated most of the interest and the business. In these issues, firms stood out slightly, again compared to independents (6.1 to 4.5%), particularly non-resident firms, among which there could have been more concern in finding domestic partners and agreements to sell the rights than in directly exploiting the patent, insofar as they were not really interested in making actual investments in the Spanish economy. For similar reasons, resident or non-resident independents might have been also more interested than firms in commercializing their patent rights, although the figures in Table 6 do not demonstrate any particular bias

other than that the foreign independents' ratio of licensing moderately exceeded that of residents (5.5 to 3.8%).

Thus, on the one hand, our findings would confirm the importance of independent innovation and technology transfer on the periphery, as both residents and non-resident individuals not only took out the majority of patents between 1820 and 1939, but also put into practice and exploited a certain percentage not radically differing from that of firms. The Spanish data would concretely corroborate and widen the analysis of other scholars when outstanding independent invention in pioneers and first comers, as is the case of the UK or the US. Indeed, we demonstrate that foreign (mainly German, French, USA and British) independents were at least as relevant as foreign corporations in taking out and exploiting patents on the periphery throughout the nineteenth and during the first forty years of the twentieth century. Moreover, if we attend to other qualifying patent data in Spain as the percentage of assignments and licenses or the patent time extension, foreign independent bias was close to that of foreign firms, suggesting similar effectiveness and technical quality, although firms slightly stood out.

On the other hand, our findings reveal that in latecomers and underdeveloped economies, with high rates of technological dependency, domestic firms could have played a key role in the processes of technology transfer and innovation, although resident independent patents largely outnumbered those of corporations. Further research and case studies are needed, but as is demonstrated in Tables 5 and 6, resident firms were the most effective group in putting into practice the technologies patented, in maintaining the monopolies (at least for 10 years) and they were also quite active in licensing. Likewise, it seems that there was more failure among resident independents than in any other group and that the differences between resident independents and firms with respect to the quality of innovations were more evident than between non-residents or than what was occurring in pioneering countries, where independents achieved at least the same technological success as enterprises (Nicholas 2010, 2011). In reality, the key role of domestic enterprises fits well with their greater knowledge of a still imperfect Spanish market and institutions, the lack of legal protection, their better access to scarce capital, and the existence of high transaction costs in innovation processes, which taken together make independents more likely to fail in the long-term. As the contemporary and influential article of R. Coase (1937) 'The Nature of the Firm' pointed out, enterprises beat individuals in diminishing search, information, policing, enforcement or keeping-trade-secrets costs. Nowadays we also know that firms act as 'nexus of contracts', which could increase legal security among the different agents involved, something that might be crucial at the European periphery during the first push towards globalization.

Table 7: Distribution of Independent Patents by the Professional Status of the Applicant, 1820-1939

	1820-1879			1880-1939		
	Residents %	Non-residents %	Total %	Residents %	Non-residents %	Total %
Civil servants	9.5	5.3	8.2	8.2	4.6	6.8
Lawyers & attorneys	0.5	0.0	0.4	0.3	0.3	0.3
Military officers	3.3	2.5	3.1	5.0	1.9	3.8
Engineers & technicians	0.2	0.4	0.3	0.4	0.9	0.6
University, education	2.0	1.3	1.8	0.5	0.4	0.5
Politicians & high civil servants	0.6	0.7	0.6	0.5	0.8	0.6
Low civil servants	3.0	0.3	2.1	1.5	0.3	1.1
Professionals & Technicians	24.0	46.2	30.9	30.9	63.5	43.6
Lawyers & managers	3.7	1.4	3.0	3.9	2.6	3.4
Engineers & scientists	14.9	40.8	22.9	19.9	53.6	33.0
Physicians & pharmacist	3.0	2.9	3.0	4.0	2.2	3.3
Privateeducation	1.9	0.2	1.3	1.0	2.3	1.5
Inventors, designers…	0.0	0.3	0.1	0.3	1.7	0.9
Artists, musicians…	0.3	0.3	0.3	1.0	0.7	0.9
Other liberal professions	0.2	0.3	0.2	0.7	0.6	0.6
Businessmen & Entrepreneurs	63.9	46.3	58.4	52.8	22.8	41.1
Capitalists & 'owners'	7.8	5.4	7.0	2.6	1.5	2.2
Salesmen & traders	13.5	11.3	12.8	10.8	3.0	7.7
Manufacturers & industrialists	19.8	15.4	18.4	31.9	15.7	25.6
Craftsmen	22.9	14.2	20.2	7.6	2.6	5.7
Miscellaneous	2.6	2.3	2.5	8.0	9.0	8.4
Workers & employees	1.3	0.3	1.0	3.1	0.3	2.0
Students	0.6	0.0	0.4	0.8	0.0	0.5
Housewifes, retired-men	0.0	0.0	0.0	0.1	0.0	0.1
Clergy	0.3	0.3	0.3	1.0	0.4	0.7
Nobility	0.5	1.5	0.8	1.6	2.5	2.0
Others	0.0	0.2	0.1	1.3	5.7	3.1
*Patents with profession**	2,644	1,189	3,833	16,486	10,521	27,007
% patents without profession	19.5	41.9	28.1	70.6	77.8	73.9
Total patents	3,283	2,047	5,330	56,043	47,419	103,462

