Between the Workshop and the State: Training Human Capital in Railroad Companies in Mexico and Chile, 1850-1930

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Abstract

This paper analyzes the human capital training strategies adopted between the 1850s and 1930s by railroad companies in Mexico and Chile. These two countries enable one to contrast the different routes taken by the same type of firm, technology and labor force. A propos of this, we suggest that because of its complexity, capital intensity and new work methods, railway technology had a positive impact on human capital training in the cases studied. During the period when railways were the main form of land transport studied - covered by this study- they combined the labor force with foreign workers and modern technology and it was not until well into the 20th century that a formal system of technical schools was established. Instead, informal and formal learning cycles and routes tended to be followed. That is why this paper considers three aspects: I) the institutional and social factors that helped or hindered industrial operations, maintenance and production training; II) the way learning, training and talent retention cycles were shaped and talent migrated towards other activities or was dispersed or lost; and lastly, III) how training was institutionalized through what were known as "firm schools" responsible for training human capital as an internalization response to coping with shortages in the labor market.

Key words: human capital, technology, railways, México, Chile.

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INTRODUCTION

Between 1850 and 1930, Latin American economies received a wave of foreign investment that led to various changes on several fronts through railroad, electricity, mining, smelting, refining and industrial manufacturing. These firms were forced to use technology and the capital incorporated into personnel training -human capital- in contexts of high illiteracy, institutional instability and cultural obstacles. Knowing how firms developed the intangible assets of their labor force under these conditions is still an issue that has barely been researched by economic history and the history of firms in the Latin American region. The past few years, however, have seen increased knowledge of the main trajectories,[1] and more recently, researchers have begun to show an interest innovation, technology, labor and business strategies.[2]

This paper analyzes the human capital training strategies adopted by Mexican and Chilean railway companies from 1850 to 1930. Neither country has an established tradition of comparative studies, unlike Argentina and Uruguay, which have been analyzed within the group of "recent colonies" (since they share features with Australia, Canada and New Zealand). They do, however, enable one to contrast the different routes taken by the same type of firm, technology and labor force, within a common scenario of economic backwardness.[3] A propos of this, we suggest that because of its complexity, capital intensity and new work methods, railway technology had a positive impact on human capital training in the cases studied. During the period when railways were the main form of land transport studied -covered by this study- they combined the labor force with foreign workers and modern technology and it was not until well into the 20th century that a formal system of technical schools was established. Instead, informal and formal learning cycles and routes tended to be followed. That is why this paper considers three aspects: The paper therefore considers three issues: I) the institutional and social factors that helped or hindered industrial operations, maintenance and production training; II) the way learning, training and talent retention cycles were shaped and how talent migrated towards other activities or was dispersed or lost; and III) the way training was institutionalized through what were known as “firm schools” responsible for training human capital as an internalization response to coping with shortages in the labor market.

In this respect, authors such as Galor and Moav (2006) and Goldin (2001) have stressed the complementarity that arose in the 19th century between physical and human capital, due to technological change, the scale and complexity of the firms that increased the demand for skilled labor and businessmen's interest in supporting public education. Chandler (1977) had already pointed out that since the second half of the 19th century, the development of communication technologies, such as the railway, the telegraphy and subsequently the telephone had led to the emergence of large industrial firms organized at various levels, with knowledge hierarchies and to the expansion of post-elementary education in the United States as from 1910. This enabled firms to become incorporated into the growing stock of scientific and technical knowledge. For Goldin, then, the modern concept of the wealth of nations emerged in the early 20th century with the incorporation of human capital.[4]

Several relevant cases attest to this phenomenon. The transport revolution, begun by railways in the Great Britain, United States, Belgium and France, permitted specialization and innovation in the production of equipment and machine tools as well as new work skills. Fishlow and Rosenberg posited that in the United States before the Civil War (1861–1865), the repair workshops set up in agrarian areas helped speed up and direct technical knowledge towards other sectors of the economy. Atack, Haines and Margo have highlighted the positive effect of railways on encouraging the shift of U.S. artisanal production towards industrial production before the 1870s. Their export to backward regions such as India created a new job market for both Americans and a large number of local workers.[5]

In Latin America, this complementarity has lagged. Achieving it took the entire 20th century and the results are still insufficient, although advances have been recorded in some sectors. In particular, the fact that much of the investment should have materialized in railways yielded a number of advantages since this means of transport combined workshops, labor and the demand for engineering products. In societies with large estates and political instability such as Latin America, in addition to having to cope with enormous challenges, railway technology also provided a wonderful opportunity to provide technical training in societies where 80–90% of the population were illiterate. The Latin American experience has involved paradoxes and imbalances, since in 1914, when high illiteracy levels had been recorded, the region was the second largest destination of international investments after the so-called “new” Western countries (United States, Canada, Australia and New Zealand).[6]

These paradoxes were present in the case studies. Coatsworth established that until 1911, railways in Mexico provided “virtually no incentive for industrial development” despite the fact that since 1903, the country had had steel production in blast furnaces, which did not tip the balance against imports. Oppenheimer said that railway construction in Chile in the central part of the country between 1850 and 1885 made it more dependent on the importation of European technology and foreign professionals. However, it should be pointed out that according to Lewis and this author's own research, by 1910, railway workshops in countries such as Argentina, Brazil, Chile and Mexico were already major industrial installations that produced a certain amount of rolling stock and contributed their human capital to other sectors of the economy.[7]

In order to explain these phenomena, the paper is organized into five sections that deal with the railway's capacity to complement physical and human capital; international models for training intangible productive assets in the labor sphere and their translation and adaptation to Mexico and Chile. The last section contains the conclusions.

1.- RAILWAYS, AN ACTIVITY THAT COMPLEMENTS PHYSICAL AND HUMAN CAPITAL

From the outset, the railway firm was a great firm that differs in certain respects from the industrial firm analyzed by Chandler (1977, 1990), which should be considered to study its demands for human capital.

The railway is a service firm whose business is the sale of overland mobility through the integration of marketing, communication, traffic, construction and both civil and mechanical engineering that extends across large stretches of territory to operate in a balanced, coordinated fashion. Infrastructure in a set territory shaped the business, meaning that its organization had knowledge hierarchies and multiple levels that did not operate as an industry confined by the space in which it was produced. A railway operates in a multi-localized, simultaneous and interactive fashion with its market through a standardized organization that is present in several places with various premises, personnel, technologies and information to shift an asset or a person from one place to another. In this respect, it has the Chandlerian attribute of scope for its activity.

A crucial aspect for Latin America is that the railway was an activity that enjoyed early state intervention. This differs from Chandler's view that large private corporations mobilized massive resources in production, distribution and financing.[8] Lastly, the railway had industrial capacities that are difficult to describe and that do not correspond to those of an industrial firm.

During the steam era, it was a technology that fully complemented physical and human capital, whose handling required a lengthy learning process. It called for personnel with vertical hierarchies to be able to work with various capacities and skills at the workshop and railway network level. Traffic personnel had a rigid hierarchy and discipline for carrying out orders, as well as knowledge about the legal rules and regulations and technical characteristics of the train's formation (which varied from day to day). Engineers and firemen had the ability to provide movement, drive, supply, anticipate a flaw and arrive at the engine shed knowing what repairs had to be done as a result of the journey.

