

Technical change and business model: the urban transport companies in Spain, 1871-1989

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**European Business History Association Conference,
26-28 August 2010, University of Glasgow,
Centre for Business History in Scotland
Business Beyond the Firm**

Business activity in urban transport display a set of peculiarities, arising from its monopolistic character, and from being a regulated public utility, which is essential for other sectors and the community as a whole. Its capital intensive nature, as well as the technological and organizational complexity, stimulated the emergence of a new business model, characterized by the importance of financial aspects, professional management, and the need to articulate modern forms of regulation.

This process was largely conditioned by the technological changes occurring in urban transport, with its evolution from the early horse-drawn transport to electric power, up to the demise of the trams, which were replaced by buses. Other significant factors that affected the business results and strategies were the different economic junctures, the dynamics of urban growth, and the institutional framework, both in the field of economic policy and the regulation of the sector.

The aim of the paper is to analyze the complexity of this interaction, taking as reference what took place in the urban transport companies of Spain. The paper is divided into two main parts. The first section will examine the process of formation and consolidation of the business model. The second part is an indepth study of the causes of the crisis of that model since the Spanish Civil War.

Technological change and business organisation

Technological change has generally been considered as the driving force behind long term economic growth. Nevertheless, its actual nature and incidence in economic processes has been subject to controversy amongst economists. Some have considered it an endogenous force to economic processes, whilst for others it is somewhat exogenous, belonging to the sphere of scientific knowledge and which, consequently, cannot be integrated into economic analysis. Another motive for debate is that there are people who consider technological innovation as a process which breaks with the past and those who insist on its gradualness.

Schumpeter (2002) was one of the first economists who paid the most attention to these questions, establishing a relevant distinction between invention, innovation and imitation. For him, invention was an exogenous factor, belonging to the sphere of science and was already given and complete. From the economic point of view, the key element was innovation, i.e. the moment in which the invention was applicable in economic terms for productive processes. This caused a creative rupture of the existing equilibrium, at the hand of the “destructive” entrepreneur and the start of a cycle of expansion.

Later, Rosenberg (1979) criticised the radical Schumpeterian distinction between invention, innovation and diffusion as well as the consistent prejudice which underestimates modest technological knowledge (specific and particularistic) as opposed to the culture represented by Science (Universalist). This lack of focus led, in his opinion, to emphasise the rupturist character of technological change faced with the elements of continuity represented by improving and adapting to concrete environments. On the other hand, innovations do not usually suggest a total rejection of previous practices but rather a selective rejection.

More recently, (Mokyr, 1991), evolutionary economics has attempted to apply the principles of evolutionary biology to the economic field, establishing a parallelism between technological innovation and genetic change. Mokyr fell in between the positions of Schumpeter and Rosenberg on the rupturist or gradual character of technical change, distinguishing between macro inventions and micro inventions, the result of which was a complementary character (although he concedes primacy to the former).

An important aspect of technological innovation is its diffusion and the factors which condition it. Amongst these, the variations in the relative prices of distinct alternatives, changes in demand, complementarity between innovations, the capacity for learning and the institutional context are generally quoted. Another element which has aroused investigators' interest in the last few years has been the relationship between the process of technological innovation and the changes in corporate organisation (Dosi, Giannetti and Toninelli, 1992).

Hall and Rosenberg (2010) provide the most up-to-date status on the question of technological innovation, with particularly interesting chapters for economic historians such as that by Mokyr on the contribution of Economic History, that by Dosi and Nelson from the evolutionary perspective or the review of literature of the last half century by Cohen.

The aim of this paper is to apply this entire problem to a concrete case (urban transport in Spain), to clarify the mechanisms which govern technical change, the factors which condition its adoption and the effects of this on the business model and business organisation. For this, we will focus on two key situations: the electrification of trams and their substitution by trolley buses and buses.

The start of the business: animal traction, 1871-1895

In pre-industrial cities, movement was carried out on foot due to the short distances. Things started to change with industrialisation and urban growth. Increased distances led to the appearance of vehicles using animal traction inside cities (buses, rippert omnibuses), used by the middle and upper classes. The tram was an important sign of progress as it combined animal traction with the use of rails (which reduced friction and increased speed and efficiency) (Mckay, 1976). This could be interpreted as a type of hybrid technology between traditional animal traction and the railway, in line with the progressive character of technological innovation.

The first trams circulated in the USA in the 1830s and spread rapidly there due to the strong process of urbanisation, the expanded urban model and the rapid growth of income per capita. USA remained the technological leader in the sector for decades although Germany started to question its hegemony from the electrification of transport which started at the end of the 19th century.

In Spain, the tram made its appearance in the large cities (Madrid and Barcelona) at the start of the 1870s, thanks to British businessmen. These played an important role in the international diffusion of the tram but only during this first phase of animal traction as they pulled out of the business when electrification of the networks occurred. This must be linked to the relative fiasco in Great Britain in the Second Technological Revolution, especially in the electrical sector.

Trams using mules used simple technology; they did not require high investment and their organisational levels were also not complex. Their entry barriers were low and the scale of their economy reduced. Consequently the business model was simple, characterised by the predominance of small companies, generally local, which could coexist in the large cities. One particularity of the composition of capital of some of these companies, (shared with other public service companies), was the number of their shareholders as they considered this investment as an example of citizenship which supported a basic service of the city. Indeed, the effect of emulation played an important role in setting up these urban infrastructures.

Setting up the service was conditioned by the size of the market, depending on the volume of population, the urban surface area, its topography and climate, the demographic density and the level of income. These factors explain the series of the diffusion of the tramway in the world and also in Spain. In the case of Spain, only 24 cities could benefit from this type of transport, installed from a minimum threshold of population of around 30,000 to 50,000 inhabitants. During the first wave, from 1871-1887, the tramway existed fundamentally in large cities. Nevertheless, most tramway networks were built in medium sized towns, from 1890-1906. The rare examples of tramways in small towns started late, once the disruption of the First World War had been overcome, i.e., between 1921 to 1924.

Due to the intrinsic inefficiency of this technological business model, tariffs were high especially in relative terms. This explains the elitist character of this means of transport, used mainly by the bourgeoisie. This characteristic was reinforced by the route of the networks, which were schematic and would essentially serve the needs of the new areas of settlement of the bourgeoisie (the Ensanches), built during the second half of the 19th century. The use (mainly in times of festivals or for leisure) led to the service being seasonal with usage highs and peaks on Sundays and in the summer, which burdened its efficiency and profitability. The awareness of these limitations led to the need to electrify the lines but the process was far from easy in small and medium

sized towns due to investors' lack of confidence when faced with the high need for capital and the uncertainty around the business expectations. This led, on occasions, to transferring business to Belgian businesses as they had greater resources and experience in the sector but the Belgian capital could not always fulfil this task successfully (Martínez, 2006). In general, tramway operations during the era of animal traction produced relatively modest results.