*Calculations were made based on an average of 28.3% of independent patents between 1820 and 1939. The rest indicated no profession. Corporate patents are always excluded.
Source: See Graph 1.

However, although there is no doubt that corporations were essential players in international technology transfer and an active part of the socials networks of innovation, it is necessary to go beyond the boundaries of the firm and carefully scrutinize independents. This is not only based on the evidence that individuals outnumbered firms in taking out patents, but also on the fact that independent applications may offer interesting data on the patentees' socio-professional belonging and, therefore, on the social framework of innovation throughout the period studied. In Table 7 we have distributed resident and non-resident independent patents in Spain before and after 1880 according to the profession or social status mentioned by the patentee himself. From 1820 to 1879 that data is available in 72% of the patents, whilst between 1880 and 1939 it is only specified in 26%. Notwithstanding, the sample is representative enough to deserve a detailed analysis, in which we have grouped the professions or status into four main categories: a) civil servants, which includes low-level clerks, high-level appointments, lawyers, military officers, university professors or technicians working in an administrative position; b) liberal professionals and qualified technicians, such as lawyers and managers, engineers, architects, chemists, physicists and other scientists, physicians and pharmacists, inventors and designers, artists, musicians, writers, journalists, photographers and other professionals, self-employed or not, but always emphasizing their academic title or technical skills; c) businessmen and entrepreneurs, including capitalists and 'owners' (terms that indicate capacity to have access to capital, land and natural resources)[9], manufacturers, industrialists, master craftsmen, autonomous skilled workers, salesmen and traders; and d) miscellaneous, that is, a heterogeneous group including unskilled and semi-qualified laborers, students, housewives, retirees, nobility and clergy, and others not easy to classify, such as simply 'graduate'.

The distribution demonstrates that before 1880, i.e. during the beginnings of modern economic growth in Spain, the networks of independent innovation and technology transfer were mainly developed through businessmen and entrepreneurs directly related to production processes (58.4%), followed by qualified professionals and technicians (31%). The former were principally craftsmen, manufacturers, or traders driven by learning-by-doing/using and incremental innovation processes, who applied for patents themselves, mentioning the economic activity to which they were devoted and in which they had created or introduced novelties. It was unlikely that they possessed scientific or academic qualifications, but had significant technical and practical training, a useful and reliable knowledge that was the soul and spirit of technical progress in countries as the UK or the US during the first stages of industrialization (Mokyr 2002). Our evidence also demonstrates that this social group slinks to the real

[9] Among 'owners' there are also some farmers.

economic world allowed it to take an active part in technology transfer, from pioneers to latecomers. This is also the social class inclined towards participating in, or founding, joint-ventures and future firms, which fits well with the increasing role of non-independent innovation in the following phases. On the other hand, among the group of qualified professionals, engineers stood out prominently (23%) followed, with lesser ratios, by other skilled practitioners, such as lawyers or managers. Thus, engineers and scientists were the new emerging technical top class that would progressively capture independent innovation during the second industrial revolution, as new and complex science-based technologies spread. Finally, the presence of civil servants (mainly military officers) and other groups was very low (10%).