There were two main areas in the maintenance workshop: engines and material that had been towed in that could not be organized as an industry of standardized, continuous processes, except in certain parts of the process. Instead, artisanal forms had to be combined with industrial ones to deal with a wide range of equipment, tasks and contingencies.

Workshops used reverse engineering to break down a vehicle into its component parts, repair it, re-assemble it and manufacture spare parts, reproducing limited amounts of the manufacturers' parts and pieces. This might create the impression of being autarchic, which it was not, because several kinds of communication networks and logistics converged on the railway workshop. Its directors had to be aware of the new types of equipment and materials, input prices, how to respect manufacturers' patents, what improvements should be incorporated into the engines and carriages and where to hire a first-rate mechanic and transfer him from one hemisphere to another.

All these processes were highly labor-intensive and converged on a single activity: maintenance. Despite its being a crucial activity in all modern firms, studies on maintenance are virtually non-existent, although its importance was pointed out by Hirschman (1958), who observed that it provided an opportunity for Latin American labor to train in technology-intensive industries, where "they could acquire the habit of maintenance, which would then extend to the rest of the economy."[9] Hirschman's statement holds true for Chile, where workers trained in mechanical maintenance were employed in other sectors of the economy long before 1929 (Guajardo 1990, 1992, 1993, 2008).

Maintenance training was an activity that had to adjust to a set organization, institution and work culture that was transferred from the railway producing centers. Great Britain and the United States were the main references for Chile and Mexico that coexisted with French, Belgium and German references, which American technology and organization would begin to dominate from 1900 onwards.

2.- Two models of human capital training: Great Britain and the United States

Railway technology was internationally disseminated, with innovations taking place in an increasingly global market. This situation, however, did not displace the original matrix that defined the organization, operation and training of its personnel and shaped the activities of the workshops that provided everyday support for mobility. Workshops incorporated technological progress as well as training the labor force.

The initial matrix of many Latin American, particularly South American, railways was Great Britain, whence a workshop organization was transferred that also considered the production of its own rolling stock. The latter can be explained by the strongly hierarchically, artisanal form of industrial work that was still present in 19th century Great Britain, where workshop and material overseers wielded enormous decision-making power over purchases and production. Consequently, early railways began building their own engines and carriages since they had acquired industrial skills, while independent industrial firms specialized mainly in exports. Material production was governed by the "purchaser's initiative" which determined the characteristics of assets and dictated innovation, a pattern that was reproduced on the American continent in Canada where, from the 1860s onwards, lines such as the Grand Trunk and the Great Western built their own carriages, engines and machinery, which provided a significant boost for industrialization.[10]

The situation was different in the United States, where the technological initiative was largely assumed by the manufacturer, who influenced equipment buyers and operators. In a new country, without artisanal traditions, with a labor shortage, an abundance of natural resources, a border that was expanding its domestic market and encouraging rapid industrial growth, a more practical, flexible business profile was created to provide less expensive solutions.[11] The railway's response was that equipment production was externalized towards independent providers, leaving the workshops for maintenance, although they preserved a certain industrial margin. During the 1890s, companies such as the Pennsylvania Railroad and Baltimore & Ohio built engines in their workshops and by 1900, nearly 90% of the engines had been built by independent firms, unlike British railroads, which were self-sufficient. Some repair workshops were also great carriage producers: Between 1872 and 1873, railway company workshops built 38% of the country's freight wagons, producing 143,000 by 1900.[12]

Unlike British workshops, in American companies decisions were made by traffic and railway engineers responsible for the movement of trains, transport marketing and extending the lines, leaving the heads of the workshops in the third line of decision making. This also materialized in the American tendency to produce equipment with materials and designs compatible with earning conditions and expectations.[13] The strategy was institutionalized in the "American system" of producing exchangeable parts and pieces for manufacturing large quantities of goods that would lead to the mass industrial production of the 20th century.[14] Conversely, the British industry operated with higher costs because of its fragmentation and the limited amount to be produced. This was reflected in the lack of homogeneity of its assets. Firms were forced to have high, "inward" vertical integration, as a solution to cooperation and communication problems due to the difficulties of subcontracting parts of the production process, particularly precision parts.[15]

Thus, "Atlantic" forms could take one of two routes: externalization (as in the United States), or internalization (as in Great Britain) as summarized in Table 1.

[Table 1]

This also applied to human capital training, since in the British case there was an educational internalization through apprentices' school that produced skilled workers, of which James Watt & Co. was the most successful example. This was an initiative by the middle and working classes that together encouraged the creation of education and professional institutions for the industry. The situation was different in the United States, where there was a tendency towards externalization in schools outside firms guided by a distinct utilitarianism that linked engineers' and technicians' training to industrialists' interests.[16]

The competition between these paradigms was in turn transferred to the Latin American region.

As from the 1850s, the initial pattern of railway expansion in Latin America was influenced by Americans in countries such as Argentina, Brazil and Chile. The financial conditions of these endeavors, however, led to the predominance of British business management, as happened in railways along the Pacific Coast of Peru and Chile. In Mexico, British influence focused on the slow construction of the line between the port of Veracruz and Mexico City, which received French, American, British and Belgian technological contributions until its inauguration in 1873. From the 1880s onwards, however, the main trunk lines began to be built with American investment, organization and technology,[17] creating a technological model with powerful transnational links and growing standardization, although this did not mean that their workshops became the basis of a local industry.

In Chile, these two paradigms began to compete at an early stage in the central part of the country, where railway lines were publicly owned from the 1850s onwards, eventually becoming consolidated as a single state firm in 1884. This was expressed in different styles, since British influence led to the internalization of production in the railway workshops and skilled labor that migrated to other sectors of the economy. Thus, the case studies show differences based on the role played by the state in relation to competing paradigms. As Vertova points out, the historic possibility of specialization in advanced technologies has required the institutional restructuring of the economic and social bases. In this process, state intervention plays a key role in mobilizing accumulated knowledge and the productive and institutional base.[18]

3.- THE TRANSLATION OF HUMAN CAPITAL TRAINING MODELS IN CHILE AND MEXICO

As noted earlier, Mexico and Chile do not share a broad tradition of comparative studies. Mexico is a country with an ancient, pre-Hispanic tradition, while Chile has an old mestizo population with a small contribution of immigrants during the 19th century, with significant differences in size. In 1900, Mexico had 13.6 million inhabitants, while Chile's population was barely 2.9 million. By the 1950s, they had populations of 27 and 6 million, respectively.[19] Chile is a long way from the world's industrial centers, which did not, however, prevent it from trading with England in 1820. Mexico shares a 3,326-km border with the United States, which accounts for 80% of its foreign trade.