The Electrical Revolution and the consolidation of the business model, 1896-1929

The electrification of trams has been one of the most significant changes in urban transport. It led to price reductions, increased speed, better regularity, comfort and convenience and the popularisation of this means of transport. Its introduction required a new business model, characterised by massive investment, modern management and the use of more sophisticated technology. In peripheral countries (where these factors were not very abundant), electrification led to the entry of powerful foreign business groups. These were mostly Belgians, often backed by German electro mechanic multinationals, interested in new openings for their products. Their strategy was very clear. Firstly, they initiated the unification and homogenisation of networks. Then they carried out electrification. Once the basic network was set up, they pulled back out of the Spanish market, pressured by the nationalist surroundings of the twenties.

On an international scale, the electrification of urban transport (tram, underground, suburban railway) must be linked to the great importance acquired by electrical and electromechanical companies and their interest in opening new markets for their products. In this sense, one must highlight its noticeable presence, at the height of the First World War, in the largest companies of each country on a worldwide level (Table 1). Four giants stand out, two German (AEG and Siemens) and two North American (General Electric and Westinghouse), all electromechanical and which frame the guidelines in the sector. In Spain and Italy, only electrical fluid production/distribution firms were involved, i.e. without the component of technological innovation from outside. It is also important to note the lack of British electrical companies as this highlights the fact it was behind in this key sector of the Second Technological Revolution and explains its international withdrawal in the transition of animal traction tramways to electrical ones.

Table 1. Number of electric companies among the twenty biggest ones in 1913-1919

Spain	Italy ²	Great Britain	Germany	EEUU	World
3	1	0	2	2	3

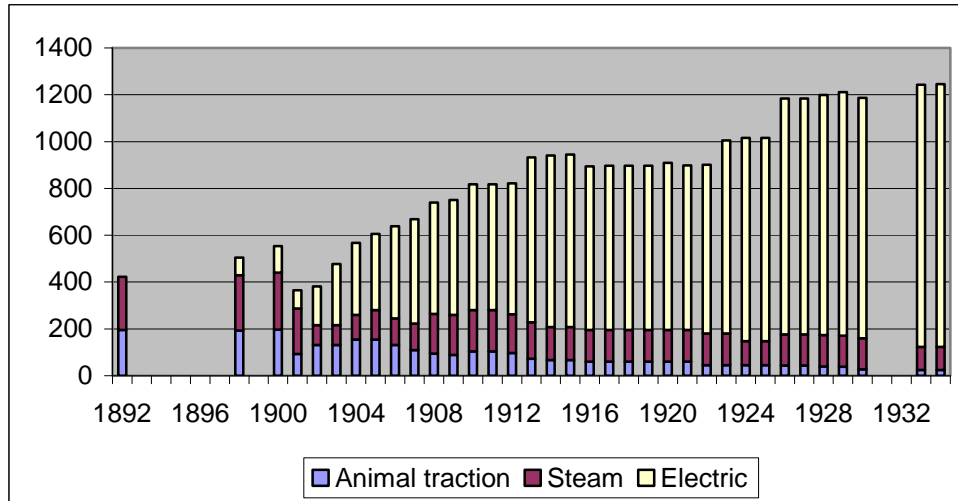
Source: Carreras and Tafunell (1997), García Ruiz (coord.) (1998), Vasta (2004).

During the first years, at the end of the 19th century and the start of the 20th century, electrification advanced slowly, due to the technological limitations of electrical production (thermal generation) which made it more expensive (Graph 1 and Graph 2). The process accelerated in the decade previous to the First World War, coinciding with the second phase of Spanish electrification. The hydroelectric generation and technical advances in long distance transport allowed a substantial cost

² Among the ten first ones.

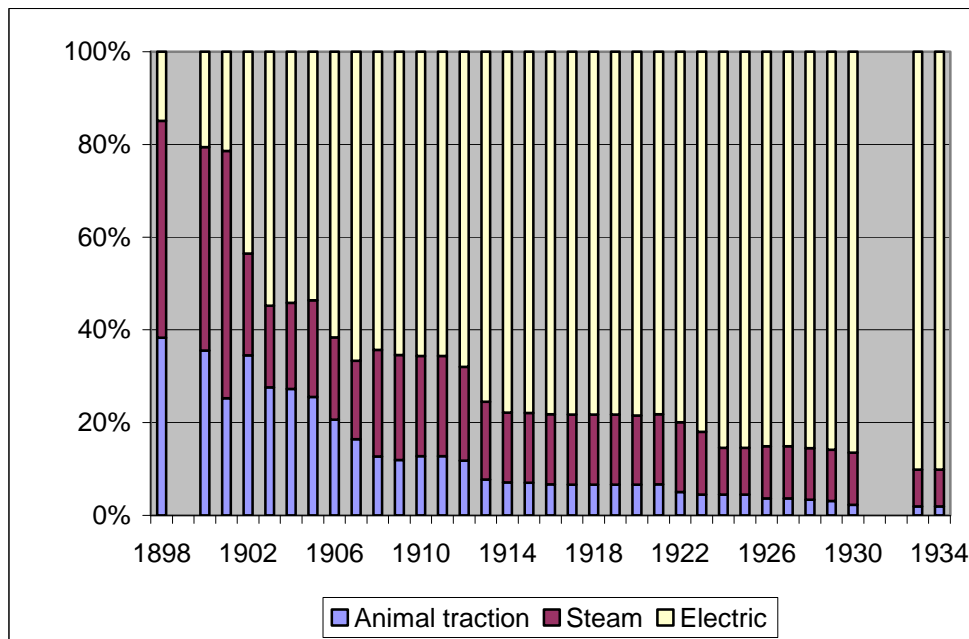
reduction and the consequent spread and diversification of its uses. The difficulties of the Great War and later crises put a halt to the growth of the network and the process of the substitution of animal traction and steam for electrical traction. Nevertheless, this dynamic was reintroduced in the mid twenties, coinciding with an expansive phase of the economy, urbanisation and business concentration. In this way, on the eve of the Spanish Civil War, the double process of expansion of the tram network and its electrification can be considered as practically concluded.

Graph 1. Running Tramlines, depending on their type of traction in kms, 1892-1934



Source: 1892: *Memorias de Obras Públicas*, 1892; 1898-1900: Ministerio de Fomento. Dirección General de Obras Públicas, *Estadística de las obras públicas de España*, 1898-1900. Madrid, Minuesa; 1901-1930: Ceballos, 1932: 381; 1931-1934: *Anuario Estadístico de España*, 1931-1934.

Graph 2. Running Tramlines, depending on their type of traction, in percentages, 1898-1934



Source: 1898-1900: Ministerio de Fomento. Dirección General de Obras Públicas, *Estadística de las obras públicas de España*, 1898-1900. Madrid, Minuesa; 1901-1930: Ceballos, 1932: 381; 1931-1934: *Anuario Estadístico de España*, 1931-1934.

The start of electrification took place in the largest and most dynamic cities (Bilbao, Madrid and Barcelona), whose strong expectations of growth of demand made them more attractive for the powerful international investor groups who took the lead in these actions. These very cities had also been the pioneers in the introduction of the tram led by animal traction. In the three cities, electrification was carried out by Belgian-German capital, dominated by SOFINA. The business strategy was quite similar, especially in the cases of Madrid and Barcelona (Martínez, 2002 and 2006). In both major cities there were initially various small tram companies of generally indigenous capital but there were also some foreign ones, mainly British. Consequently, there was a plethora of lines, of different widths, without a coherent global design and with different management systems. This complex structure, with its intrinsic characteristics of animal traction and high tariffs led to a reduction in demand and negative results in operation.

