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Transportation Costs and the Social Savings of Railroads in Latin America. The Case of Peru

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Abstract

This article estimates the social savings of the railroads in Peru in the late 19th and early 20th centuries. The construction of railroads made it possible for Peruvians to substitute the traditional system of mules and llamas, although only for a few routes. Using primary and secondary sources, I estimate the social savings for 1890, 1904, 1914 and 1918. Social savings ranged between 0.4% and 1.4% of GDP in 1890, but then increased to a range between 3.7% and 9.5% of GDP in 1918. The social savings of railroads in Peru were comparable to those for the United States and Great Britain, but were much lower than those for Mexico, Brazil and Argentina.

Keywords: Railroads, Transportation, Economic Development, Peru, Latin America

JEL: N70, N76, R40

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Costos de Transporte y el Ahorro Social de los Ferrocarriles en América Latina. El Caso del Perú

Resumen

Este artículo estima el ahorro social de los ferrocarriles en el Perú a finales del siglo XIX y principios del siglo XX. La construcción de ferrocarriles hizo posible que los peruanos sustituyeran el sistema tradicional de mulas y llamas, aunque solo para algunas rutas. Usando fuentes primarias y secundarias, estimamos el ahorro social para 1890, 1904, 1914 y 1918. El ahorro social se encontró entre 0.6% y 5.1% del PBI en 1890, pero luego aumentó a un rango entre 1.8% y 8.2% del PBI en 1918. El ahorro social de los ferrocarriles en el Perú fue comparable con el de los Estados Unidos y Gran Bretaña, pero mucho menor que en México, Brasil y Argentina.

Palabras clave: Ferrocarriles, Transporte, Desarrollo económico, Perú, América Latina

JEL: N70, N76, R40

Introduction

The calculation of the social savings of the railroads has received much attention in the economic history field.[2] Railroads yielded social savings because they provided lower-cost and faster transportation than the best alternative. Shippers and passengers saved in transport costs and therefore experienced an increase in their surplus by using railroad services. In a seminal article, Fogel (1964) indicated that railroads led to a reduction in transportation costs in the United States in the 19th century, but the savings in transport costs (social savings of the railroad) were relatively low.[3] Railroads did not have a large impact on transportation costs, because there was a system of navigable rivers and canals, which tended to provide fast and low-cost transportation for long distances.[4] Other studies extended the analysis to other countries.[5] In general, it seems that social savings were low in countries where waterways were available. In most of Europe, a system of rivers, canals and coastal routes were also available and, consequently, the social saving of the railroad was

[2] In theory, the social savings of the railroad (or the direct effects of the railroad) measure the increase in social surplus due to the lower transport costs of the railroad with respect to the best alternative. The indirect effects refer to the backward and forward linkages of the railroad with other productive sectors. Our focus on this article will be on the direct effects of the railroad. As indicated by Gunderson (1970), the social saving or direct effects of the railroad measures the social value of the railroad by comparing two economies: one economy which uses railroads (the actual economy), and another economy which is the same actual economy except that it does not have railroads (a hypothetical alternative economy). Empirical research has been conducted by Fogel (1962, 1964, 1979), Fishlow (1964), O´Brien (1983), Hawke (1971), Fremdling (1977), Coatsworth (1979) and Summerhill (2005), among many others. Some might question the relevance of the social savings approach in the sense that railroads were perhaps not an isolated system but rather formed part of a new system. Railroads probably facilitated coordination of other modes of merchandise and passenger transportation. Edgerton (2006), for example, shows the persistence and even amplification in the use of animals in England up to the 1930s. Yet, the social saving approach still yields a rough estimate of the increase in social surplus due to the railroad.

[3] According to Fogel (1964), the social saving of the railroad in 1890 was 8.9% of GDP. Also for the United States, Fishlow (1964) reports a social saving of 3.7% of GDP in 1859.

[4] According to Fogel (1979), "The crux of the transportation revolution of the nineteenth century was the substitution of low-cost water and railroad transportation for high-cost wagon transportation. This substitution was made possible by a dense network of waterways and railroads … Railroads were indispensable, however, in regions where waterways were not a feasible alternative" (p. 50).

[5] Some have calculated the social saving of the railroad for European countries. O´Brien (1983) summarizes the main results for Western Europe. For Great Britain, Hawke (1970) estimates the social saving in 4.1% of GDP in 1865 and 11% in 1890. For Russia, Metzer finds a social saving of 4.6% in 1907. For France, Caron (1983) indicates that the social saving was 5.8% of GDP in 1872. For Germany, according to Fremdling (1983), the social saving was 5% in the 1890s. In the case of Spain, Gómez-Mendoza (1983) indicates that the social saving was 11.8% in 1878 and 18.5% in 1912. For Belgium, Laffut estimates the social saving in 2.5% in 1865 and 4.5% in 1912.

usually as low as in the United States. In England and Wales, for example, prior to the railroad, freight was carried by a system of canals and only occasionally by the most expensive system of non-rail land transport.[6]

On the other hand, the evidence indicates that the social savings of the railroad in some Latin American countries of the region was large due the lack of waterways. For Mexico, Coatsworth (1979) indicates that the social saving of the railroad was larger than in industrialized economies due to the lack of navigable rivers and canals.[7] Most transportation in Mexico was then conducted by wagons and mules. "Except for local freight across three large lakes near highland population centers and short hauls up several rivers from the Gulf to the base of the mountains, internal water transport was unknown".[8] Also, considering that most Mexicans lived far from the two coasts, coastal shipping did not play the same role as it did in the United States and in Europe. In these circumstances, the construction of railroads led to a large reduction in transportation costs. Similarly, in Brazil, the social savings of Brazilian railroads were large.[9] As indicated by Summerhill (2005), prior to the railroad, freight had to travel over Brazil´s coastal mountain range o the backs of mules, or at best on wagons or carts. This system of transportation was costly, so the construction of railroads had a large impact on transportation costs.