In both countries, the agrarian sector has had considerable economic and political importance, albeit with specific differences that explain why Chile did not experience an agrarian revolution. Mexico entered the 19th century with a widespread indigenous communal agriculture, unlike Chile, where indigenous communities were scattered and not organized, enabling landowners to exert greater control over both the land and the work. These conditions enabled it to export wheat to Australia, California and Great Britain from the 1840s onwards. Nevertheless, mining exports dominated and displaced agriculture in exports, enabling it to generate the fiscal income required for an increasingly centralized national state. All of these elements made Chile a successful case of export growth before 1914.[20]

Mexico had to wait until after 1876 to achieve the minimum conditions of political stability that would enable it to ensure property rights and attract foreign investment. From 1877 to 1910, per capita income in Mexico increased at an annual rate of 2.3%, achieving an export income of $10.7 USD in 1912, approaching Brazil's rate of $14.2 and making it the country with the largest amount of direct foreign investment. In 1914, of a total of $7,569 million USD in foreign investment in Latin America –in addition to large receiving countries such as Argentina and Brazil– 15% was in Mexico, ahead of Chile, which received 6.5%.[21]

This performance was altered by the outbreak of the Mexican Revolution in 1910 and the First World War in 1914. Although Chile felt the economic impact of the European conflict, it did not change its laws to prevent investment. Conversely, in 1917, Mexico established nationalistic laws discouraging foreign investment and private property rights.

The impact of the Mexican Revolution remains a matter of debate. Reynolds (1970) indicates that between 1910 and 1925, Mexico's GDP showed a net annual increase of 2.5% due to the performance of the mining and oil enclaves that were sheltered from the most severe effects of the violence. This is why the period from 1913–1917 was the time of the worst conflict, reaching its lowest point in 1915, but not affecting the entire decade. Womack (1978) questions the degree of destruction involved, pointing out that it was not sufficiently widespread to destroy the economic system.[22] Conversely, Haber and Razo have qualified the impact by focusing on the physical capital of industries and foreign trade. In the case of the railways, however, according to Ortiz Hernán (1988), Kuntz and Riguzzi (1996), Guajardo (1996, 1999) and Grunstein (2008), the normative and material destruction of the Revolution was both radical and definitive.

In addition to the railways, the Revolution had a major impact on the countryside that considerably delayed investment in agrarian mechanization, thereby reducing the development of the internal market and railway traffic. In his study of 3,611 rural villages in the 1930s that housed 17% of the country's population, Tannebaum found that 93.1% of the towns had no access to the railway, 96.5% had no access to tractors, 95.8% had no telegraphs and 54.3% lacked steel plows. This was compounded by the low per-hectare yield in comparison with other Latin American countries. Between 1934 and 1938, Mexico had a maize yield of 5.6 quintals per hectare, Chile had 13.8 (near the United States with 14 quintals). Mexico produced 2 quintals of beans per hectare compared to Chile's 8.5.[23]

Following the outbreak of the First World War, growth in Chile became unstable, particularly after the 1929 depression, compared with the performance it had achieved from 1870 –1913, when the country joined the international economy,[24] but it turned into a country in sync with foreign trade that would contribute to training its labor force.

4.- MEXICO: THE RELATIVE IMPACT OF TRANSPORT MECHANIZATION

The arrival in Veracruz in 1857 of the equipment and tools for the Mexican Railway marked the start of the massive introduction of machinery into the country. However, political instability meant that its impact was delayed until the lengthy dictatorship of General Porfirio Díaz (1876–1880/1884–1911) with the advent of engineering factories that produced metal goods rather than material for railways. Díaz's dictatorship reactivated the economy thanks to the expansion of the mining sector, which facilitated access to sources of public and private financing, while the indirect fiscal link contributed to the construction of railways and encouraged an export boom that boosted the growth of the market and the expansion of production. From the 1880s onwards, the federal state encouraged railway construction without implementing a technical education policy. Railway construction entailed an enormous fiscal effort with tax exemptions, land concessions and cash subsidies that covered between 20 and 35% of construction costs.[25]

This was different from public intervention in Japan and Germany, where state action also encouraged technical education since Mexico lacked the institutions and key actions to implement this. Porfirio Díaz' government only trusted foreign investment and despite having an overwhelmingly illiterate population, it did not assume active public action: in 1895, 82% of the population over 10 years of age was illiterate, a figure that fell to 61% by 1930, which was still high and similar to that of extremely backward regions.

These figures –with all the statistical problems of the time– show that in 1910, Mexico had nearly the same figures as czarist Russia and the Balkans, which until 1914, had educational levels that were only slightly better than they had been in medieval times, with illiteracy totaling between 75 and 80%. Mexico emerged from this situation in 1950 when an additional 50% of its population over the age of 10 years was recorded as being literate; the Federal District alone registered 40% literacy rates.[26] This was compounded by a labor structure with a low presence of services, which was barely exceeded by the manufacturing sector with a predominance of the primary sector (see Table 2).

[Table 2]

In this scenario, railway construction and operation constituted a lost opportunity to train engineers and mechanics for various regions. Mexico had no institutions capable of meeting these demands. The education system was limited and scattered because the University of Mexico (the forerunner of UNAM) was closed in 1833, 1857, 1861 and 1865. There were only a few independent schools that had to wait to join the National University until 1910, the same year the Revolution started. Technical education at trade schools had to overcome a series of difficulties until the Instituto Politécnico Nacional was created in 1937. For this reason, degree courses in mechanical, electrical and industrial engineering had a hazardous existence between 1876 and 1911, during which period, nearly 448 engineers graduated. Between 1901 and 1927, 37.2% of university graduates were lawyers, with engineers accounting for 17.3%. Unlike France, where railway line construction between 1829 and 1885 demanded 30% of the graduates from École Centrale, in Mexico, from the 1930s onwards, conditions were in place to link technical professions to the economy.[27]

Another reason is that the American paradigm operated through the intense use of capital, technology and the selective migration of engineers and mechanics. This was the railway and mining foundries "package" implemented from the 1880s onwards.[28]

In the 1880s and 1890s, railway concessions linked Central Mexico to three points on the northern border: Nuevo Laredo (Nacional Mexicano); Ciudad Juárez (Central Mexicano), and Piedras Negras (Internacional Mexicano). At the same time, two lines linked the high plateau to the port of Veracruz. In Yucatán a narrow gauge network was built that was separate from the rest of the country. By 1910, Mexico had 19,280.3 km of railway lines.[29]

All this created a new labor sector over which company registers and official data disagree. In 1907, the federal state created the Ferrocarriles Nacionales de México (FNM) company by consolidating the largest companies in which government would be the majority shareholder. By 1911, this large, semi-private firm had a staff of 30,000, although the 1910 census recorded 18,000 railway workers for the entire country. The 1895 census had a total of 55,678 persons working in transport activities and by 1921, it recorded 58,974. That same year, the payroll of FNM, which controlled nearly 60% of the lines and moved 80% of the freight tons, listed 47,486 employees, equivalent to 80% of all land transport workers. By

1921, it is estimated that the number of railway workers fluctuated between 60,000 and 70,000.

This labor force, which was crucial to the movement of the Mexican economy, had to be trained without government support and until 1910, was a responsibility assumed by workers' unions in order to nationalize jobs.

4.1- *STATE ATTEMPTS TO PRODUCE SKILLED LABOR*

In 1890, during the growth of the railway line and in order to create opportunities for Mexican workers, the government commissioned Daniel Palacios, a mechanical engineering professor from the National School of Engineers (ENI), to design a project for the Practical School of Engineers, which meant that the Secretariat of Public Works and Buildings created the Practical School of Engineers on the ENI premises. In 1891, 82 students enrolled, the majority of whom were under 16 years of age and had not completed elementary school. A year later, the Secretariat of Justice and Public Instruction (to which ENI became answerable in 1891) ordered that the Practical School be incorporated into the National School of Arts and Trades for Men, after which it disappeared.[30]

4.2.- *THE "UNION" ROUTE TO FIRM SCHOOLS*

Railway companies were not affected by the government's inactivity, since they taught Mexicans on the job, and kept the more skilled positions of engineers and mechanics for foreigners, a policy that was questioned by the workers.