The tendency for a natural monopoly and to take advantage of the economies of scale stimulated, in a quite rapid sequence, unification, homogenisation and electrification of networks. The process was undertaken by powerful Belgian/German business groups, a result of the merge of financial interests of these countries, of the metallurgical industry and Belgian mechanical construction, and, above all, of the German electro mechanical multinational AEG (Martínez, 2003). The electrification of networks of the large cities was carried out quite quickly, having been completed at the start of the 20th century. Without this, it was not possible to carry out efficient and profitable management.

Electrification of average sized cities took place in the decade before the First World War, mainly due to the increase in the number of tram businesses during that period. Foreign capital investment was low as the market was less attractive. Local financial groups were now more prone to invest, due to previous experience in the large cities, the lower need for capital and the euphoria on higher returns.

The War and post War crisis meant a sudden halt to this investment, which was reintroduced at the start of the twenties, partly in small cities which profited from the advantages of latecomers to directly create new technology. In this sense, one must note the acceleration of the technological change, seen in the progressive reduction of the interval between the introduction of the tram of animal traction and the electric tram (Table 2). In this final phase, the initiative came almost exclusively from local capital in relation to the nationalist situation of the moment and the small markets involved.

Table 2. Geographical spread of electric tramway

City	The year the tram started	The year the electric tram started	Interval, in years, between the start of the tram and the electric tram
Madrid	1871	1898	27
Barcelona	1872	1899	27
Santander	1875	1908	33
Bilbao	1876	1896	20
Valencia	1876	1912	36
Valladolid	1882	1910	28
Zaragoza	1885	1902	17

San Sebastián	1887	1897	10
Sevilla	1887	1900	13
Gijón	1890	1909	19
Las Palmas	1890	1910	20
Palma de Mallorca	1891	1916	25
Alicante	1893	1924	31
Oviedo	1895	1922	27
A Coruña	1903	1913	10
Granada	1904	1904	0
Murcia	1906	1906	0
Vigo	1914	1914	0
Avilés	1921	1921	0
Ferrol	1924	1924	0
Pontevedra	1924	1924	0

Source: Alemany y Mestre (1986), Alvargonzález (1990), Cava (1990), Fraga (2000), López Bustos (1986), Núñez (1999).

Electrification of networks demanded significant investment on the part of tramway companies and this led to their expansion. These firms were amongst the largest ones in the country.³ This is especially true in medium-sized and small cities, in which utilities businesses often represented the first and main example of a large modern company.

Whereas small companies of animal traction could originally satisfy their (reduced) needs with their own resources and self-financing, the greater financial demands of electrification and the network expansion obliged them to accept a radical rethinking of the companies' financial strategies. These had to be increasingly backed by banking institutions, both to solve treasury problems and, above all, to ensure long term financing. This banking support was shown not so much in the direct package of resources but in the placing of securities (shares and debentures between its clients), which tended to expand local capital markets, mainly in medium-sized cities. In other cases, especially in large towns, they were electro-mechanical companies (mainly German) which either directly or frequently through electro-tramway holdings or banking institutions, provided the financial resources⁴. The significant investment effort occasionally made the financial balance of companies difficult, especially in small cities and when the results obtained did not respond to the expectations generated. This lag occurred mainly in suburban lines, threatened by the competition of buses and lorries. (Martínez (dir.), 2006).

Electrification meant there would be a significant change in companies' assets, with a higher weight of fixed capital assets as opposed to working capital. Rolling stock valuation increased due to the higher cost of engines. The change did not affect purely the size and business financing, but also the actual management of companies. Electrification demanded a thorough reorganisation of companies, in order to optimise

³ In 1917, three tram companies (one in Madrid and two in Barcelona) figured amongst the 50 largest Spanish companies. Nevertheless, the progressive growth of other sectors of the Spanish economy and its growing investment reduced this to one single company in 1930 (Carreras and Tafunell, 2005: 788-789).

⁴ In France, the 1880 Law prevented tramway companies from giving out debentures of a higher amount than their capital. This led electro-mechanical groups to participate although these tended to part with their share packages after the Great War (Larroque, 1994: 1138).

resources (both human and material) which were now more technical and expensive. All this led to the application of the new managerial American model based on separating property and management, with growing professionalism of the latter and greater weight put on technicians. The companies' management passed into the hands of experts who came from the field of engineering, reflecting the importance given to this factor. In fact, in many small and medium-sized companies, it was the utilities companies, which introduced these new methods in the local business surroundings, acting not only as technological disseminators but as management models. The car-km costs reduced with electrification, although so did income, due to the initial lower occupation of wagons, to larger distances and to the fact the tickets were now cheaper. However, despite the fact that the unitary margin of exploitation reduced, global benefits increased as did the volume of business⁵.

In relative terms, the contribution of traction to electrical consumption was modest as it practically never went over 10%⁶. Nevertheless, for electric companies, especially in cities with little electrified industry, the demand from trams, with public lighting, made up a relatively significant part of its business⁷, which was especially relevant during the first years, when private consumption was still scarce. Tram companies represented a safety net for volume and stability with regards to fluctuations and uncertainty of private demand. This interest by electrical companies to boost this segment of demand explains its presence – direct or via holdings or connected banks –, in the shareholdings of tram companies, especially those in the phase of moving from animal traction to electrical.

Electrification demanded a very high volume of investment, in absolute terms and in kilometres of lines when compared to the era of animal traction. The rails needed were heavier and more expensive. Finally, the overhead cable and electrical sub stations had to be installed. All this new infrastructure generated a significant source of demand which was essentially met through previous imports from Germany and Belgium, and through companies connected to electro-tramway holdings of these countries (*Unternehmensgeschäft*), following guidelines in line with competition law. In this sense, a large number of rails, wagons and chassis came from Belgium whilst the Germans provided practically all of the electrical installations (engines, overhead cables and sub stations).

Electricity was one of the main innovations of the Second Technological Revolution. Its flexibility, versatility and economy meant a significant improvement as compared to previous energy sources. The first experiments in the field of transport developed in trams, due to their clear superiority compared to animal traction and to steam in an urban environment (Mckay, 1976). Spain, like other countries in Europe,

⁵ In other countries such as France, the behaviour was less favourable as the operating ratio of the period between the wars went back to the levels of the period of animal traction, 85% (Larroque, 1994: 1140). In Britain and American urban railways, electrification meant an initial deterioration of the operating ratio, although figures were more favourable, 55%-70% (Reilly, 1989: 24-26).

⁶ The invoiced consumption would be somewhat higher, not including losses and self consumption. Nevertheless, in terms of income, the percentage would be less as the average price of kwh per traction was less than per strength and overall, than for lighting (0.08 pts, 0.11 pts and 0.60 pts in 1935, respectively, Bartolomé, 2007: 18).