The aim of this article is to estimate the social savings of the railroad in Peru for the period 1890-1918. Using primary and secondary sources, I find that railroads allowed Peruvians to save transport costs. Mules and llamas were the direct competition to railroads; and they transported freight at a higher cost and more slowly than railroads. If railroads had

[6] Hawke (1970) indicates that "for the general merchandise and mineral flows considered here [i.e. the type of output that railroads transported], canal transport is dominant since the flows are mainly inland, and for such cargoes land transport was so expensive as to be considered only when speed was vital" (Hawke, 1970, p. 79).
[7] Coatsworth (1979) indicates that the social saving of the railroad in Mexico in 1910 ranged from 24.6% and 38.5% of GDP.
[8] Coatsworth (1979), p. 947
[9] Summerhill (2005) indicates that the social saving of the railroad ranged between 18% and 38% of GDP in 1913.

not been built, Peruvians would have had to afford higher time and money transport costs and then experience a decline in social surplus. Our estimates indicate that the social savings of the railroad ranged 0.6% and 5.1% of GDP in 1890, but then increased to a range between 1.8% and 8.2% of GDP in 1918. These social savings were similar to those in the United States and other industrialized economies, but were much lower than in Mexico, Brazil and Argentina.

The Peruvian case is interesting because it challenges our view on the factors that influenced the social savings of the railroad. From the studies for the United States, Western Europe and Latin America one might conclude that the social savings of the railroad were large if waterways were not available. The lack of waterways implied that transportation was conducted by the expensive system of overland transportation in wagon or on the backs of animals and men. When looking at the case of Peru, however, one finds that the lack of canals and navigable rivers was not a sufficient condition for large social savings. Peru lacked waterways; but the social savings of railroads were not very high: they were similar to the social savings in the United States and other industrialized economies, and were much lower than in Mexico, Brazil and Argentina.

Railroads were built in Peru from 1850. By then the construction of railroads was considered promising by Peruvians. Several argued that Peru would be able to take advantage of its great endowments of natural resources (mining resources and land) with the introduction of the railroad. In the 1850s, Ernest Malinowski argued that with reliable rapid transportation, Peruvians "should be able to compete with analogous goods from other countries. And not just in foreign markets, but even in this country, as wheat, coffee, cacao, and so on prove, which for the coastal consumer now come largely from abroad –even when

interior growers can supply them in sufficient quantity, even superior quality".[10] Later in 1860, Manuel Pardo indicated that the construction of railroads would reduce transportation costs dramatically, allowing the exploitation of natural resources, especially in the central highlands.[11] According to Pardo, "if the locomotive, in other countries, facilitated production and commerce, in ours its mission is much higher: to create what today does not exist; to fertilize and give life to the elements of wealth, which today lie in an embryonic, latent state."[12] In the following decades, several millions of dollars were invested in rail construction.[13] The total railway track increased from only 25 kilometers in 1855 to 1,792 kilometers in 1875.[14]

Several historians have questioned the assertion that railroads had a large impact positive on the growth of the Peruvian economy. In his encyclopedic *Historia de la República del Perú*, Jorge Basadre argued that railroads were not as beneficial as believed in the 19th century, and that Peru required much more than only investing fiscal resources on large rail investment projects. According to Basadre, "it was not enough with spilling the public fortunes to stimulate and develop work, to give to the laborer the conscience of his own strength, to multiply the value of properties and to assimilate the public and private welfare, as it was believed back then."[15] More recently, Contreras (2004) argued that railroads may have helped solving transport problems in the central highlands, but the mining sector faced

[10] Taken from Gootenberg (1993), p. 91. Malinowski was the Engineer in charge of building the Central Railway.
[11] Manuel Pardo was an important businessman and politician, and President of Peru between 1872 and 1876.
[12] Gootenberg (1993), p. 80. The support for railroads was not limited to the central region. In Arequipa, for example, several businessmen led by Patricio Gibbons and Joseph Pickering also supported the construction of railroads, because they would foster the "industrial life" of the region.
[13] Total rail investment reached up to 220 million dollars from 1850 to 1900.
[14] In the late 1870s and 1880s, however, railway track experienced a slow growth. By 1904, total railway track was 2,042 kilometers. In 1919, Pedro Dávalos y Lisón argued that most mining companies located in Pallasca, Huailas, Cajabamba, Hualgayoc, Cajatambo, Huallanca and some others experienced an "anemic life" because of the lack of means of communication, especially railroads.
[15] Basadre, Vol. V, p. 136. On the other hand, Virgilio Roel did not doubt of the potential positive effect of railroads. His criticisms to the actual railroad policies were rather directed against the allocation of railroads, which according to him reoriented the routes of commerce and led to large regional inequalities. The railway system, Roel argued, benefited the coast and deeply hurt the developing of the sierra, practically untouched by the steam machine. The criticism of Roel to the railway system is in Roel (1986), p. 184, 185.

other bottlenecks, such as the lack of disciplined working force and irregularities in provision of inputs.[16] Moreover, Miller (1976b) argued that the Central Railway only favored the industry of copper.[17] Overall the railway´s impact on the economy was much lower than in the copper sector.[18] For instance, little development in arable agriculture took place in the central highlands.

