TECHNOLOGICAL MODERNIZATION IN NETWORKS WITH WEAK TRAFFIC FLOWS: SAFETY IN IBERIAN PENINSULA RAILWAYS DURING THE XXTH CENTURY

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At the end of 19th century, the Iberian railways companies -Companhia Real dos Caminhos de Ferro Portugueses (CRCFP) and Madrid a Zaragoza y Alicante (MZA) and Norte- were showing excellent operating rates (operating costs divided by total income). They had several characteristics in common.

1) The role of foreign capital has been extensively studied by economic historians. All three companies relied on debentures issued on the French market rather than share capital to fund building works. Bond dividends had to be paid in French Francs, and bonds had to be redeemed in Francs. It represented a very heavy burden of financial charges.

2) Spanish and Portuguese companies faced very little demand for transport services. So, revenues were short.

3) High financial charges and low traffic forced to the companies to reduce the operating costs, specially the ones relating to railway safety.

In this article we discuss the views on Iberian railways safety put forward by managers and engineers. We argue that they were perfectly aware of the latest technological advances. Many of the engineers came from France; others had received training in that country. But, in order to reduce financial costs and achieve the highest possible results, the managers of CRCFP, Norte, and MZA, under the orders of their committees in Paris, took several decisions on matters of infrastructure that impacted directly to safety. That strategy concerned the infrastructure and maintenance, rolling stock and traffic movement. We must also point out that, given the low investment on technology; the most important factors affecting safety were the insufficient number of workers and their low salaries.

1. WEAK INFRASTRUCTURES AND LACK OF MAINTENANCE OF TRACKS

In 1861, the Spanish entrepreneur, Jose de Salamanca, forced on Portugal a 1,67 m gauge. This was done in order to allow the building of a continuous track from Lisboa-Porto to Madrid for the use of the three firms in which he had an interest: CRCFP, Ferrocarril Ciudad Real-Badajoz (FCB), and MZA. Salamanca was highly experienced in finding funds in international financial markets. In the case of Portugal, Salamanca raised the funding through the method of issuing a disproportionate amount of debentures. Although the rate of interest applied was very low, interest payments were, for many years, a heavy burden on the results of CRCFP. Salamanca displaced to Portugal two close collaborators the French engineer Antoine Chatelus and the Spanish engineer Eusebio Page, in order to build the CRCFP track. Both had been working for Salamanca in MZA. In view of the possible differences that might arise between Salamanca, as builder, and CRCFP as the managing

society, both parties agreed to appoint Paulin Talabot as arbitrator. Paulin Talabot was a director in the French company Paris-Lyon-Mediterranee.

The quality of the works performed was dubious. But this was not acknowledged, as the Board of Directors of the Portuguese company was nominated by Salamanca during its first five years, as provided for by the regulations of CRCFP. A Board of Directors ruled in favour of Salamanca and against Talabot in all the issues arising from the quality of the work undertaken. In the end, the railway line built by Salamanca was expensive, and ignored the technical regulations imposed by the Portuguese State. In the second decade of the 1860s, there was a fall in traffic in the Iberian Peninsula, as a consequence of a deep financial crisis. This resulted in CRCFP not honouring its payment obligations, a situation that was repeated a year later in the case of Norte.

Given the heavy burden imposed on the companies by their debenture capital, the directors Eduard Goudchaux (CRCFP), Gustave Noblemaire (Norte) and Ernest Lemasson (MZA) took recourse in fare increases and a reduction in operating costs. They were of the opinion that the majority of accidents were caused by the difficulties inherent in managing heavy traffic; but this was not true for Spain and Portugal, where traffic was much reduced. They were perfectly aware of the fact that this was a risky policy, but their approach to reduce overheads meant reducing maintenance expenditure, concentrating passengers and cargo on a small number of trains, and making workers redundant. This policy resulted, as it could only result, in a high accident rate. This obliged national governments to intervene.

Governments, having subsidised the companies, had to intervene in order to guarantee safety, as they felt responsible for the public interest. The managers of the companies had a very different view, arguing that their right to take decisions was being interfered with. Just to give an illustrative example, in July 1870, the French engineer Le François moved from MZA to CRCFP, in order to improve the financial situation of the Portuguese company. He drastically reduced the number of employees and their wages, attempted to reduce the number of trains, and proposed lower speeds in order to reduce coal consumption. This had an important impact on the safety of CRCFP and the Portuguese government was forced to intervene to enquire into the matter of safety.