⁷ In 1929, the final electrical commercial consumption in traction was 9.9% of the total in Spain, only overtaken in Mediterranean and Northern Europe by Portugal and, probably Greece, which showed its negative correlation with electrical intensification and the level of industrial development (Bartolomé, 2007: 18). In neighbouring Portugal, the percentage of electrical consumption in traction varied considerably from some cities to others, with a positive correlation to its size, at around 15%-25% of the total from 1930-1945 and representing 2-5 times more than public illumination (Cardoso de Matos et al., 2004: 392).

remained a straggler in technological innovation, especially in leading sectors such as the electrical sector. This delay was seen in the reduced number of patents registered by nationals: 35.2% in electrical material between 1882-1935, with a Technological Developing Advantage of 0.7 (Sáiz, 2006: 62).

In the case of electrical traction, the patents registered for the Spanish in 1883-1935 only signified 11.5% of individuals and 3.6% of companies. In the former, the Americans predominated, with a third in total, followed by the Italians, French, British and Germans with 8%-14%. Amongst companies, the concentration was larger, dominated by the French -especially Thomson Houston de la Méditerranée⁸-, with half, followed by the Swiss with a quarter (Brown Boveri) and the Germans (Siemens) with 12% (Cayón et al, 1998: 96-99). The French company was a branch of a homonymous North American group and used to channel the patents of General Electric. In turn, the Swiss electrical sector maintained strict links with German multinationals⁹.

From this, one can gather that the technological innovation spread in Spain came overwhelmingly from the two leading countries: the USA and Germany. One can see a certain specialisation in companies / countries. The French North Americans dominated the general improvement of the engine, transmission and suspension, governing systems (electric traction), the third rail and the underground channel. In turn, the Swiss and Germans controlled locomotives and electric motor units, apparatus of power points and, above all, the overhead power cables.

These managed to hold the most relevant patents which they ended up imposing. Most electric transport patents refer to traction (58%), as opposed to 42% of alimentation systems. Among the first, those linked to wire apparatus dominated (22%). With regard to alimentation systems, most patents referred to the underground channel (52.6%), as opposed to the overhead power cables (43%) and the third rail (4.4%), although it was the overhead power cable which ended up being imposed in Spain, like in the rest of the world (Cayón et al, 1998: 99; McKay, 1976). We do not know the chronological evolution of the type of patent registered, but it is highly likely that, like in other countries, the basic patents of traction and alimentation until 1914 and those linked to travellers' safety and comfort during the period between the Wars took precedence¹⁰.

From 1897-1901, the highest number of patents was registered, coinciding with the boom of tram patents in general and companies being set up. Until 1920, most inventions were related to trams, whilst the relative saturation of this market and plans to electrify the railways from this date stimulated the market towards railways. The period between the Wars was the Golden Age for electric trams, making it a mature sector, as the level of technological innovation reduced, increasing the barriers for the greater needs of businesses¹¹. Indeed, most of the material (both fixed and rolling stock) was acquired and installed in the fifteen years before the start of the Great War.

⁸ For Thomson-Houston's strategies for the electrification of urban transport, see Froelicher, 1991. Rail electrification in France was due to American technology, even if it became progressively independent during the period between the wars, a step in which French technology had a notable influence on Spain (Bouneau, 1993).

⁹ On the international strategies of the electromechanical companies of these two countries, see Broder (1982), Hertner (1990) and Segreto (1994).

¹⁰ This was what happened in France for example (Larroque, 1994: 1143).

¹¹ In France, the curve of registration of urban transport patents also declined progressively from 1904, the decline of the twenties and thirties being especially notorious (Larroque, 1994: 1143).

Progressive obsolescence of this material occurred between the Wars¹². On the other hand, each urban tram network used to belong to a different company as the process of business concentration in the sector had been limited generally to the range of each city. For this, there was a lack of standardisation of materials, partly eased by limiting their origin to certain manufacturers, most of which were foreign¹³.

Traditional public transport using animal traction had serious limitations for satisfying urban populations' demand for mobility e.g. low capacity, reduced speed, rigidity and hygiene problems all of which resulted in higher fares. This limited its use to the enjoyment of the Upper Classes. As compared to steam, the advantage of electricity was its lower environmental impact, its low cost and possibility of travelling over rough terrain. Electrification allowed these restrictions to be overcome, bringing about a real revolution of urban transport, facilitating what one could call "the conquest of mobility" (Monclús y Oyón, 1996). This would form part of a larger process of modernisation of Spanish society and, especially of its cities (urbanism, public services), which developed during the first third of the 20th century (Cardesín and Mirás, 2008).

Electrical traction allowed the speed and frequency of trams to increase, although its dependency on the source of supply made it more vulnerable as usually occurs with more sophisticated technology. The carriages could now be larger, hold more people and were more comfortable. The high cost of the new fixed and mobile rolling stock encouraged a more intensive use to recoup costs more quickly: from here, there was an increase in kms travelled by railcars and lines. These could now extend to the suburbs, including on uneven surfaces and slopes. The advantages of electricity were especially evident for intense traffic and for long distances, particularly on uneven territories, providing that the concession was long enough to allow the redemption and repayment of the high investment needed¹⁴. Large companies which were involved in the unification and electrification of networks aimed to secure greater line concessions. On the whole, they achieved this, prolonging concessions until after the Civil War.

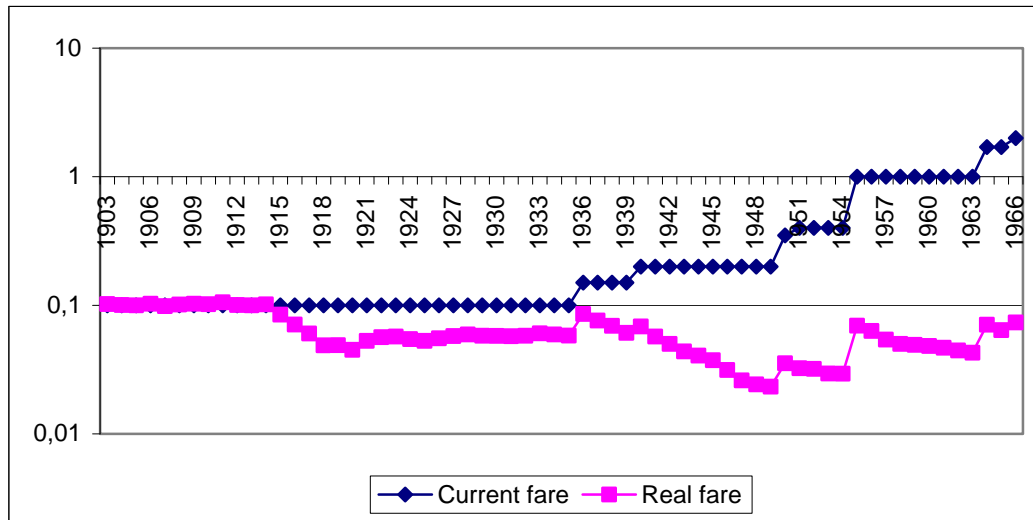
The increase in the scale of operations reduced unit costs and this facilitated the reduction of tariffs (Graph 3). The fall in tariffs was due more to the inflationary effect of the First World War and post War as in reality nominal tariffs stayed the same. On a long-term perspective, we see how later changes in traction (trolleybuses in the '50s and '60s) were accompanied by the increase in nominal tariffs, justified by an improved service and inflation (although they did not manage to compensate the effects of this).