This article complements previous historical studies on Peru by calculating the social saving of the railroad. By calculating the social savings one can determine whether the effects of railroads on transport costs were large or rather small in comparison to the size of the overall economy. The structure of the article is as follows. Section 1 describes the transport system in Peru in the 19th and early 20th century. Section 2 estimates the freight savings, i.e. the savings in transport costs of shippers due to the railroad. Section 3 estimates the passenger savings, making a distinction between savings on travel fares and time savings. Section 4 compares our results for Peru with those for other Latin American countries. Section 5 concludes the paper.

1 Railroads and alternative modes of transportation

Railroads operated in Peru since the mid 19th century. The first railroad, which ran between Lima and Callao, started to operate in 1850. Several railroads were then built in the North, Center and South of Peru, especially during the government of José Balta (1868-72). In the 1860s and 1870s there was much optimism on the construction of railroads. There seemed to be almost a consensus that with the construction of railroads Peru could exploit its vast natural resources in mining and agriculture, and foster economic prosperity. The

[16] Contreras (2004), p. 172.
[17] In particular, copper mining and smelting at Cerro de Pasco, Morococha and Casapalca.
[18] More recently, Zegarra (2011) indicates that the railroad had forward linkages with the sugar and cotton sectors, and with the copper sector.

State invested large sums of money, mostly obtained during the guano boom. In 1865-78, the State invested more than 100 million dollars in building railroads. The railway track then increased from only 87 kilometers in 1865 to 1,792 kilometers in 1875 (Figure 1).

The decline in guano reserves and fiscal revenues in the mid 1870s slowed down railroad construction. Moreover, several railroads were destroyed during the War of the Pacific (1879-83) between Peru and Chile.[19] Railroad length then declined from 2,030 kilometers in 1877 to 1,509 kilometers in 1883. Furthermore, the war caused a severe economic contraction in Peru and hurt its fiscal finances, making it practically impossible to continue with the construction of railroads for several years.

With the signing of the Grace Contract between the Peruvian State and the Peruvian Corporation in 1889, this corporation took over the administration of state railroads and was committed to invest in reconstructing the damaged lines and expanding the railway track.[20] A British Vice-Consul then looked at the future of Peru with optimism: "The prolongation of the railroads of Peru, consequent on the Bondholders' contract with the Government," argued the Vice-Consul, "will lead to the opening up of immense agricultural and mining fields, and will give life to all the great national industries of the interior, which so long have been awaiting the means of communication with the coast in order to spring into activity … Peru may reasonably look forward to a prosperous future."[21] Overall, however, the construction of railroads was a slow process in the 1890s and early 1900s. The railway network increased from 1,509 kilometers in 1883 to only 1,848 kilometers in 1903.

[19] The following railroads were destroyed during war: Pacasmayo-La Viña, Chimbote-Recuay, Ancon-Chancay, Ilo-Moquegua and the mining railroad of Cerro de Pasco. Also, as Peru was defeated in this war, it lost the province of Tarapaca, including the railroads located in this province, such as the railroads of Pisagua-Sal de Obispo and Iquique-La Noria.

[20] In 1889 the Peruvian State granted the Peruvian Corporation (constituted by the creditors of the State) the administration of the state railroads for 66 years in exchange for debt obligations of the Peruvian State.

[21] Report of the Trade and Commerce of Callao (Vice-consul Wilson), Parliamentary Papers, 1890, LXXVI, 421, cited in Miller (1976a).

The process of building railroads sped up from 1905. The railroad length increased to almost 3,000 kilometers in 1910 and 3,487 kilometers in 1918. However, in terms of railroad density, Peru was far behind many countries in Latin America. By 1913, for example, Peru only had 0.7 kilometers (around 0.4 miles) of railway track per 1,000 inhabitants, below the Latin American average of 1.4 kilometers per 1,000 inhabitants (Figure 2). Peru was far behind Argentina, which had 4.3 kilometers per 1,000 inhabitants, around seven times as much as did Peru. Other countries with a clear lead over Peru were Chile, Costa Rica, and Uruguay. All of these countries had more than 2 kilometers per 1,000 inhabitants. Other countries with more railway length per-capita than Peru were Mexico, Brazil, Cuba, Dominican Republic, and Panama. In South America, Peru only performed better than Colombia, Ecuador and Venezuela.