In those days, the causes of the railways accidents changed. Before, the engineers did their best for having good track, controlating at the same time the steam power. In accordance with a Norte rapport from 1865, most of accidents were due to the railway equipment deficiencies. But, soon the situation changed absolutely. Since then, the managers put the blame on the workers. They positioned so that no one could put the blame on them, nor did the firms. With reference that subject, the rapport sent by Le François to the board of directors of the Portuguese company in October of 1870 is quite expressive. In the previous year there had been nineteen derailments in Portugal. Most of them were due to mistakes or negligence workers. According to Le François the excess of speed, wrong shunting at the station and wrong handling of switches were responsible for eleven; the chief of maintenance track was responsible for four, and the rest were provoked by different causes, but no one related with the firms. Nevertheless, at the end Le François admitted that actually the deterioration of railway equipment had to do with several derailments.

As the accidents became too frequent, Le François was forced by State to resign, holding his office the Portuguese engineer Afonso de Espregueira, who had studied at École des Ponts et Chaussés de Paris. For the CRCFP the tight control of overheads carried out by Le François was very successful. In according with the

statistical series of the firm, during the short space of time Le François was Director Manager (1870-1871) the overheads fell meaningfully and revenues increased. The company resumed the interest repayments to the bondholders, and in recognition of his services. Le François was appointed member of committee of Paris of CRCFP.

However, the Portuguese and Spanish states intervened differently on the railway companies. Given the danger for traffic movement, the Portuguese state even closed the Tejo Bridge. Meanwhile, on the other side of the border there were also serious problems with the bridges; according to public opinion it was due to lack of infrastructure maintenance. In 1872 a viaduct in the Almansa-Tarragona line collapsed during a storm; seventeen corpses were swept out to the sea. One year later, one train from Norte derailed on leaving a bridge; twenty one people were killed. On 27 April 1884 a passenger-goods train of MZA with various cars full of soldiers fell down a river, sinking to the bottom of it; fifty nine people lost their lives. On the beginners of the twenty century it was obliged to put check-rails on the new bridges, though in the old civil engineering only it was recommended its use. In 1904 a train from Norte derailed when it crossed an old bridge; forty three people were killed. But, according to the Spanish Inspection the causes of accident ought to attribute to chance or without justifiable reason. Any case, the firms were released of responsibility.

After long experiments on material tracks in France, it was produced a changed at the beginners of 1870s. With the similar prices the steel tracks had a better resistance than the iron ones, and above all they reduced the maintenance costs. Wore out the iron tracks from the lines with more intensified traffic, since 1873 MZA introduced the steel tracks for its improvement of it Mediterranean line. Soon later, Norte made it in mountainous branch lines. CRCFP began changing by the steel vignole rail by the steel vignole their defective iron champignon tracks in 1876. The renovation was very slow. On September 1878, after thirteen years working, it was produced the first accident in CRCPF; one passenger was killed. It had been broken one old iron track. At once, the Portuguese State obliged to CRCFP to renovate all the tracks.

During the 1880s, the steel vignole rails had spread all over the networks in both countries. Nevertheless, the arrival of more powerful and fast locomotive brought out the lightness of this track; it was specially proved true on the routes with a lot of traffic, slopes and curves, being necessary to improve the ballasting and increase the number of sleepers. Even so, keep running slowly was the economical solution of all these problems. According to the report submitted to International Congress of Paris (1889), in England it hadn't speed limit, letting the locomotives run 120 kilometres an hour. The Iberian Peninsula didn't figure among in the report. Neither their fast trains were authorized to run over 60 kilometres an hour. The financial and traffic problems advised companies to the train speed in order to get better safety.

2. A MINIMUM AMOUNT OF ROLLING STOCK TO CONCENTRATE THE OFFER OF TRANSPORT

As the traffic density of personal and goods by a kilometre was very low, the Iberian managers decided to concentrate the flows on a short number of passenger-goods trains in order to reduce the traction costs. In Portugal, CRCFP began to operate on July 1864. Not long after, according as a report from a Commission that

had been appointed by State, the company lacked of efficient equipment for giving a suitable service. By then, with over 500 kilometres already working, CRCFP supplied only eight daily passenger trains, six of them were passenger-goods trains and the two mail cars; they ran through the branch lines Vila Nova de Gaia and Badajoz, linking to Lisbon-Entroncamento line.

As regards the international traffics, there was agreement between Spain and Portugal since the beginning. On both sides of the border, CRCFP, FCB and MZA shared many features: the gauge was the same, and also the of working and financial methods; some Members of Board of Directors were the same, and so political influences; the threes firm receive funding from the French Crédit Industriel et Commercial. One of the most noteworthy features was the low ratio of working, co-existent with a very poor net return of profit. As has already been mentioned, all these companies were burdened with excessive charges for their loan interest.

FCB showed very soon signs of having serious financial problems, so that its works, directed by the Spanish businessman Gándara, had often to be delayed. At the moment Gándara was member of Board of Directors of MZA, and later he was appointed as Delegated Administrator at the Paris Committee. Once the networks of both countries were connected in 1867, the Spanish Government authorized the free movement of traffic between both countries, provided that Spanish engineers had certificated that the railway equipment of CRCFP worked properly. In any case, there was less traffic of wheat, oil and minerals than CRCFP had expected to receive from FCB. On the other hand, since 1868 there was only one passenger train with first class car that runs from Lisbon to Madrid; the cars belonged to CRCFP, FCB y MZA.