¹²A similar process occurred in France, including the countless repairs of material in the companies' own workshops. By contrast, American firms commissioned 17,500 new trams between 1921-1939 (Larroque, 1994: 1145-1146).

¹³ In contrast, the two main Spanish rail companies (Norte and MZA) went from owning 55% of the total number of wide track locomotives in 1877 to 74% in 1914 (Comín et al, 1998: 103).

¹⁴ *Congreso internacional de ferrocarriles, tranvías y electricidad celebrado en París en 1900. Memorias de los ingenieros de caminos, canales y puertos*. Madrid, 1901: 273-279.

Graph 3. Current fare and fare in pts of 1913 in A Coruña, 1903-1966

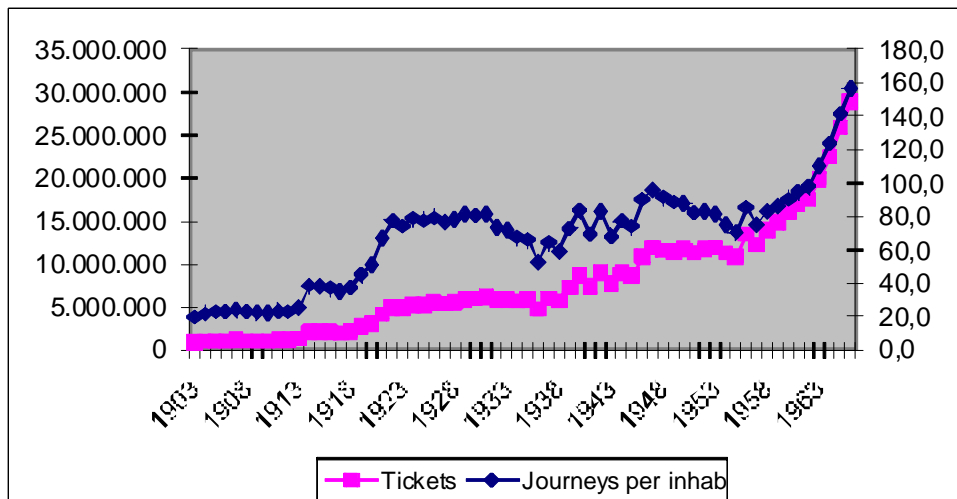


Source: A Coruña Tramways Company, Board of Directors´s Reports.

The reduction of tariffs and the improvement of the service, which accompanied electrification, led to a sharp and rapid increase both in the number of users and in the annual average of journeys (Graph 4), a phenomenon that occurred once again with the new change of traction in the '70s.

The tramway progressively became a more popular means of transport¹⁵, used increasingly for daily work journeys, not simply weekly or yearly (Table 3). Nevertheless, this increased mobility depended on the size of the population in the centre and on the substitution of the combined artisanal model (working / residential space) by the industrial model whereby working and living took place in separate spaces (Capuzzo, 2000: 631-632).

Graph 4. Tickets and journeys per inhabitant in A Coruña, 1903-1966



Source: A Coruña Tramways Company, Board of Directors´s Reports.

¹⁵ In 1910 in European cities, transport signified 2.5%-4.5% of the salary of a qualified worker (Capuzzo, 2000: 630-631).

Table 3. Percentage of travellers transported monthly in the urban lines of A Coruña, 1909-1965

Year	January	February	Mach	April	May	June	July	August	Sept	Oct	Nov	Dec	Standard deviation
1909	7,41	6,54	12,97	5,69	7,93	7,76	8,82	11,37	9,14	8,23	6,91	7,24	1,96
1915	8,09	6,97	7,51	7,26	8,13	8,75	8,82	10,72	9,04	8,59	7,97	8,15	0,94
1920	7,50	7,08	7,42	7,72	10,51	9,26	8,82	10,86	8,69	5,65	7,83	8,66	1,40
1925	7,94	7,53	7,98	7,93	8,68	7,13	7,55	11,47	8,20	7,53	8,75	9,31	1,11
1930	8,00	6,84	7,67	7,51	7,96	8,19	9,01	10,87	8,73	8,92	8,32	7,97	0,96
1935	7,97	7,29	7,81	7,86	7,85	8,11	8,66	10,50	8,75	8,44	8,10	8,66	0,77
1940	7,21	7,06	6,73	8,35	8,71	8,56	8,84	9,70	9,13	8,84	8,41	8,46	0,85
1945	9,30	8,50	9,44	9,76	10,49	10,01	8,26	6,88	6,81	2,21	9,10	9,24	2,14
1950	7,95	7,60	8,47	7,97	8,33	8,27	8,77	9,71	8,77	8,43	7,78	7,95	0,55
1955	8,28	7,24	8,23	7,82	8,43	8,20	8,46	9,83	8,73	7,95	7,95	8,88	0,61
1960	7,84	7,39	8,09	7,84	8,28	8,11	8,73	9,37	8,58	8,73	8,29	8,76	0,51
1965	7,83	7,05	7,94	7,67	8,03	8,10	9,18	9,60	8,59	8,71	8,38	8,91	0,68

Source: A Coruña Tramways Company, Monthly Statistical Reports.

Once the crisis of adaptation to the Post-War had been overcome, the economy of Spanish cities went through a brief yet intense growth phase in the '20s. This led to a demographic increase, urban expansion and modernisation of public services. In the case of transport, concessionary companies faced these challenges by expanding the networks, not only in urban surroundings but also by connecting these to the suburbs and by completing their electrification. All this demanded significant financial effort which occurred without excessive problems due to the investing euphoria of the situation and to the solid banking support of these companies¹⁶. The volume of the activity increased significantly, thus allowing people to enjoy more the inherent scale economy. In this way, the sector reached full maturity during these years, both as a public service and as a business model. Nevertheless, the very maturity of the business meant that from the mid 1920s the growth rate slowed down, threatened in suburban lines by the incipient competition of buses. These lines were the Achilles heel for many companies as the high amount of investment required and the lack of profitability threatened financial equilibrium for a long time. These types of lines usually connected the town centre with the outskirts where the Bourgeoisie had many recreational villas. This factor, along with the determination of tram companies to construct these lines (despite the doubts around their profitability) and maintain operations (despite their deficit character), suggests that these decisions were adopted more for advisors' property interests than for company interests. Nevertheless, it is clear that by setting up and maintaining these lines, local groups and institutions played an important role, acting through lobbies, providing capital and subsidies and putting pressure on so that operations could not be abandoned.

¹⁶ Nevertheless, in certain cities, the voluminous and little thought out financing plan of suburban lines compromised companies' financial stability during the '20s and '30s, leading to investors' mistrust, especially in increases in capital.

¹⁸ The decree of 1940 established bonuses and discounts to facilitate the substitution

Crisis, technological obsolescence and first transition: the trolleybus, 1930-1951

The design of the public transport system did not change substantially during the '30s despite the slow and hesitant introduction of bus services. It remained practically stable until the end of the '40s in most Spanish cities. This stability of the system has also been highlighted by Hughes (1983) for regional electrical systems which reached their maturity at the height of 1930. In this sense, tram transport would make up a sub sector of electrical development. The spread of electrical appliances would compensate for the preference of buses over trams in the '50s and '60s.