The railroad system of Peru of the early 20th century was constituted by a large list of railroads, but most of them were very short and were not part of a unified network. Of all the railroads, only two linked the coast and the *sierra*: the Central Railway and the Southern Railway. The Central Railway connected the port of Callao with the city of Lima and several towns in the central highlands, largely dedicated to mining.[22] The main line of the railway was Callao-Lima-La Oroya. The Peruvian Corporation then built a branch from Ticlio to Mororocha in 1900; the Cerro de Pasco Railway Co. built another line from La Oroya to Cerro de Pasco in 1904, extending the area of influence of the Central Railway far beyond La Oroya. Then the railroad reached Jauja and Huancayo in 1908. Another railway system, the Southern Railway, connected the coast and the highlands in the South: it linked the port of Mollendo with the departments of Arequipa, Puno and Cuzco. In addition, there were a

[22] This was actually one section of the Central Railway. Another section was Lima-Ancon-Chancay.

number of short railroads that connected coastal valleys, the main coastal cities and the Pacific seaboard.[23]

The traditional system of mules and llamas was the closest substitute for railroads in the early 20th century. Several sources indicate that in the absence of railroads in most of the Peruvian territory, mules and llamas were largely used for transportation. The road system in most of the territory was inadequate for wagons. In 1906 Carlos Cisneros indicated that "most transportation was conducted on the backs of mules".[24] In 1921, E. C. Vivian indicated that "the cross-country roads are in general nothing but steep ill-made pack-mule trails".[25] In 1927, Clarence Jones indicated that most towns largely depended on the traditional system of mules and llamas.[26] Horses could also used for transportation in the coast; however, in the extreme conditions of the Peruvian sandy and dry desserts, mules were probably better fit than horses.[27] Even in the route Lima-Callao, traffic was "unthinkable without mule trains".[28]

Mules had some advantages and disadvantages in comparison to llamas. One of the advantages of mules with respect to llamas is that mules could carry up to 300 pounds; whereas llamas could not carry more than 125 pounds, and even 100 pounds was usually

[23] Located mostly in the North, these railroads were not part of a unified railway system. Some of the Northern railroads were Paita-Piura, Eten-Chiclayo-Patapo, Pacasmayo-Guadalupe and Yonán, and Salaverry-Trujillo-Ascope. In the department of Lima, the steam railroads of Lima-Callao, Lima-Chorrillos and Lima-Magdalena operated until the 1900s, when they were replaced by the electrical railroads. Some short railroads were also built in the Southern coast; two of them were Pisco-Ica and Tambo de Mora-Chincha Alta.
[24] Cisneros (1906), p. 123.
[25] Vivian (1921), 111.
[26] Jones (1927), p. 24.
[27] The mule was the "camel of the desert": the endurance of mules under fatigue and indifferent nurture was extraordinary. "… The mule, which more easily supports the difficulties of a severe journey on the sparest food, is, in Peru, the camel of the desert. Without mules a long journey on most parts of the coast would be impracticable. The horse obeys the spur until he falls dead under the rider. Not so the mule: when too weary to journey onward he stands stock still, and neither whip nor spur will move him until he has rested. After that he will willingly proceed on his way. By this means the traveler has a criterion by which he can judge of the powers of his animal…" (Tschudi, 1847 p. 205-06).
[28] Waszkis (1993), p. 137.

considered a full load.[29] Mules were then more appropriate for carrying heavy items. In addition, mules were faster than llamas: mules could complete as much as 60 kilometers per day, whereas llamas could only accomplish 25 kilometers or less. Finally, mules could stand the heat of the coastal desert; llamas could not. For journeys into the coast or from the coast, then mules were required at least for part of the route. On the other hand, llamas were better fit than mules for the difficult terrain and weather of the Andes,[30] and did not require much care since they were mostly fed from any herbage, which lowered their maintenance costs.[31]

Waterways, more efficient than roads, have been widely used wherever they are available. However, in Peru the government never built canals, and rivers were not navigable in the habitable regions. Jones (1926) indicated that the lack of navigable rivers imposed enormous trade handicaps. "No large navigable rivers offer routes into the interior and other means of entering the mountain zone are not easily provided. Between latitudes 5 degrees and 35 degrees South no pass in the Andes lies at an elevation of less than 11,000 feet. The trade handicap because of this situation is enormous."[32] The Pacific Ocean constituted a faster and cheaper mode of transportation than mules and llamas, especially after the invention of the steam machine. However, its use was naturally constrained to coastal towns. Ocean transportation was as fast and cheap as railroads; however, ocean transportation was not a substitute to railroads: only one railroad ran parallel to the shore.[33]

[29] Hills (1860), p. 101.
[30] Contemporary travelers were aware of those differences between mules and llamas. Hills (1860), for example, indicated that a llama "has spongy hoofs and claws, which enables him to pass over beds of ice with ease, and is well protected by his fleece from any cold to which he may be exposed" (Hills, 1860, p. 101). Moreover, Cisneros (1906) observed that llamas could live in places where mules would die of hunger and cold. In addition, Tschudi (1847) pointed out that llamas could carry freight from places where the declivities were so "steep that neither asses nor mules can keep their footing" (Tschudi, 1847, p. 308).
[31] Cisneros (1906), p. 124.
[32] Jones (1926), p. 151.
[33] The railroad Lima-Ancon-Chancay was one branch of the Central Railway. Built in 1869, this was the only railroad that ran parallel to the coast, connecting the city of Lima, the town of Ancon and the valley of Chancay,

In the early 20th century, most Peruvian territory lacked railroad facilities and waterways, and therefore relied on the traditional system of mules and llamas. A large number of towns were not connected by railroads. Dávalos y Lissón (1919) indicates that according to a study by the Engineer Tizón y Bueno, there were around 10,000 towns in Peru in the 1910s and that only 300 of them were connected by railroad in the late 1910s. Similarly, Milstead (1928) indicates that railroad infrastructure was very deficient not only in the highlands but also in the coast. According to Milstead, in the early 1920s primitive transportation facilities persisted in around 85% of the country. Although some railways had been constructed from the 1850s, there was no an integrated railway net: "… most of the railways consist of short isolated lines of varying gauges connecting an ocean port with the chief towns and plantations of the adjacent irrigated valleys".[34]

2 Freight savings

The freight saving of the railroad measures the increase in consumer surplus for freight transportation due to the railroad. Shippers saved in freight transport costs due to the railroad, because railroads charged less than mules and llamas. Two elements have a determinant influence on the size of these freight savings: the difference in freight rates between railroads and the best alternative to railroads, and the demand for freight transportation. I calculate the freight savings for 1890-1918. Data on freight services comes from *Anales de las Obras Públicas* (1890-1918),[35] and information on rail freight rates comes from Miller (1978) and the magazine *Economista Peruano*.[36]

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and passing through several haciendas. During the War of the Pacific, however, the section Ancon-Chancay was destroyed.