This tendency, with the predominance of entrepreneurs and engineers above all other groups, is confirmed in the second period analyzed. From 1880 to 1939, almost 85% of independent patents were still concentrated in the same social framework. There has been, however, a significant shift. As we advanced above, engineers, scientists and, to a lesser degree, other highly-skilled technicians, have become the main source of independent innovation and technology transfer during this stage, outnumbering manufacturers, industrialists, craftsmen or traders (43.6 to 41.1%), who, nonetheless, still played a relevant role among independents, particularly among residents. Table 7 demonstrates that there were significant and determinant differences in these international social networks of innovation according to the place of residence. Among non-residents, the ratio of qualified technicians and engineers was already very high between 1820 and 1880, equaling that of independent manufacturers (approximately 46% each group), and predominated from 1880 to 1939, reaching percentages of 63.5% (53.6% engineers) to only 22.8% of industrialists and traders. Among residents, the presence of qualified technicians also increased in the second period, but manufacturers, traders and craftsmen always prevailed (63.9% before 1880 and 52.8% after that year). Thus, during the final decades of the nineteenth and the first third of the twentieth century the networks of innovation expanded, connecting the ongoing scientifically-applied knowledge of the second industrial revolution to domestic producers at the periphery through links between foreign engineers and technicians and local entrepreneurs, industrialists and firms. As some scholars have pointed out, the increasing role of international agents, legal practitioners and intermediaries in the markets of technology during the same period was fundamental in this process (Guagnini 2002, 2012; Lamoreaux and Sokoloff 2003; Gálvez-Behar 2006). Indeed, very recent research on Spanish innovation agency reveals that in the 1860s, practically half of the patent applications in Spain involved an agent, a percentage that exceeded 80% by 1890 (Pretel and Sáiz 2012).

4. Concluding Remarks

Apparently, corporations had almost monopolized invention and innovation activities throughout the second half of the twentieth century, turning into the main users of the patent offices all over the world. It is well-known that the tipping point between a nineteenth-century innovation system, completely dominated by independent inventors, and the present-day incorporated framework took place during the so-called second industrial revolution, from the decade of 1880 up until World War II. Thus, from that period onwards, the firm and the corporation quickly became the key research topic for most scholars – economists, sociologists or historians – interested in any of the multiple facets of technological change. Independent inventors and scientists, previously the new heroes of modernity, were suddenly neglected, dropped from the studies and turned into amateurs without relevancy outside the firm's boundaries. However, and paradoxically, recent analyses demonstrate that in the 1930s, half of the patents were still granted to independent applicants in more advanced North Atlantic economies, and that they were not just stay-at-home hobbyist with worthless ideas, but as successful as those within the larger companies. Furthermore, nowadays independents still obtain one third of the patents in many relevant countries, and in certain cases they continue to produce crucial knowledge with a highly valuable economic impact.

Although the scant research available has shed some light on the outstanding historical role of independents in a few advanced countries, such as the US, the UK or Japan, we still lack relevant analysis on latecomers and late-developed economies on the periphery with high rates of technology transfer and technical dependency. By analyzing corporate versus independent patents in Spain in the long-term, we have demonstrated that independents also contributed significantly to innovation and technological diffusion processes, as they were involved in 90% of the Spanish patents before 1880 and in almost 60% in the 1930s. That presence was remarkably high in the case of domestic residents, among whom independent patents reached five times those granted to firms during the entire period studied. Non-resident independents were also very active, taking out patents in Spain and they outnumbered foreign firms up until the interwar period. During the 1920s, multinational corporations from advanced countries, particularly from Germany, France, the US, the UK, Switzerland and the Netherlands increased their technological expansion towards less developed economies, progressively displacing independents belonging to these same countries, which was a very noteworthy process in the case of Holland, Switzerland or Germany. Firms were also more effective at putting into practice the technologies patented, a compulsory requirement in the Spanish system, as well as at maintaining the monopolies time extension. In both cases, resident firms were by and large the most effective, demonstrating the importance of local markets and institutional knowledge.

The same reasoning could be applied when independents' professions are analyzed. Among residents, the group made up of manufacturers, industrialists, craftsmen, businessmen, traders, i.e. people actually connected with production processes and ultimately with enterprises, was the most significant during the entire period, with more than half of total resident patents. Although master craftsmen and small manufacturers without formal schooling or qualifications were also common among independents in the British or the USA patent systems before 1850, they were increasingly substituted by engineers and technicians with scientific training during the second half of the century (Inkster 2003, 187-92; Lamoreaux and Sokoloff 2005, 18-9 and Figure 2; MacLeod 2007, 359-65), a process that is also evident in the Spanish patent series after 1880, when foreign engineers increased their participation, but which we can hardly verify among Spanish residents.

Thus, the emergence of international networks of innovation throughout the nineteenth and the first decades of the twentieth century seems to have been mainly based in streams of technical information and entrepreneurial initiatives shared among engineers and technicians from scientific and technologically advanced countries, and businessmen, manufacturers and small-scale industrialists from latecomer and less-developed nations. These social networks of innovation were progressively linked to complex relationships within the firm and the multinational corporation, which would increasingly capture the international system of innovation and employ researchers. Patent agents were essential in the configuration of those networks. Corporate expansion notwithstanding, our evidence suggests that independent webs not only survived, but even played a significant role in technology transfer and catch-up processes at the European periphery during the entire twentieth century, a role that has been incomprehensively neglected.

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