The creation of the "Unión Fraternal" in 1890 marked the start of a labor movement that would culminate in 1910 with the "Union of Drivers, Engineers, Guards and Firemen" founded in Monterrey, which promoted Mexicans' entry into these positions. Between 1904 and 1908, the Grand League of Railway Employees, together with the Mechanics' Union, set up a school in Monterrey for technical instruction.[31]

Once FNM was created, the company's Mexican directors supported the creation of the Department of Instruction and schools in 1910 so that Mexicans could be employed as telegraphers, train drivers, engineers and firemen. Incomes increased following the strike declared in 1912 by FNM's U.S. employees, whose guilds wanted to control Mexicans' access and impose operating orders in English.[32] The company refused and the Americans withdrew. This decision was finalized in 1914 by the increased violence of the Revolution and the invasion of the port of Veracruz by U.S. troops. In 1909, the number of foreigners in FNM was 1,075, of a total of 26,106 employees, which was equivalent to 4.1%. As a result of the Revolution, this figure fell to 179 in 1917, which was equivalent to 0.5% of a total of 32,796 employees. By 1925, these totaled 38, in other words, 0.08% of the personnel.[33]

4.3.- *LOSS OF TRAINING DUE TO THE REVOLUTION*

The outbreak of the Revolution meant that companies lost control over their labor force, jobs and hierarchies were altered and competing sides put an end to unionized firm schools and hampered activities within the Department of Instruction. A battery of skills that had taken decades to create were lost, foreign workers migrated and the few skilled Mexican workers either ended up with one of the competing sides or migrated. Serious intangible damage with repercussions for the future was caused by the fact that the merit system and the mechanisms for validating knowledge and skills were abolished.[34]

In 1916, according to the executive president of FNM (which was confiscated in 1914), the majority of the personnel who had joined because of the Revolution, were incompetent or controlled by the military. In order to arrive at a solution, central government, led by Venustiano Carranza, was forced to oppose the "carbine rights," in other words, labor rights obtained by force by personnel admitted under the protection of the military leaders, who opposed "the merit system."[35] In 1916, the Deposit of Revolutionary Railwaymen was created and the Secretariat of War and the Navy set up schools for those that had joined as a result of the military campaigns. The idea was to demilitarize economic activities and reduce the military's power.[36] But the fighting continued, as did forced recruitment. By the early 1920s, the engineering and traffic personnel who had promoted the nationalization of jobs had changed. They were unproductive and their merits were more political than technical.[37]

4.4- *THE CONSOLIDATION OF HUMAN CAPITAL WITH LOW PRODUCTIVITY*

The alteration caused by the Revolution led the government of President Álvaro Obregón (1920–1924) to take measures to restore railway activity, but they lacked personnel trained at firm schools. In 1920, Ernesto Ocaranza Llano, general manager of FNM, ordered that all new engines be assigned to competent engineers and took up the railway school project.[38] In 1922, the Ministry of Education (SEP) promoted the creation of Railwaymen's school to train six types of professionals ranging from engineers to firemen in three years. Unlike in 1891, the premises were built in Mexico City in early 1922, but by the end of that year, construction was suspended. Work resumed in 1923 as part of the School of Arts and Trades for Men.[39] Once again, the School of Arts absorbed another railway school.

The year 1923 proved crucial in putting an end to the attempts by FNM –the country's largest company that would absorb other lines– to train its own labor force by adopting high standards through the institutionalization of schools. This occurred because of conjunctural political reasons, whose consequences would be structural. The rebellions of the time forced governments to make a pact with this labor sector to pacify and create a reliable political base, by imposing the criteria of political performance over technical and economic efficiency.

The effects began to be felt in 1921, with the strike that broke out in FNM over the two organizations' attempts to achieve official recognition: the Order of Engineers, and the Union of Drivers, Engineers, Guards and Firemen. In order to deal with the strike, in 1921, Mexican consuls in California, Arizona, Texas and New Mexico were ordered to recruit Mexican railwaymen who had migrated as a result of the Revolution; in Mexico, staff from the South-Pacific Railway line signed up.[40]

Personnel brought in by the government joined the Union of Drivers, Engineers, Guards and Firemen, but once the strike was over, the FNM decision ordered that they sit an examination in order to be able to retain their positions, for which they were given 90 days to prepare. The Union asked for a period of 120 days for the exam according to the "custom" established in 1912 by which Mexican personnel were given a period of up to four months. Some of the applicants sat the exam up to 18 months after they had been promoted, while those who failed were given time to pass it. Thus, with little respect for formalities, they all passed the exam and were confirmed in their positions, and the process was repeated nine years later.[41]

This explains why the projects put forward by certain unions were frustrated. In October 1923, the leaders of the Third Grand Convention of the FNM Department of Driving Force and Machinery went to José Vasconcelos, Education Minister, to inform him that since they could not set up their own school within the contract with FNM, they wanted the SEP to assign a budget to install it. In November, a rebellion that several of the workers joined did away with the initiative.[42]

The situation was compounded by the elimination of the FNM Department of Instruction, created in 1910, during the movement to nationalize personnel. It was closed by Ocaranza Llano in 1923 because it had failed to achieve satisfactory results and only "a significant minority" had attended.[43] The Department was refloated three years later, but only for transport instruction. Both government and the unions wanted teaching alternatives, but the merit system adopted by Mexican workers before 1910 was being marginalized. It was replaced by an unproductive work culture based on empirical learning with an ever-decreasing yield (see Table 3).

[Table 3]

Physical productivity fell to less than one third during the period from 1916–1917 and subsequently recovered after the worst part of the conflict. It improved after FNM was handed over to an administration run by U.S. shareholders in 1926. This recovery was due to the engineers. In the workshops, however, productivity was extremely low, since they were run by "other operators in the mechanical department," who, since 1921, accounted for nearly 50% of the personnel in this department and were a burden on productivity. In this context, improvements occurred among the groups whose members could be rationalized, while the authorities tolerated those who had joined because of the conflict that developed with a powerful political base. Since the 1920s, the railway, petrol and electricity unions acquired enormous political importance and defined the working rules for the following decades, which were consolidated during the first collective work contract at FNM in 1925.[44]

Over the next few years, training followed a slow route of trial and error until the Institute of Railway Training was established in the 1950s and in that same decade, as part of the change to diesel traction, the Diesel School opened. In 1966, the School of Specialization in Railway Transport was founded. It was intended to be an organization with a greater capacity for training professionals in all branches of railway transport, but failed to achieve this and was closed in 1971.