[34] Milstead (1928), p. 68.

[35] The *Anales de las Obras Públicas* reports information on ton kilometers for most railroads. Data is never missing for the Central Railway, the Railroad of Pacasmayo, the Railroad of Trujillo, and the Cerro de Pasco Railway. Data is missing only once for the Southern Railway, for the railroads Paita.Piura, Eten-Chiclayo,

Considering that most roads were not appropriate for the traction of the wheel, I assume that in the absence of railroads all freight transportation would have been conducted on the backs of mules and llamas. Two alternative scenarios have been considered: the first scenario assumes that only mules could be used instead of railroads, and the second scenario assumes that llamas (cheaper but slower than mules) were used as much as possible in the absence of railroads. The first scenario yields an upper bound for freight savings, and the second scenario yields a lower bound for freight services.

A study for the Peruvian government indicates that renting a mule cost 31.7 cents per ton kilometer in 1900 prices.[37] An alternative method for estimating the cost of mule transport provides similar results.[38] For the second scenario, I assume that llamas were used

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Chimbote-Tablones, Tambo de Mora-Chincha Alta, Ilo-Moquegua, and for the electrical railroads. For the railroads of Lima, which operated until 1905, I was not able to find information on the total freight service (in ton-kilometers) for 1890 and 1904. Using the average freight rate of this railroad from *Anales de las Obras Públicas 1890* and *Boletin del Ministerio de Fomento 1905*, I estimated the volume of ton kilometers by dividing the total revenues between the average freight rate. Also, for the year 1890, there is no data on the freight service in ton kilometers for the railroads of Paita-Piura, Piura-Catacaos and Chimbote-Tablones. For Paita-Piura I assumed that the average distance traveled by freight in 1890 was the same as in 1892, for Piura-Catacaos I assumed that the average distance traveled by freight in 1890 was the same as in 1894, and for the railroad Chimbote-Tablones I assumed that the average distance traveled by freight in 1890 was the same as in 1891; I then multiplied the average distance by the total volume of freight (in tons) transported by each of those railroads. For 1904, for the Southern Railway and railroads of Piura-Catacaos and Pisco-Ica, there is data for the total volume of freight in tons, but there is no data for the level of freight service in ton kilometers. For the Southern Railway. I estimated the distance traveled by freight using interpolation for 1903 and 1905 multiplied such distance by the total tonnage to obtain a figure in ton-kilometers. For Piura-Catacaos I assumed that the distance traveled by freight in 1904 was the same as in 1905, and for Pisco-Ica I used the average distance traveled by freight in 1903. For 1904, there is also no data of freight service in ton-kilometers For 1914, I estimated the freight service in ton-kilometers for the railroads of Piura-Catacaos, of Ilo-Moquegua, and the electrical railroads, using the average distance by freight of nearby years. I used the average distance in 1918 for the first two railroads, and the distance in 1913 for the electrical railroads. For 1918, I estimated the freight service of the railroad Tambo de Mora-Chincha using the average distance travelled by freight in 1914.

[36] Information on freight rates comes from Miller (1979) and *Economista Peruano*. Miller (1979) reports average freight rates for the Central Railway, the Southern Railway and the railroad Pacasmayo-Trujillo which accounted for 86% of total rail freight output (in ton kilometers) in 1890 and 87% in 1904. I used Miller´s data to estimate the average rail freight rate in 1890 and 1904. The average freight rate is the weighted average of those freight rates, where the weights are the freight output of those railroads in each year. For 1914 and 1918 I used the average freight rate of all railroads from the Peruvian Corporation, which accounted for 55% of freight service in 1914 and 66% in 1918. These rates were reported by the magazine *Economista Peruano*, Año XI, Vol. IV. Num. 125, p.1418.

[37] The study is Briceño (1921). The original figure is in current soles. I deflated that figure by a CPI index reported by Quiroz (1993) to convert the figure into constant soles of 1900.