Beyond the common interests of the firms, between the Iberian countries there were also many obstacles during the nineteenth century, as the existence of customs, the problems associated with currency change, and the diversity of the tariffs (Pinheiro, 1995). Moreover, several technical questions were not solved. For example, neither of countries adopted measures for standardizing the components of the carriages like it had been done among Germany, Italy or Switzerland. In the beginning, as the Iberian firms didn't know how to make their own railway material, they turned to French, Belgian and English manufacturers. The supplies of cars and wagons were heterogeneous, what made very difficult and expensive their maintenance, because of the lack of unified components. Soon, the companies were aware of the error. In 1867, CRCFP wanted to reduce the variety of carriages, but never had it assumed the cost. In Portugal and Spain, if one car or wagon broken down when it was in transit by other company, it was necessary to change the goods to the other one and wait till the spare-parts were received. Often it stayed in the shops for a long time. Unfortunately agreements about standard and exchanges of material never were reached among the firms and countries.

The only exception took place in 1880 on occasion of the opening the line Madrid-Lisbon, when the traffic of mineral fertilizers in charge of CRCFP, flowing on Spanish soil, was intensive. Then, the CRCFP managers applied for an import licence of spare-parts and tools of repair and maintenance of wagons and carriages that stayed out of action in Spain. On the other hand, since 1882 one express linked Galicia-Porto to Lisbon and Madrid. The traffic was increased dramatically. So, Pedro Ribera, who had worked in CRCFP as Chief Engineer of Locomotive, Carriages and Wagons, and at the moment he worked in Norte as Chief Engineer of Traffic, presented a project in 1884 where he proposed to unify the rolling stock. Unfortunately, the traffic of mineral fertilizers didn't last. Even though, CRCFP tried various times to settle in Spain, but didn't get it.

Within the rolling-stock, the main responsibility of the accidents was accounted for by the couplings. In other countries where the traffic was very intensive like England, the hitching and unhitching of wagons and carriages manoeuvres ought to be done very fast. In the Iberian countries there weren't any common criteria with regards to the buffers and couplings. A Conference on Technical Unity of Railway Equipment and Tracks was held in Berna in 1886, and at the end of eighteen century and the start of the twentieth one the railway managers of European countries tried to impose the automatic couplings; it of course improved the safety, but meant to unify boxes and pieces. Although it was recommended to make use of them, Iberian Administration didn't establish any rule about it till the twenty century.

At the beginning of railways, the brakes were set up on the locomotive, tenders and tail wagons; sometimes they were on the van of the chief of train, and distributed all over the wagons and cars. The number and place depended on the number on vehicles and the line slopes. In order to low the speed, it was necessary to close the locomotive regulator, and apply the brake. Simultaneously, the driver blew his whistle ordering the brakemen to turn the wheels, close the air flows and apply the wooden brake-blocks. This kind of braking was unsatisfactory. On the one hand, it limited the train speed, due to it couldn't synchronize the driver order with the brakemen working. On the other hand, its frequent use wore out the wheel rims, braked block and the iron tracks.

At the end of the 1870, air brake and vacuum brake were introduced in Europe (Pereira, 1998); its objective consisted in stopping automatically the train wheels when it had been produced a couplings breakdown or it had happened a derailment. In Portugal and Spain the braked improvements were delayed. In according with Pereira (Pereira, 1998), in 1880 CRCFP had some dining cars and sleeping bogie coaches, and vacuum brakes. On December 1881 MZA introduced the bogie coach with the Westinghouse brakes on the Madrid-Barcelona route, but only in a very short distance. In fact the braking hardly improved until the arrival of outside factors.

In 1887 one luxurious Sud-Express, should run from Lisbon and Madrid to Paris and Calais. Started working; it had been equipped with bogie cars from Belgian Compagnie Internationale des Wagons-Lits. Its fast and heavy framework required powerful locomotives, solid infrastructures and automatic brakes in order to stop a train. Due to its excellent quality, that had proved in the Sud-Express, the automatic braking was introduced to luxurious trains by CRCFP and the Spanish MZA, Andaluces and MCP. The Express Lisbon-Porto is a representative example of the new brake efficiency. In 1877 the journey took along eleven hours and fifty minutes, but at the end of 1880's, when the trains were provided with compound locomotive and automatic brakes, it lasted only eight hours. Nevertheless, Norte delayed its incorporation. Unfortunately it happened a tremendous sinister, because of lack of effective braking. On September 1891, there was a head-on crash between one train coming from France and the other passenger-goods train. In this accident fourteen passengers lost their lives and twenty five were killed.