5.- CHILE: A TECHNOCRATIC ROUTE TO TRAINING HUMAN CAPITAL

Although Chile shares some of the traits of the Mexican scenario, it differs because of early state participation, the emergence of a sector of industrial businessmen linked to the railway and the fact that during the period from 1910–1914 it enjoyed institutional stability, taking a different route by assuming a formal means of training. As a result of the early development of the state apparatus, whose nucleus were public works, Chilean civil engineers defined their professional profile and the role they would play in public decisions. They structured this profile in the 1880s when they created the State Railroad Firm (EFE), the Institute of Engineers, the Ministry of Industries and Public Works (MIOP) and the Head Office of Public Works. Their autonomy increased in 1928 with the Ministry of Public Works and Buildings in the years following the state's intervention in the economy.[45]

This began with the advent of the railway in Chile, which was encouraged by sectors that were inserted into the international economy: metal mining, and agriculture. In order to deal with mining, the Copiapó Railway was inaugurated in 1851, while the landowners and merchants in the central zone of the country formed the railway companies between Santiago and Valparaíso (FCSV) and the South (FCS) in 1852 and 1856. Whereas the lines for mining were built with the participation of foreign capital, railways in the agrarian provinces received contributions from private capitals and the state, whose positive response was to extend lines, offer low tariffs and create the EFE in 1884, which consolidated the 940 km of state-owned lines.[46]

When this new means of transport arrived, the prevailing view was that the country's only advantage was the laborers' work. The railways and workshops were a positive influence, as French scientist Claudio Gay noted in 1865, because of their ability to change the habits of a country accustomed to monotony and resignation.[47] For everyday operations, the companies had to recruit a group of foreign workers and provide a handful of Chilean workers with industrial training, thereby creating a small sector within a mass of workers dominated by farm workers. In 1875, the state railways (FCS and FCS) employed nearly 4% of the country's group of metal mechanic trades: 8.3% of the engineers, 10.4% of the mechanics and 28.3% of the firemen in Chile. These workers had a significant presence in the mining provinces, in the capital of Santiago and in Valparaíso, the main port.[48]

The engine bosses and overseers hired labor abroad through import firms, but the increase in the scale of operations led firms to take initiatives to train more local labor. In 1865, in the FCSV, Superintendent Ángel Prieto y Cruz conceived of the idea of annexing the School of Arts and Trades (EAO), an institution founded in Santiago in 1849 following the model of French technical education, with workshops from the company in Valparaíso to provide workers in a "timely, immediate fashion." The annexation would provide access to 100 apprentices who would have to adapt to industrial discipline rather than regarding themselves as master craftsmen, but the proposal did not prosper.[49]

Equally unsuccessful was another attempt at annexation by the National Foundry in 1869. This state establishment was set up in 1865 to produce cannons for the war with Spain over its attempts to reconquer Chile on the South American coast.[50] Its subsequent growth led its director to propose the annexation of the EAO, a proposal that was rejected by the war ministry and a group of foundry workers who feared the competition. Given the impossibility of having their own school, the railroads continued training in the production process itself, encouraged by the pressure of the traffic. The same thing happened in the

FCSV when the increase in wheat exports in 1866 facilitated the entry of “the children of the country” and the hiring of EAO students.[51]

5.1.- *“On the job” training*

As in Mexico, the commonest method was to train the farm hands who came in from the countryside during the production process itself. In 1875, at the Valparaíso station of FCSV, farm hands accounted for 60% of those employed in the workshops and in the shunting yards.[52] The shift towards worker status began by filing the rust off the equipment being repaired. In 1857, an engineer by the name of Robert Anderson suggested to the FCS directors that he train Chilean fireman, in return for extra pay, an example that was followed by other foreigners. The apprentices were given simple tasks that helped them learn, such as moving the American-made engines that lacked injectors for the cauldron water, which had to be moved short distances. However, their lack of mechanical knowledge meant that trainees were unable to prevent the engines from breaking down, which led to higher operating expenses.[53]

Another incentive to nationalize jobs came from the salary increase in the 1870s, which required mechanizing, but also lowering qualification levels and incorporating Chilean apprentices. At the FCS workshops in Santiago, machine tools were introduced in 1871 to “economize workers’ time” as a result of workers' migration to Peru. However, the mechanization process was not very drastic because the increase in price of foreign labor and the economic crisis, which reached this point in 1878, raised costs. A year later, the outbreak of the war between Chile and Peru and Bolivia intensified Chileans’ learning since many foreign mechanics began working for the Navy.[54]

These phenomena affected the composition of the personnel. In 1882, in its engine and arsenal department, the FCSV had 308 technically qualified people, including engineers, firemen and other workshop specialists, 40.5% of whom had been hired since 1879. If unskilled personnel are included, then 25.3% of the employees were foreigners.

5.2.- *OTHER TRAINERS: THE STATE AND INDUSTRIAL BUSINESSMEN*

The creation of EFE in 1884 enabled Chilean engineers and workers to be promoted to nearly all levels of skilled labor when there was a strong demand for skilled labor from industry, mining and private railways. This demand had to be met by a sector of engineering firms which, from the 1880s onwards, began to build carriages and engines for the state railways and shared the same labor base.

The emergence of a sector of engineering industries was one of the main differences from Mexico, which did not have a railway carriage-producing firm until 1952. This provided Chile with a set of public and private initiatives for establishing technical schools, because of the degree of activity of the Sociedad de Fomento Fabril (SFF), a trade union organization of the industrialists founded in 1833, and by the MIOP. This period saw the emergence of proposals such as that of an industrialist called Santiago Hardie, who proposed setting up an EAO in Valparaíso. In 1887, Lever, Murphy y Cía. gave EAO a full-size wooden model of an engine for practices.[55] It is interesting to note that its owner, William J. Murphy, born in Smethwick, had received his education at James Watt & Co.'s schools before starting work with Pacific Steam Navigation, the firm through which he arrived in Chile.[56]

In the early 20th century, technical education under the supervision of the MIOP centered on EAO which, from the 1880s onwards, had been reformed, providing it with a 37,150-square meter building to house 300 boarders, 100 day students and 22 teachers. Its installations had industrial capacity and were connected to the railway which, in 1897, enabled it to repair an engine and suggest to EFE that it build carriages and an engine. This petition was rejected by the industrialists who produced material for the firm. There was also an Industrial School in Chillán, while the SFF had 12 night schools with a total of 725 students.[57]

5.3.- *THE NEED TO INTERNALIZE TECHNICAL SCHOOLS*

In the early 20th century, the growth of EFE operations called for a change in the technical base and the personnel's skills. An examination of this subject was drafted in 1899 by the government's technical consultant, a Belgian engineer by the name of Omar Huet, who would subsequently implement a number of changes. He pointed out that Chilean workers were jacks-of-all-trades, which was incompatible with manufacturing and railways where perfect knowledge of the profession was required. There was a need to regulate jobs, define responsibilities, introduce industrial discipline and have knowledge acquired at schools. The characteristics of the country, however, meant that these demands would have to be reduced and adapted.[58]

Another examination was drawn up by Máximo Dorlhiac, a French engineer who retired as an EFE workshop inspector in 1911. Dorlhiac found that there was a total lack of elementary scientific notions and when he did find suitable workers, he was unable to hire them, since the others refused to accept someone who would be promoted more rapidly, as was the case of the few EAO students. The bosses did not train personnel to take over from them, due to the lack of labor stability. In 1912, of a total of 23,140 state railway employees, 15% had contracts and 85% were day workers.[59]

Once again the solution was to absorb the EAO in order to have personnel and an industrial capacity capable of producing spare parts, providing maintenance and building 5–8 wagons and one engine a year. The idea was part of the solutions that were discussed to reorganize EFE in keeping with a more corporate management model and to stress the role of engineers in their exploitation.