[38] I use a sample of 32 mule freight rates to estimate the effect of distance, railroad competition and economic activity on mule freight rates. With the OLS estimates, I then estimated the mule freight rates if there have not been railroads. The dependent variable is the mule freight rate in soles of 1900 per ton kilometer denoted as

for transportation in the highlands, but not in the coast. Llama freight-rates were usually lower than mule rates. Llama rates were usually lower than 0.3 soles per ton-mile; whereas in most cases mule rates were higher than 0.3 soles per ton-mile.[39] Following Tizon (1909) I assume that llama rates were half of mule rates. To calculate the cost of transportation in the second scenario, I assume that mules would have carried 30% of freight, and llamas 70%. These percentages reflect the relative importance of highland and coastal freight service, and consider the fact that llamas could not transport freight in the coast.[40]

Let us define as the total freight service in ton kilometers, as the freight rate per ton kilometer, and as the demand function for freight transportation. The freight saving of the railroad ( ) can be calculated as , where is the freight rate of railroads, and is the freight rate of the second-best alternative to railroad in freight transportation. In the special case in which the demand for freight transportation is

RATE. I measure distance in kilometers, denoting this distance as DIST. I also include a dummy variable to control for the existence of railroads in the same route; this dummy adopts a value of one if there was railroad competition and zero otherwise and is denoted as DUMMY. The regression is ln(RATE) = -0.2539 ln(DIST) - 0.7618 DUMMY + 0.0295. According to the results, an increase of 1% in distance leads to a reduction of 0.25% in the mule freight rate, and railroad competition leads to a decrease of 76% in mule freight rates. I also include three export variables to control for the effect of economic activity: total exports, silver exports and copper exports, but the main results do not change: the estimate for distance remains practically unchanged; whereas the estimators the three export variables are not significant. I used the results from the basic regression and the average distance traveled by rail freight to estimate the mule freight rate in the counterfactual economy. The average distance was calculated using information on total freight service (in ton kilometers) and total volume of freight (in tons) from *Anales de las Obras Públicas*. The predicted freight mule rates in soles of 1900 per ton kilometer are 0.38 in 1890, 0.35 in 1904, 0.33 in 1914 and 0.35 in 1918. These results are similar to the rate of 0.31 obtained from Briceño (1921). The sources for the mule freight rates are Miller (1976), Pinto and Salinas (2009), Contreras (2004), Flores-Galindo (1993), Deustua (2009), Bonilla (1976), Mc.Evoy (2004), and Tizon (1909), as reported by Zegarra (2011).

[39] The lower cost for using llamas is not surprising considering that llamas did not require much care, since they mostly fed upon practically all species of herbage from the mountains, and were better fit than mules for the natural conditions of the Andes. Hills (1860: 101). In addition, by the mid-19th century, the price of a strong grown llama ranged between three and four soles, and a regular llama could be purchased for two soles (Tschudi, 1847: 308), whereas the price of a regular mule ranged between 45 and 50 soles, and could reach up to 250 soles (Deustua, 2009: 176-177).

[40] In 1904, around 70% of freight was transported in "highland railroads". To calculate this percentage, I consider as highland railroads the sections of the Central Railway and the Southern Railway located above 1,000 meters of altitude. As a percentage of total length, the highland sections represented 77% of the Central Railway and 92% of the Southern Railway (Costa y Laurent, 1908). Assuming that these figures represented the percentages of tonnage carried along the highland sections of the Central and Southern Railways, I find that the highland railroads carried around 70% of total freight service in 1904.

perfectly inelastic, the introduction of the railroad does not increase the volume of freight service. Then the saving of the railroad can be calculated as .

Table 1 reports the estimation of freight saving for 1890-1918, assuming that the demand for freight transportation was perfectly inelastic, i.e. that mules and llamas would have transported the same freight as railroads. Our estimations indicate that freight rail services increased from 19 million ton kilometers in 1890 to 208 million in 1918. Railroad revenues then increased from 2.2 million soles in 1890 to 7.8 million soles in 1918. The system of mules and llamas was more costly than railroads for carrying freight. In the first scenario, freight savings increased from only 1.5% of GDP in 1890 to 3.5% in 1904 and 7.5% in 1918.[41] In the second scenario, freight savings were 0.68% of GDP in 1890, 1.9% in 1904 and 4.5% in 1918.[42]

INSERT TABLE 1

To understand the changes in freight social savings over this period, let us decompose total freight savings. Denoting PN as the price of non-rail transport, PR as the price of railroads, and QR as the total rail freight service, then freight social savings (FSS) can be decomposed as follows:

[41] GDP figures have been calculated using information from Seminario, Alva and Ponce (2010). Seminario, Alva and Ponce (2010) report estimates for the GDP of Peru in constant dollars of 2000 from 1830. I converted the GDP of 1900 from dollars into soles (soles of 1900). To obtain GDP figures for 1890, 1904, 1914 and 1918, I used the growth rate of real GDP (in constant dollars) of those years with respect to 1900. The final GDP figures are in constant soles of 1900.

[42] Under the alternative method of estimating mule and llama freight rates, freight savings were not very different. In the first scenario, freight social savings increased from only 1.95% of GDP in 1890 to 3.9% in 1904 and 8.2% in 1918. In the second scenario, freight savings were 0.97% of GDP in 1890, 2.2% in 1904 and 5% in 1918.

The first element in the last expression, ———, measures the size of the railroad sector (as percentage of GDP); and the second element, —— , measures the relative difference in freight rates between non-rail and rail transportation. The freight social savings are large if the size of the railroad sector is high and/or if the difference in prices between non-rail transport and railroads is large.