Soon later, as consequence of the accident, it was ordered to introduce a unified system of braking. The main companies incorporated then the Smith-Hardy vacuum system, but for a long time they didn't unify the system. According to MZA inventories, until the second decade of twenty century lived together the systems brake of Carpenter, Westinghouse and Smith-Hardy. Neither was unity in the rest of Europe, except in Germany. For a long time, Spanish and Portuguese rail managers were against the automatic braking. Firstly because the cost was

too high and it couldn't pass on to the tariffs; then, because it hindered the formation of passenger-goods trains, that were majority in the Iberian Peninsula; finally because its weigh supposed an increase of traction expenses.

3. THE OVERDUE AND LIMITED TECHNOLOGIES IN THE CIRCULATION

Soon, the traffic density required from the companies to have stronger control traffic in order to improve the safety of passengers and goods movement, without only depend on human factor. But, that wasn't the situation of Spain and Portugal where the traffic was very short. That's why the firms didn't refuse to assume any cost related with the safety matter.

A frequent incidence at the beginning of the railroad was the breakage of the traction apparatuses and the escape by the way of cars and wagons that crash against other rolling stock. In order to palliate these accidents, several European countries introduced a system of electrical bells in stations, squares of guard and grade crossings, that allowed to warn of the loss of vehicles and other aspects of the traffic- exit, direction of the trains, necessity of an aid machine, etc.-. In 1855 the first Siemens bells were used in Germany and, shortly after, they were improved by Leopolder (they were known as Austrian bells). By the end of the seventies, almost all the lines of single track from Germany, Austria, Hungary, Holland, Belgium and France had some both of systems.

Since the 1860s, the block system was incorporated in many countries. It consist on dividing the track into short stretch, doing feasible the movement of various trains in the same direction. For controlling the great density of traffic, in France was built 3 143 kilometres with block-system, and United Kingdom over 20 000 kilometres. Not either of control traffic system was adopted in the Iberian countries during eighteen century. No one train from the other countries ran through its railways track. According to the managers with the telegraph block system and a more efficient performance of workers, keeping the rules of circulation on single track, were enough for a good safety.

At first, many derailments had place at the stations because of the erroneous shunting, what produced damages and losses to the companies, and took traveller's alarm. A wrong movement along the track or from one track to another was responsible for lots of rail accidents. As we have already said, the managers claimed that ignorance of workers was to blame for them. The refused to accept their responsibility for his own mistakes and lack of investment. Nevertheless, in Portugal the State Inspectors considered that the shunters shouldn't do any other task as load and unload merchandises from the trains because it took their attention away. On the other hand, lots of accidents were caused by mechanical failures. For example, the tremendous and continuous hitting of wheels on the track switches and crossings frayed easily the tracks. That is the reason why in France all the old track switches had already been replaced with the other new ones in 1868; ever since then the number of incidents fell dramatically. Likewise, since sixties the gear levers were brought together in the one point so that the shunters didn't have to move from one point to another. The adopted solution in Iberian countries wasn't technical one. In order to minimize the incidents the statutes of companies stated to slow down the speed of the locomotives when they had to take a detour.

Given that the density of traffic was short in Portugal and Spain, the block sections were marked out by advanced signals boards at the stations. Therefore in order to get an efficient control of traffic it was only

necessary to relate the lever points with the signals. An other hand, the interlockings appeared 1854 and soon were spread on several European countries. In spite the advantages, it wasn't introduced in Portugal till 1882, just when the company Tarragona a Barcelona Francia (TBF) placed the first Saxby-Farmer interlocking. Before the eighteen century MZA has spread to whole net and CRCFP to Cintura and Urbana of Lisbon line and Lisbon to Sintra and Torres Novas section.

4. CONCLUSIONS

As has already been said, Spain and Portugal were several years behind England, France or Germany in building railway, so the Iberian managers were complete awareness about the technological advances about safety matter. Since the traffics were short and the finance charges too high, in order to get a low coefficient of exploitation the companies carried out similar strategies on the safety. In both countries: 1) the firms built fragile infrastructures and didn't provided enough resources for their maintenance; 2) the concentration on a short number of passengers and goods trains ought to be reduce the operating costs and accidents; 3) the expense in running technologies was minimum; 4) and, finally, the number of permanent staff was reduced.

A great controversy about safety measures broke out among the companies and the States. The engineers maintained that they were able to harmonize the firm interests with the passengers' interests. Actually it was only matter of concern when someone was killed or injured. Both the State and companies were interested in avoiding the shock that disasters produced in the society. Even so there were differences between Portugal and Spain. After the first accident that left people dead in Portugal, the State intervened quickly so that CRCFP had to improve the safety system. On the contrary, in Spain the most of disasters were imputed by managers to forces beyond their control. In this case, the improvements were introduced only when the traffic density required them.