In 1913, a Chilean engineer named Domingo V. Santa María, a member of the commissions for reorganizing EFE, said that workers should be recruited from among the personnel's children. At the same time, EAO should contribute the technological knowledge, workshops and practice, while families should provide “industrial discipline.”[60]

5.4.- *REORGANIZATION AND TECHNOLOGICAL CHANGE ON THE WAY TO FIRM SCHOOLS*

Changes began to take place in 1907 and were implemented by Omer Huet as Director General of EFE, who created regulations for the personnel, rationalized tasks, reassigned, reduced and hired new personnel. By that time, it was felt that as a public firm, EFE was subject to the pressure of political parties and that therefore, these measures would affect its influence. As a result, the Personnel and Control Service was created to review the situation of 3,000 contract workers, many of whom were recommended by parliamentarians.[61]

The 1907 reorganization was designed to lower operating costs, increase efficiency, reduce and improve the quality of the personnel and change the technology. A new reorganization in 1914 stressed changing the structure and creating schools to train workshop and engine personnel. Work also began on the construction of the San Bernardo Central Workshops with modern organization and technology to concentrate workers at a site far from the capital, with more room for workshops and dwellings and also to cover other aspects, as noted by the Ministry of Industries: "moving them away from government headquarters prevents the latter from being subjected to the pressure that may be exerted by the operators." The first workshops with fewer personnel began operating in 1920.[62]

The new 1914 EFE Regulations stipulated that workshops would give preference to students who had completed diploma courses "at the industrial establishments of the state or at others with equivalent studies." EAO students were admitted to the workshops and in 1917, several engines were repaired at the School's workshops. During this process of change, workers wished to establish their means of training. In 1914, the First EFE Convention of Engineers and Firemen was held, at which it was suggested that employees' children should have a normal education. A school and library would be built to provide technical instruction for the workers, and the most outstanding of these would be sent abroad.[63]

5.5.- *FIRM SCHOOLS: THE UNIVERSIDAD POPULAR FERROVIARIA, THE INSTITUTO FERROVIARIO AND THE MIGRATION OF HUMAN CAPITAL TO OTHER SECTORS*

The year 1914 marked the end of a type of railway labor trained using the incentive of workers' self-instruction processes. By then, the labor mass involved in these changes was considerable, since the EFE workshops were as important as the sector comprising the factories that produced transport material, foundries and metal, which that year employed 3,680 operators who received approximately six million pesos in salaries. Conversely, the EFE Department of Traction and Arsenals employed approximately 6,425 workers, who received 16 million pesos in salaries.[64]

What was happening was that new engineering personnel were taking over tasks that had previously been carried out by personnel trained "on the job," meaning that a number of problems had to be ironed out. An example of this was the request by the "Santiago Watt" Federation of Engineers and Firemen, who in 1919 requested that the job of coal inspector be given to a person with practical training, rather than to recently graduated engineers, a petition that was turned down by the EFE Board of Directors.[65]

In 1920, at the request of a group of engineers and the professor from the school of machinists, the Railway University opened with 30 students, the aim being to improve the personnel's "culture and technical training." The following year it had 80 students and began to be subsidized by the EFE Head Office. This establishment enabled personnel to be trained and retained, since by this time, the firm had to stop the enormous flow of people towards other sectors of the economy, particularly once they had completed their instruction.[66]

This establishment was subsequently renamed the Universidad Popular Ferroviaria (UPF) and by 1934, it had 143 students and a small library of 686 books. In 1935, it reformed its program and the UPF was turned into the Instituto Ferroviario, increasing its coverage and courses with humanities, civic education and political economics, and replacing the certificate of Assistant Engineer with one of a certificate of maturity in a four-year cycle. By that time, there were nearly 1,000 students at various types of EFE schools. The Institute's aim was "to provide general humanistic and technical training for non-professional railway personnel and instill character, personality and a spirit of discipline as a complement to education."[67]

The growth and autonomy of its graduates was such that in 1958, when the College of Engineers and the College of Technicians were founded to regulate the exercise of the profession and train the country's engineers to "occupy positions of an administrative, fiscal, semi-fiscal, municipal or private nature, which would require holding the respective degree," the only exception was that EFE could nominate the graduates of the Instituto Ferroviario.[68]

CONCLUSIONS

Railway technology had a positive impact on human capital training in the cases studied because of its complexity, capital intensity and new work methods. This occurred through cycles and routes of informal and formal learning, which in either case, led to firm schools with different results. This is different from certain approaches currently in vogue in the Latin American region, such as dependency sociology, which has stressed the relations of domination implicit in the relationship with the United States and Great Britain. The cases of Chile and Mexico indicate that the links with centers of innovation is an advantage that failed to be exploited due to factors of an internal nature.

Despite its smaller size and distance from a center of innovations, Chile managed to complete the route from workshop to school, shifting from an empirical system involving the training of intangible assets to a formal one, although it preserved traces of the former system as well as the inefficiency characteristic of economic backwardness. This was helped by the development of a British model of industrial and educational internalization, the early existence of a training establishment such as EAO which followed the French model. Its autonomy enabled it to survive attempts at annexation and conversion into a firm school, while contributing the scarce skilled labor to various sectors. It provided a platform of skills enabling Chilean railroads to shift towards the American model from 1914, when relations with Great Britain and Europe were weakened.

Another factor was the early development of the national state, which relied on an apparatus of administrators and engineers responsible for nationalizing jobs without rejecting the contributions of immigrants, as regards both production and management, since in addition to British engineers, EFE had Belgian and German directors who were replaced by Chilean engineers. This key intangible, greater political stability than other parts of Latin America enabled various social actors such as administrators, technocrats, artisans, the working class aristocracy and the middle classes to use convergent strategies to satisfy their interests, define class identities and train human capital.

Conversely, the Mexican case combined complexity with greater backwardness, which is all the more striking because of its resources, position, foreign investment flows and proximity to a center of innovation such as the United States.

In this case, nationalistic historiography has defended union power and railway statization by denouncing the negative impact of foreign investments that would have ousted national workers and professionals from better paid positions. Nevertheless, as Lorey points out, the problem in Mexico was that when the railways were built, there were no capital asset industries or a technical professional education for dealing with the growth of infrastructure and production, which therefore had to rely on foreign technology and skills.[69] And contrary to what nationalistic historiography suggests, this was actually positive: foreign capital, technology and workers created a modern sector within a backward economy. The delay was caused by the interruptions and slowness with which the tracks were built and the lack of interest in creating a university and technical education apparatus. The initiatives were too late and incomplete to take advantage of being next to a center of innovations. There were, however, some sectors that managed to take advantage of this.

Imitating the American model of unions and workers' guilds was a powerful method that enabled Mexican labor to be trained within a technological and organizational model that externalized to provide cheaper solutions, unlike the British model that was defined on the basis of safety and quality, which proved difficult to achieve in the New World.