The evolution of business in the '30s is marked by three events: the general economic crisis (which had repercussions on urban transport), the Civil War (which aborted attempts to develop a transport system in the suburbs with buses) and the economic policy of Franco's Dictatorship (which exerted intense pressure on operational margins by limiting updating tariffs despite inflation and the consequent increase of costs). Through the '30s, operations reached crisis point due to the debilitation of the occupation of vehicles, the reduction of income in suburban lines, deadlock of the service in urban lines and the inflationary nature of costs. The tram business flagged slowly until administrative control was relaxed on importation and the end of the Second World War created the perfect condition to undertake extensive restructuring of the transport system: trams were substituted by trolley buses in urban lines and by buses in average and long distance journeys.

In general terms, one can see progressive loss of economic viability caused both by the reduction of the actual value of the average ticket price and a sustained growth of running costs; the profit margin for tickets remained relatively stable until the '40s when more prosperous tramway lines were replaced by trolley bus services. The irregular behaviour of operations during the '30s caused a serious financial problem: the difficulties in covering payments caused by debts which financed the growth of the networks in the '20s. As a consequence, various businesses no longer paid dividends for several years. During the '40s, economic policy would be marked by interventionism and autarky which led to harmful effects on the Spanish economy (not just short term), so most macroeconomic indicators did not recuperate their Pre War levels until the start of the '50s (García Delgado, 1987: 166-169). In our sector, although it had been traditionally subject to a certain level of both governmental and town regulation, this led (apart from rigidity in business management) to strict price fixing and energy restrictions (although people also benefitted from the noticeable actual fall in electricity costs).

Demand for transport did not stop growing during the forties, due above all to demographic increase and price freezing which reduced (in real terms) the cost of journeys, even taking into account lower income levels during the Post War. The biggest problems for businesses came from the area of offer, mainly due to factors of economic policy. This is the case for example of energy strangling that was very significant in businesses with crucial and high-energy consumption. The main source of energy used in urban transport was electricity. This indigenous production had a significant discrepancy between offer and demand. The latter grew due to the scarcity of petrol (a political weapon of the USA, shortage of currency) and, to a lesser extent, coal. On the other hand, the offer came to a standstill as the control policy of prices de-capitalised businesses and prevented the necessary investments from increasing production (Catalán 1995: 257-264). There were, moreover, difficulties in acquiring the necessary implements and tools due to the insufficiency of currency and to the frequent and corrupt diversion of assigned quotas. (Sudriá, 1987: 332-335).

Company activity in the period after the War was clearly determined by the lack of material, not only to develop projects of expansion and transformation of the network but also to carry out ordinary repairs; many firms found themselves obliged to reduce the number of cars in service. The impossibility of carrying out imports meant that tramway projects and buses evolved towards a system of trolley buses with electrical traction.

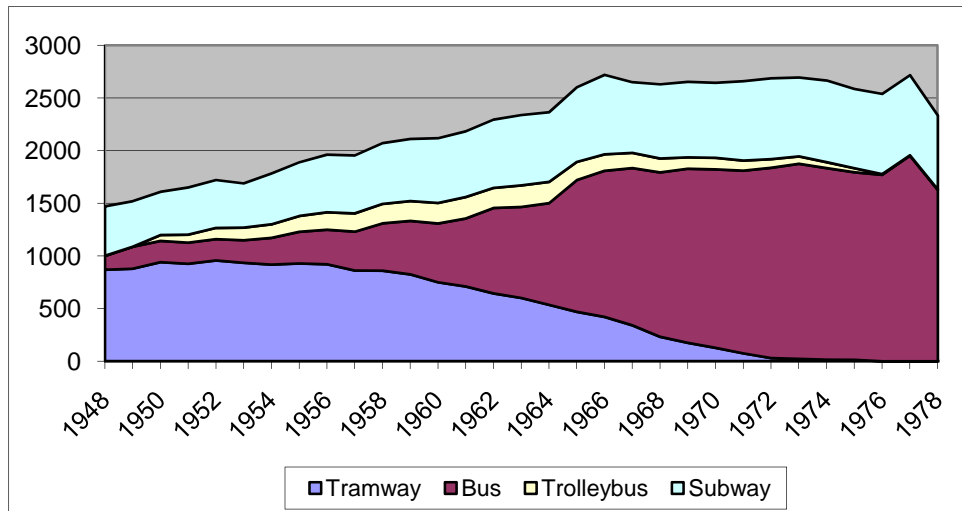
In the tramway business, the evolution of operations was marked by three circumstances: fluctuation in electrical supply, (especially intense during the summer due to the drought), the loss in value of takings (as a consequence of inflation), and the difficulties in obtaining the necessary supplies for vehicle and network maintenance. These limitations, more specifically the failure in energy supply, led to frequent and repeated service suspensions. These anomalies were especially frequent and relevant in the early years of the 1940s when the service had to be frequently reduced, above all during the summer.

The deterioration in the tram network in the period after the War due to increased usage and no maintenance (due to the difficulty in obtaining spare parts), as well as the relative imminence of expiration of concessions and the social awareness of technological obsolescence, led to progressive substitution of trams by trolley buses and buses. This started in 1940 and would culminate in 1951 in the case of trolley buses. As compared to the tram, the trolley bus had the advantage of not depending on rails and thus the public road was not so affected. Also it was more efficient economically per kilometre travelled. Tyres allowed more autonomy of movement and were less noisy. Unlike what happened with the electrification of tramways, their substitution by trolleybuses was not generalised, carried out in barely ten cities, (mainly the largest), nor complete as the coexistence of different forms of traction predominated. It was probably due to the fact that the greater age and size of its tramway networks favoured partial substitution of the tramway network. In smaller cities, recovery of investment had not been completed and the smaller size of its networks made the coexistence of technological systems difficult.

The precariousness of the economic situation of increasing tramway operations came dangerously close to bankruptcy (with the exception of municipal companies, backed by public external funds). This meant that the Government ordered the creation of Commissions in all Headquarters of Public Works to study alternatives for the economic viability of these businesses. There were essentially four alternatives at that time: updating tariffs, granting subsidies, municipalisation or the definitive abandonment of services and their substitution by more efficient technology. Tariff increases were authorised but not enough to cover costs. The delicate situation of the Public Treasury did not advise increasing expenditure via subsidies to technology which was considered inefficient. Municipalisation was carried out in some cities, basically in the largest ones where the gravity of the situation advised this action. On the whole, there was a preference for boosting the substitution of trams by buses. This process was favoured by the Government with the approval of a legal-economic frame, favourable for the transformation of these systems¹⁸.

The abandonment of the tram as a means of public transport in favour of the trolley bus and especially the bus was a generalised phenomenon in Spain from the '50s (Graph 5). Buses did not require all same ground and air infrastructure needed for the tram. Repair works of the rails were a hindrance, buses were more versatile, not as noisy, breakdowns had no effect on the whole network and moreover it allowed traffic to go wherever it needed to (a definitive motive for the elimination of the tram).