Table 2 shows the decomposition of freight social savings. The results indicate that the size of the railroad sector remained below 2% of GDP over this period of time. In fact, although the size of the railroad sector increased from 0.8% of GDP in 1890 to 1.7% in 1914, it then declined to 1% in 1918. The main factor that explains the changes in the freight social saving is the relative price of non-rail transport with respect to railroads. In the first scenario, the ratio —— was 1.8 in 1890, was above 3.5 in 1904 y 1914, and then increased to near eight in 1918. These changes in the relative price of non-rail transportation with respect to railroads is explained by the decline in constant soles of the rail freight rate 0.11 soles per ton kilometer in 1890 to 0.07 in 1904 and then to 0.04 in 1918. In contrast, our estimates of mule and llama rates are the same over this period of time.[43]

INSERT TABLE 2

The assumption that mules and llamas would have transported the same freight as the railroad is questionable. This assumption implies that the demand for freight transportation was perfectly inelastic. However, the demand for freight transportation may be elastic to the freight rate; so in the absence of the railroad, the more expensive system of mules and llamas would have probably carried a lower volume of freight. Facing a higher

[43] With the alternative method of estimating mule and freight rates, these rates are also relatively stable over this period of time.

cost of transportation, the economy would have optimally chosen a lower volume of transportation. Therefore, the assumption of null price elasticity may overestimate the total freight transport cost for using the alternative system of mules and llamas, and may then overestimate the lower bound of the freight consumer savings of the railroad. To calculate the true lower bound of the freight savings, we need to use an upper bound of the price elasticity of the demand for freight transportation.

Table 3 reports the estimates of freight savings for alternative assumptions about the price elasticity of the demand for freight services for 1918, employing the formula

to calculate freight savings. The values of the freight savings in the first scenario range from 10 million soles to 58 million soles. The values of freight savings in the second scenario range from 9 million soles to 35 million soles.

I will use a value of one as an upper bound of the price elasticity of the demand for freight transport.[44] Therefore, I will use a price elasticity of one for the calculation of the lower bound of the freight saving of the railroad. Meanwhile, I will use a price-elasticity of zero for the calculation of the upper bound of the freight consumer saving. Table 4 reports the upper and lower bounds of freight social savings for 1890-1918. Freight social savings ranged between 0.5% and 1.5% of GDP in 1890, increasing then to a range between 1.7% and 7.5% of GDP in 1918.

INSERT TABLE 3

INSERT TABLE 4

3 Passenger savings

[44] Summerhill (2005) estimates an upper bound of one for the price elasticity; whereas Coatsworth (1979) estimates an upper bound of 0.75.

The passenger savings of the railroad measure the increase in consumer surplus for passenger transportation due to the railroad. I calculated the passenger savings for 1890-1918, considering savings on travel fares and time savings.[45] Passenger service (in passenger kilometers) was obtained from *Anales de las Obras Públicas* for 1890-1918.[46] In addition, the magazine *Economista Peruano* reports the average passenger fare of the Peruvian Corporation for 1913-1914 and 1918-1919, without distinction between first and second class passengers. I used these average fares for estimating the total savings on travel fares for 1914 and 1918, respectively.[47] I also assume that the cost of travelling on mule was 7.6 cents per person per kilometer in 1900 prices.[48]

[45] There were probably other types of social savings for rail passengers. The comfort of travelling on train rather than mounting a mule or simply walking yielded benefits to rail passengers. Those comfort-benefits for passengers were not included in the estimation of social savings.

[46] For the calculation of passenger social savings, it is important to have information on passenger kilometers per class. I then assumed that in each railroad the distance traveled by first and second class passengers was the same. Data on passenger service in passenger-kilometers has been obtained or estimated from the *Anales de las Obras Públicas* for several years. Data on passenger service for the Central Railway, the Southern Railway, the Railroad of Pacasmayo, the Railroad of Trujillo, and for the railroads of Pisco-Ica and Supe-Barranca was never missing, whereas data for the railroad of Paita-Piura, Eten-Chiclayo, Chimbote-Tablones, the Cerro de Pasco Railway and the electrical railroads is missing once. Data on passenger service in passenger-kilometers is available for most railroads. In a few cases, I had to estimate the level of passenger service. For the railroads of Lima, I estimated the level of passenger service in 1890 and 1904 using information on the total revenues from passenger transportation, the total number of first-class and second-class passengers and the first-class and second-class fares. For 1890, data on passenger service is missing for the railroads of Paita-Piura, Eten-Chiclayo, and Chimbote-Tablones. Since the *Anales* reports data on total passengers for those three lines, I estimated the passenger service multiplying the total number of passengers by an estimate of the average distance travelled by passengers. For the railroads of Eten-Chiclayo and Chimbote-Tablones, I assumed that such distance in 1890 was the same as in 1891. For the railroad Paita-Piura, I followed a similar method, but used the average distance of 1893 as a proxy for the distance of 1890. For 1904, in the cases of the railroads of Tambo de Mora-Chincha Alta and Pisco-Ica, I had to interpolate the number of passengers using information for 1903 and 1905. The *Anales* also provides information on passenger kilometers for most railroads. For the electrical railroads and for the short railroads of Piura-Catacaos, Tambo de Mora-Chincha Alta and Pisco-Ica, there is no information on passenger kilometers. For the electrical railroads and the railroad Piura-Catacaos, I estimated the number of passenger kilometers using information on the total revenues from passenger transportation, the total number of first-class and second-class passengers and the first-class and second-class fares. For the railroads of Tambo-Chincha Alta and Pisco-Ica, I used the distance traveled by passengers in those railroads for 1901 and 1903 to estimate the number of passenger kilometers traveled by those railroads. For 1914, I estimated the level of passenger service for the railroad Piura-Catacaos, Cerro de Pasco Railway, the electrical railroads and the railroad Ilo-Moquegua: for these railroads, I assumed that the average distance of passengers in 1914 was similar to that in 1918. For 1918, I estimated the level of passenger service for Tambo de Mora-Chincha Alta, assuming that the average distance of passengers in 1918 was similar to that in 1914.