The American work ethic absorbed by Mexican employees adapted almost symbiotically to the process of state participation in over one half of the Mexican railways begun by FNM from 1907 onwards. Government interest coincided with that of the unions: achieving autonomy in relation to American personnel, which they achieved in 1912. Union and state initiatives overcame the problems of American externalization, which made it possible to build the majority of the 19,000 km existing in 1920, which had not established a local fabric but rather pragmatic links with the industry and world of work north of the Rio Grande.

The tragedy in the railway sector –and others– was that just as a generation of "Americanized" Mexican workers was beginning to emerge as regards the conception of work, skills and perspectives of development, the Revolution broke out which, with its more destructive phases from 1913 onwards, put an end to this weak fabric of human capital trained in the "merit system." Instability at every level lasted just over a decade, completely changed the scenario and the order of factors. American pragmatism gave way to a form of collectivism disguised as nationalism and xenophobia that justified the implementation of "carbine rights." These rights had not been fully eliminated even after 1920, and activity was restored on the basis of political pragmatism that used parts of what already existed to move traffic without "gringos." The industry was forced to return to the initial matrix, but within a context of greater backwardness: the engineers' and mechanics' unions became part of the sector on which attempts at recovery depended and coexisted with a broad mass of workers who joined industry without much prior training and once again, had to be trained as they went along.

American-style unions and associations were forced to give way to the reproduction of unions as apparatuses for political control and social mobilization, reducing the importance technical training had once enjoyed in order to forge a social identity. Simulation and centralization in corporate unionism, which had no need to justify its productivity, marked the history of Mexican railways until their privatization in 1996.

The Mexican Revolution has been portrayed as an event that favored workers' sectors. Our evidence, however, indicates that it destroyed an important social fabric in the industrial and service sector that was maturing in the form of initiatives, institutions and confidence in work.

The economic nationalism that replaced it never managed to stop resorting to the American center of innovation, although it was forced to do so slowly because of the small scope for maneuvering that labor legislation established for hiring foreigners. It was allowed to purchase equipment but not industrial or management talent, meaning that it had to wait until the latter was locally trained. The "dependent" part of the American model of "biggest and fastest" continued to be reproduced. FNM adopted it again in the 1940s and in the following decade by importing diesel engines. The Engine and Diesel School for training engineers and mechanics meant that a small number of workers were able to increase the volume of traffic without questioning the other processes, in other words, employing the same post-revolutionary strategy.

Lastly, cultural patterns played a key role in hampering the development of human capital, but that goes beyond the scope of this paper.

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Table 1. STYLES WITHIN THE ATLANTIC PARADIGM OF PRODUCTIVE INTERNALIZATION AND EXTERNALIZATION IN THE 19TH CENTURY

Equipment	UK internalization	Canada internalization	U.S. externalization towards suppliers	U.S:-Northeast Pennsylvania-type internalization	U.S:-West "Far West" internalization
Locomotives	X	X	X	X	
Freight wagons		X	X		X

Table 2. MÉXICO: ECONOMICALLY ACTIVE POPULATION (EAP), 1895–1910

Socio-professional categories	**1895**	**1900**	**1910**
Total EAP	**5,017,655**	**5,430,230**	**5,591,823**
• Farm workers and pickers	2,625,234	2,563,101	3,122,956
• Mine workers	89,337	105,824	101,290
• Craftsmen and industrial work	849,369	1,011,858	972,134

Source: Cardoso and Hermosillo (1987), Table 3: 46–48.

Table 3. MÉXICO: PRODUCTIVITY INDICATORS OF FNM PERSONNEL, 1908–1930

Years	Tons of commercial freight per FNM post	Thousands of Ton-km per FNM post	Thousands of Tons-km per equipment maintenance workshop jobs.	Thousands of Tton-km per engineering post
1908-09	218.6	75.8	-	-
1909-10	-	77.9	-	-
1910-11	219.0	78.7	-	-
1911-12	207.7	74.2	-	-
1912-13	229.4	77.6	-	-
1916-17	65.9	-	-	-
1917-18	115.7	39.1	139.3	-
1920-21	79.9	29.6	101.0	1,530.0
1921-22	98.8	38.0	126.5	2,591.9
1922-23	131.6	49.0	143.4	2,978.8
1923-24	132.4	51.7	146.9	3,374.1
1924-25	149.1	56.4	166.2	3,845.8
1925-26	-	60.0	180.2	4,736.3
1927	-	101.2	356.2	9,864.9
1928	166.8	71.0	-	-
1929	171.1	80.0	-	-
1930	160.7	78.2	262.9	7,119.5

- Figures for 1927 are higher because the social year comprised the period from July 1,1926 to December 31, 1927 because at this time, the old measurement from July 1 to June 30 of the following year was changed to January to December of each year.
- In order to calculate productivity, we have adapted the measurement by Ferrocarriles Nacionales de México in 1992 based on dividing the number of jobs by traffic units, which are the sum of tons-kilometer and passengers-kilometer. But in this case, since we only have freight data, we have divided the total number of jobs by tons-kilometer (Ton-km), a unit obtained by multiplying freight tons by the mean distance covered by the latter, which is used to measure traffic performance.

Source: Drawn up on the basis of FNM.INA, between June 30, 1909 and December 31, 1936. Ferrocarriles Nacionales de México, 1992: 54-55.

NOTES

[1] Bulmer-Thomas 1994; Thorp 1998; Triner 2003; Ibarra 2003; Knight 2006.

[2] Guajardo 2007, 2008; Marichal 2008.

[3] Guajardo 1998, 2001, 2005, 2007; Vío 1990; Topik 1994; Knight 1992; Riguzzi 1994A, 1994B; Meller 1990.

[4] Goldin 2001:2.

[5] Rosenberg 1976:145; Fishlow 1965:154-155; Rosenberg 1972:97; Atack, Haines and Margo 2008:2-6; Sangwan 1988:223-224.

[6] Maddison 1997, table 3.3: 92.

[7] Coatsworth 1984:108-110; Oppenheimer 1976:XIII, XIV; Guajardo 1990, 1996, 1996-97, 1998, 2000, 2001, 2005; Lewis 1985, 1991.

[8] Maier 1993:774, 775, 781, 782; Parker 1993:623-636.

[9] Hirschman 1973:144, 146.

[10] Craven and Traves 1987:118.

[11] Rosenberg 1970:559; Mowery and Rosenberg 1991:36; Morgan 1993:563-604; Licht 1995:127; Pursell 1995:179; Sanderson 1995:20-29; Broadberry 1993:784; Inkster 1991:47; Roderick and Stephens 1985: 62; Sinclair 1985:103; Field 1983:424; Habakkuk 1977:15; Fontana, Guerzoni and Nuvolari 2008:2.

[12] Licht 1995:110, 124; White 1993:153; Channon 1998:3.

[13] Channon 1998:7, 8, 16.

[14] Hounshell 1985.

[15] Rosenberg 1970:562, 564.

[16] Inkster, 1985:185; Sinclair 1985:103.

[17] Fifer 1991; Miller 1986; Guajardo 2001; Coatsworth 1984; Grunstein 1991, 1994; Riguzzi 1992, 1995.

[18] Vertova 2001:606, 611.

[19] Maddison 1997, cuadro A.3d: 156-157; Twomey 2000:154-192.