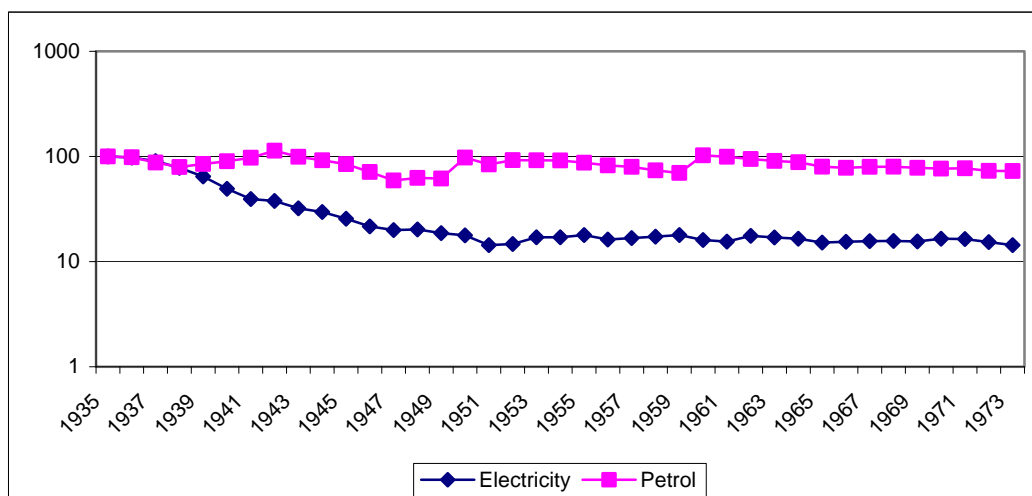
Graph 5. Urban transport in Spain, 1948-1978, in millions of passengers



Source: Gómez Mendoza y San Román, in Carreras y Tafunell (coord.), 2005: 557-558.

One cannot spurn the cultural factor associated to buses and above all the private motorcar for its convenience, independence, flexibility, and modernity. At its time the electric tram was considered thus, as opposed to that pulled by mules or driven by steam (McKay, 1976: 244). One must not lose sight of the interest by oil multinationals to diffuse a new transport system which had a huge potential demand for products and which could be stimulated by a suitable price policy. Note how (Graph 6) the differential between energy prices reduced from the 1950s, after the sharp fall in the actual price of electricity due to the governmental decision to block tariffs during the '40s. Actually, something similar had happened with the interest shown at the start of the century by foreign financial groups (Belgo-German mainly) in promoting the change of electrical traction in trams to provide a way in for their metallurgic and electro mechanical products.

Graph 6. Wholesale real prices of electricity and petrol in Spain, in index numbers, 1935-1973



Source: Carreras y Tafunell, 2005: 433-436.

This reorientation of the model of transport can be linked, although not in a mimetic way, to the sharp increase in businesses tied to the motor industry (petrol refinery, fabrication of cars, lorries, buses and production of tyres) in the ranking of the largest companies, in comparison with the electrical sector, a sector which was already mature at that time (Table 4). To compensate for the loss of the tram and trolley bus market, alternatives would be sought in the diffusion of electrical appliances.

Table 4. Number of electric and oil complex companies among the 20 biggest ones in 1948

Country	Electricity/electromechanical	Oil/cars/tyres
Spain	6	2
Italy ²⁰	1	1
Great Britain	2	4
EEUU	2	10

Source: Carreras and Tafunell (1997), García Ruiz (coord.) (1997), Vasta (2004).

The substitution of trams and trolley buses by buses, 1952-1989

From the start of the '50s, (in line with the USA) two novelties could be seen in the Spanish market: the noticeable growth rhythm and the gradual reorientation of economic policy (which would relax previous rigidity and facilitate progressive opening despite being accompanied by inflationary tension which would culminate in the 1959 Stabilisation and Liberalisation Plan) (García Delgado, 1987: 170-176). For urban transport, these changes would lead to overcoming energy restrictions and difficulties in acquiring spare parts (both fixed and moveable assets) as well as relaxation of price control. From the point of view of demand, this was favoured by strong demographic increase, expansion of towns and improvement in salaries.

As we have seen, trams were only substituted by trolley buses in some Spanish cities. Therefore, in most of these, the deterioration of the system continued as did the economic difficulties of its operation through trams. The trolley bus can be considered as an element of transition between the electric tram and the bus, not only from a technological point of view but also as a model of transport²¹. This is especially true for Mediterranean and Western Europe, as in central Europe and especially Eastern Europe, the trolley bus and the tram have remained until the present day²².

Although the trolley bus made advances in certain aspects as compared to the tram (a lower cost of infrastructure and vehicles, more flexibility), over time, similar faults were attributed to it. In fact, compared to the bus, it was considered that the trolley bus was more expensive to install and maintain, not only due to its need for an

²⁰ Among the ten first ones, in 1952.

²¹ See Rodríguez, Novales y Orro 2003 for the technological evolution of the tramway long term and its differences with trolley buses and buses.

²² In 2000, there were 250 European cities, as well as some in North America which had trolley bus lines (Fraga, 2001: 151-152).

electrical infrastructure but also for the higher cost of its vehicles.²³ Its vulnerability was also criticised as an electrical fault could paralyse the entire service. Finally, it was considered not as fast, less flexible and less adaptable to rapid journey changes.

The prevailing urban configuration in Spain played an important role in the disappearance of tramways and trolley buses during the '60s and '70s. The strong increase of per capita income led to an accelerated growth of the vehicle fleet. The entire city started to redesign itself for the motor car. Roads considered themselves exclusively as areas for traffic, preferably for private vehicles. Any element which was a "nuisance" to the circulation of cars was seen as an obstacle to progress which had to be removed. In this sense, tramways and trolley buses, with their rails and electrical overhead cables, were seen as competitors of cars for urban space. This worsened with the significant urbanisation which took place during the years of the economic development policy, and led to significant changes in the traditional network structure, with the construction of rapid access roads and highways, opening out or closing roads, construction in new areas and industrial and commercial parks, etc. This changed the traditional road network and led, (along with the strong immigration of country- city of these years), to spatial redistribution of the urban population. These dislocations did not suit a very rigid transport system which was based on fixed infrastructures (rails and overhead cables) with great difficulty adapting quickly to the changing environment.

These problems were compounded by the lack of dynamism on the part of the companies of the sector, used to a monopoly and to routine in management. This type of routine could be valid when the sector lacked competence both at the hand of other companies and by its users. But the internal combustion engine had introduced significant changes. Competition, often illegal, of buses had already started in the '20s in suburban lines and would reach urban markets due to the policy of economic development in the '60s. On the other hand, the particular user did not yet make up a captive market by having an alternative to his private vehicle. The imbalance between the offer and demand of transport was not perceived nor satisfied by traditional transport companies which left opportunities for new entrepreneurs in the sector. There would be greater aggression and intuition to detect business opportunities, like the Schumpeterian businessman.

The introduction of the bus was not merely technological but it greatly affected the business model of organisation and its methods of management. Buses did not need high investment of fixed material like tramways and trolley buses. On the other hand, their greater flexibility allowed them to adapt easier to the changes of demand. In keeping with this, the barriers to enter (and exit) were then very inferior to those of the tram and favoured an inrush of new companies in the sector or, at least, significant changes in the shareholders and management²⁴. The business model of the tram era was based on a company with strong financial backing due to the high demand of capital of this infrastructure. Its shareholding structure had been concentrated progressively since the '20s and was in the hands of a few families, originating from the more selective local bourgeoisie who controlled the management and shared the more representative tasks. Its organisation was relatively complex and had become rigid and bureaucratic²⁵, with monotonous management. Stability and routine, in short, characterised this model, in line with a mature sector. All in all, we would find ourselves facing the Schumpeterian contrast of mature companies and entrepreneurial companies. The growing difficulties

²³ In 1969, a trolley bus cost 2.5 million pesetas in Spain as compared to 700,000 for a bus.

²⁴ This is what happened, for example, in cities such as Granada, A Coruña, Vigo, Ferrol or Pontevedra.

²⁵ Its employees had acquired a status of almost civil servants with great stability in the job and family and local cooptions.

from a changing environment led to the business being transferred to a new type of businessman occasionally originating from outside the city and with an initial accumulation of capital which was sometimes controversial²⁶. The transfer of the business was not easy, leading to situations of confrontation and conflict and even disputes²⁷.

With the progressive and generalised substitution of trolley buses by buses, trolley buses and spare parts stopped being manufactured which led to various problems for repositioning broken down parts²⁸. To deal with these needs, and amongst the various solutions possible²⁹, companies often opted for the only really viable solution (although it was the most expensive): building the parts needed in one's own workshops. This forced businesses to obtain a workshop supplied with installations and workers in excessive quantity (in small and medium sized cities), given the volume of these companies.

Urbanisation often led to the partial and temporal interruption of the service of trolley buses, substituting it provisionally with buses. This led to high investments in buses on the part of bus companies³⁰, with the aim to function until the work had been completed and using more expensive energy. This also implied a greater complexity of the vehicle fleet, with a need to prepare the personnel for its maintenance and repair. To tackle these issues, companies reduced personnel inside the vehicles, introducing a driver / conductor in buses. Extra conductors would follow training courses. As students of technological innovation have emphasised, its diffusion is largely conditioned by the proficiency of users to be able to apply it. In the case of the electric tram, its set up often implied temporal hiring of drivers and mechanics from other companies until the personnel was familiar with the new technology. In the case of buses as we have seen, the process of learning was formalised through educational institutions of professional training. In both cases, the change of technology implied a readjustment of personnel's functions. Nevertheless, it is worth pointing out that in the case of buses, the change of traction was used to the benefit of companies to save on manpower, thus intensifying the workload. This kept in check the growing burden of salaries and productivity increased. The process of reshuffling from the business model was finalised in the eighties with major restructuring of the lines, to ensure they satisfied social demands and the needs of business profitability. Finally, the punctual and arbitrary old system of ticket increases was substituted by objective and automatic criteria of price fixing which guaranteed stable and balanced operational methods.

The change of traction reduced costs and improved the economic viability of companies during the '70s. Nevertheless, the economic situation of the transport firms deteriorated during the '70s. On one hand, this was due to the inflation of costs derived from the recession and from union claims in the context of political transition, on the other, an increase of insufficient and irregular tariffs which did not provide a stable frame to business management. This was the peak of private motoring. The situation would manage to sort itself out, not without tension, via restructuring of the service and staff in the eighties.

²⁶ Selling on the black market (illegal commerce very spread in Spain in the '40s), for example.

²⁷ In A Coruña and Vigo, for example

²⁸ Hispano-Suiza and Maquitrans disappeared. ENASA did not yet manufacture parts of these models of Pegaso. In France, the Société des Véhicules et Tracteurs Electriques, (manufacturer of Vetra trolley buses) also stopped manufacturing parts. BUT spare parts also did not manufacture yet.

²⁹ The other two were to order parts from new suppliers or to adapt trolley buses. In the first case, they could not find manufacturers, the price was very high or profits low. In the second option, it was not easy to find equivalent functions and facility of adaptation to the rest of the vehicle.

³⁰ To reduce its costs, they usually acquired them second hand from other transport firms.

Transforming tramways and trolley buses concessions into bus concessions meant legal complications due to different administration. Whilst the former depended generally on central government, town halls granted those for buses. The different competences also meant that the payee of the levy paid by the concessionaire and the installations and material (at the time of reversion) was directed to different administrations. To favour the transition, the State granted similar bonuses to those approved for trolley buses, consistent in relinquishing having to deal with materials and installations for transforming these companies. The fact that the substitution of routes and services allowed concessionaires to depend on town halls was an opportunity in favour of the change in traction, facilitated by the legislation of 1973, approved before the oil crisis.

All in all, in the seventies, trolley buses disappeared from Spain³¹, without the change of traction generating unease in neither public opinion nor a debate on the opportunity of substituting electrical traction for that of fuel, just in the decisive moment of the oil crisis. The Government's policy to hold back and tone down the transfer of such increases of petrol prices to consumers, alongside the generalised absence of environmental sensitivity, united all to the symbolic contrast between the "obsolescence" of the trolley and the "modernity" of the bus. This shows that the movement went almost unnoticed.

Conclusions

Long term, the evolution of urban transport companies and the service itself was marked by the ruptures caused by the different changes in traction. Its modes of realization (following the theory of *path dependency*) were conditioned by its previous situation. Technological innovation in the sector presents two key moments, with exogenous inventions (electricity and the internal combustion engine) which were applied to transport in a schematic cluster layout. These innovations meant significant discontinuity then led to noticeable changes in the business model and organisation.

New technology arrived in Spain a little late but this delay reduced over time. The same occurred with its diffusion within the country. Both innovations, especially the first, were largely promoted from outside by multi nationals interested in expanding the market for their productions.

Electrification of tramways was the innovation with the biggest break-through. It popularised mobility in a context of increasing demand for public transport, and meant modern countries could use urban transport. Strong financial backing often came from abroad. (Belgium- German). The service became more complex and vulnerable, with a network which made its organisation more arduous.

The second change of traction (the internal combustion engine) had less relevant effects (although not negligible). It was carried out in a less drastic and less rapid way than electrification, with the trolley bus as a technology of transition, probably due to the significance of the investment already made in tramways (and the repayment of which needed to be made). On the other hand, the introduction of buses occurred in a period of deadlock of public transport demand, motivated by the peak of private motoring. In any case, this innovation was also accompanied by a significant change of business model, with an inrush of new companies which were smaller and more dynamic and which introduced important reshuffles in the service and its organisation.

³¹ The only one remaining was that of Pontevedra-Marín, eliminated in 1989.

All the changes of traction occurred when the service underwent strangulation and when companies experienced difficulties due to the limitations of the current technology. In this sense, the innovation led to overcoming these situations and a clear improvement of business results. We were, on the whole, in a sector whereby the transfer of the technological border would have significant effects of discontinuity, following a scaling model.

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