[20] Kay 1980:18; Meller 1990:54; Bulmer-Thomas 1994: 48-154; Valenzuela 1996: 235.

[21] Coatsworth 1990:81; Bulmer-Thomas 1994, table 3.5: 69, table 4.3:104; O'Brien 1989: 123-124; Bravo 1981:775-818.

[22] Reynolds 1970:27-28; Womack 1978:3-8.

[23] Hewitt de Alcántara 1988:72; Wilkie 1987:249, table IX-3:250.

[24] Díaz, Lüders and Wagner 2007:47, 58.

[25] Sánchez 1980:299, 349; Cárdenas 1995:264-268.

[26] Berend 1981:46-47; Ludwig 1985, Table V-8: 132; INEGI/INAH 1990, Tomo 1, Cuadro 2.3:95.

[27] Bazant 1984:258-264, 286; Guajardo 1995:123-138; Lorey 1993:42, 59; Inkster 1991:178.

[28] Buchanan 1986; Bernstein 1965; Parlee 1981, 1984; Gómez Serrano 1982; Bravo 1981.

[29] Leal and Woldenberg 1980:91.

[30] Acuerdo de la Secretaría de Fomento, 17 de mayo de 1890. AHUNAM.ENI, Caja 3, expediente 33, f. 250; Informe de la Sección al Ministro de Fomento, 20 de julio de 1890. AHUNAM.ENI, Caja 3, expediente 33, f. 255. Decreto que crea la Escuela Práctica de Maquinistas, 18 de diciembre de 1890. AHUNAM.ENI, Caja 3, expediente 33, f. 261; Bazant 1982:174; Revista de la Instrucción Pública Mexicana, Tomo II, No. 13, 15 de septiembre de 1897:373.

[31] Alzati 1946:41, 54-57.

[32] Alzati 1946:131-132, 175-180.

[33] FNM.INA, Informes anuales del 30 de junio de 1909 al 30 de junio de 1925.

[34] Kuntz and Riguzzi 1996.

[35] FNM.INA 8º informe al 30 de junio de 1916:17-19.

[36] Heriberto Toscano y otros a Alvaro Obregón, 11 de enero de 1924. AGNM.OC, expediente 242-F1-F-25; Schloming 1974:164-166; Hall 1981:156-157.

[37] "Listas completas de los maquinistas y fogoneros de camino, maquinistas y fogoneros de patio, proveedores, pasa-carbones de las diversas divisiones del sistema, que secundaron la huelga del veinticinco de febrero de 1921, figurando por orden de antiguedad en el servicio." AGNM.OC, expediente 104-F1-L-1.

[38] Álvaro Obregón a Ramón P. De Negri, presidente del Consejo Directivo de los Ferrocarriles Nacionales de México, 14 de febrero de 1921. AGNM.OC, expediente 104-F1-D-1.

[39] Reglamento para la Escuela de Ferrocarrileros, 15 de marzo de 1922. AHSEP.DETIC, Caja 72, expediente 25, f. 1-5. Informe del estado actual de la construcción del edificio de la Escuela de Ferrocarrileros por su director W. Massieu, 8 de agosto de 1922; Id. al director de la Enseñanza Técnica, Industrial y Comercial, 9 de agosto de 1922; Id. 26 y 27 de octubre de 1922. AHSEP.DETIC, Caja 95, expediente 7, f. 1-8. Expediente sobre la Escuela de Ferrocarrileros, año 1923. AHSEP.DETIC, Caja 95, expediente 8, 3 folios.

[40] Alberto Pani, secretario de relaciones exteriores de México a los cónsules mexicanos en California, Texas y Nuevo México, 17 de febrero de 1921; Cónsul en Los Angeles a Alvaro Obregón, 24 y 25 de febrero de 1921. AGNM.OC, expediente 104-P-13; expediente 407-F1-H-1; expediente 407-F-1. "Informe sobre la situación actual de los Ferrocarriles por la pasada huelga," 19 de mayo de 1921. AGNM.OC, expediente 104-F1-L-1.

[41] Federico Rendón, presidente general de la Unión de Conductores, Maquinistas, Garroteros y Fogoneros a Alvaro Obregón, 29 de abril de 1921. AGNM.OC, expediente 407-F-1. Rendón a Obregón, 29 de abril de 1921. AGNM.OC, expediente 407-F-1.

[42] Ángel Moreno, presidente de la Comisión Permanente de la Tercera Gran Convención del Departamento de Fuerza Motriz y Maquinaria de los Ferrocarriles Nacionales de México y Anexos a José Vasconcelos, secretario de educación pública, 24 de octubre de 1923. AHSEP.DETIC, Caja 56, expediente 21, f. 1-3. Jefe del Departamento Escolar al director de la Escuela Normal para Maestros, 27 de noviembre de 1923; Id. 29 de diciembre de 1923. AHSEP.DETIC, Caja 56, expediente 21, f. 4 y 5.

[43] Circular No. 253 de 17 de mayo de 1923 de Ernesto Ocaranza Llano, director general de los Ferrocarriles Nacionales de México. AGNM.OC, expediente 823-F-2.

[44] Ebergenyi 1986; Guajardo 1996, 1996-97.

[45] Whitehead 1994; Meller, 1990; Crowther 1973; Ibáñez Santa María 1983, 1994.

[46] Oppenheimer 1976:108, 109, 134, 159; Sanfuentes 1987:36-37.

[47] Gay 1973:320, 324.

[48] Censo Nacional de 1875; Presupuestos del Ferrocarril entre Santiago y Valparaíso; Ferrocarril del Sur; Ferrocarril de Chillán a Talcahuano para el año 1875, In: Anexos a la Memoria del Ministerio del Interior de 1874.

[49] Ferrocarril entre Santiago y Valparaíso. Informe del superintendente por el año 1864 y 1er. semestre de 1865:39.

[50] Ortega 1981:39.

[51] Ministerio de Justicia, Culto e Instrucción Pública. Memoria de 1869. Publicada en El Araucano, Santiago, 8 de Octubre de 1869.

[52] Presupuesto del Ferrocarril entre Santiago y Valparaíso para 1875 anexo a la Memoria del Ministerio del Interior de 1874.

[53] Escobar 1899:10, 11; Hillman, 1874:21.

[54] Ferrocarril del Sur, Informe semestral, 31 de Diciembre de 1872:21; Ferrocarril del Sur. Informe semestral, 31 de Diciembre de 1871:17; Ferrocarril entre Santiago y Angol. Informe de 1880:18.

[55] BSFF, año VI, No. 6, 1889:250; Comunicación del director de la Escuela de Artes y Oficios al Ministerio de Industrias y Obras Públicas, 21 de Octubre de 1887. ANC.MIOP, Vol. 144 "Escuela de Artes y Oficios".

[56] Guajardo 2000:87-122.

[57] Comunicación del director de la Escuela de Artes y Oficios al Ministerio de Industrias y Obras Públicas, 4 de febrero de 1898. ANC.MIOP, vol. 1012, foja 161; ANECHILE, año 1905: 224-230.

[58] Huet 1899A:12, 18; 1899B:17-18.

[59] "Los Ferrocarriles del Estado y la Escuela de Artes y Oficios", BSFF, año XXVIII, No. 6, Junio, 1911:450-455; EFEM, 1912:22-24.

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