[47] *Economista Peruano*, Año XI, Vol. IV, num. 125, p. 1418.

[48] In a report for the Peruvian government, Briceño (1921) indicates that the cost was 20 current cents (p. 14). Deflated by the CPI index, I obtain 7.6 cents in 1900 prices. Alternatively, I estimated the passenger fare on mule using the results from the regression in footnote 38. Those results provide information on the possible cost of

Railroad passengers had alternative modes of transportation to using trains. The alternative to first-class rail passengers was travelling by mule, since this was the best alternative mode of travelling (the other method of travelling was walking). For second-class rail passengers, the mode of transportation in the counterfactual economy may have been walking. Travelling by mule was too costly to these passengers. In 1904, for example, an average rail trip covered around 12.6 kilometers.[49] Doing this trip took 3.1 hours by walking and 1.4 hours by mule.[50] Considering the hourly salary, the opportunity cost of walking 12.6 kilometers (the average journey) was 0.5 soles,[51] whereas the opportunity cost of travelling by mule was 0.23 soles. Walking, however, implied no fare, whereas travelling by mule cost 0.96 soles. In sum, the total cost of travelling by walking was 0.5 soles, whereas the total cost of travelling by mule was 1.19 soles, more than twice as much. Considering these differences

renting a mule per ton kilometer. I assume that one mule was needed for a person to travel. One mule could carry around 120 kilograms. Using information on the average distance traveled by rail passengers in 1890, 1904, 1914 and 1918, I estimated the passenger fare in soles of 1900 per passenger-kilometer for each of those years. The estimated fares range between 5 and 6 cents in 1900 prices.

[49] I estimated this figure using data from *Anales de las Obras Públicas 1904*.

[50] Briceño (1921) reports information about the speed of mules and walking. Briceño indicates that mules completed 10 kilometers per hour in the coast and 6 kilometers per hour in the highlands (p. 14). In 1904 around 70% of rail passenger service (in passenger kilometers) corresponded to coastal railroads (including the coastal sections of the railroads Callao-Oroya and the Southern Railway). Then the average speed of mules in kilometers per hour was 10 X 0.7 + 6 x 0.3 = 8.8. Briceño (1921) indicates that walking took around 15 minutes per kilometer, at a speed of four kilometers per hour.

[51] The estimated salary was 0.17 soles per hour in prices of 1900. To estimate this salary, I used data on agricultural and non-agricultural salaries. Data from the *Extracto Estadístico 1928* indicate that daily agricultural wages in 1915 were 1.24 current soles in sugar farms in 1912, 1.05 current soles in cotton farms, and 0.93 current soles in rice farms. Using those wages from sugar, cotton and rice, and the respective number of workers, daily agricultural wages were 1.109 current soles. This figure was deflated with the CPI Index. Assuming that the workers labored 8 hours per day, the average hour-wage in prices of 1904 was 11.7 cents for agricultural workers. Non-agricultural wages come from Pino (1910). Pino reports average wages for men and women laborers in 18 factories in Lima in 1910. In average, men wages were 2.42 soles per day, and women wages were 1.55 soles per day. The average daily wage was then 2.125 current soles. Assuming that the workers labored 8 hours per day, the average hour-wage was 26.56 cents in current prices or 26 cents in prices of 1904 for non-agricultural workers. The figures from Pino (1910) are reported by Torrejón (2010), p. 190. Other sources report similar figures for non-agricultural wages. According to Cisneros (1911), daily wages in 1911 in current prices were 1.4 soles for carpenters, 2.6 for tanners, 2.75 for blacksmiths, 1.2 for laborers (*peones*), 3.25 for tailors, 3 for upholsterers, 3.5 for typesetters, 2.4 for weavers, 2.75 for shoo-makers, 4 for machinists. To calculate the average hour salary, I used the percentage of population in agriculture and other productive sectors. I used interpolation to estimate the total population, the population younger than 15 years old (assumed not to be part of the labor force) and the rural population for 1904, using data from the census of 1876 and the census of 1940. The portion of the rural population dedicated to agriculture of 1940 was used to approximate the population in agriculture in 1904. As a result, around 49% of population were younger than 15 and so its opportunity cost of time was assumed to be zero. Also, 23% of total population was part of the agricultural labor force and 28% of total population was part of the non-agricultural labor force.

in total cost between riding a mule and walking, I assume that second-class rail passengers would have walked in the absence of railroads.

I also assume that the same number of rail passengers (in first and second class) would have continued travelling in the counterfactual economy. Savings on travel fares ( ) are calculated as follows: , where is the price of passenger service by railroad, and is the price of passenger services by the alternative mode of transportation.

Table 5 reports the results. Our estimates indicate that first-class rail passenger service increased from 10 million passenger-kilometers in 1890 to 192 million in 1918, and second-class rail passenger service increased from 25 million passenger-kilometers in 1890 to 46 million in 1918. Savings on travel fares were always negative for second-rail passengers and positive for first class passengers. In total, savings on travel fares were negative in 1890 but exceeded 12 million soles in 1918 (or 1.6% of GDP).

INSERT TABLE 5

To calculate the value of the time saved by rail passengers, we need information on the speed of trains, mules and walking. I assume that passenger trains operated at 23 kilometers per hour,[52] mules completed around 8.8 kilometers per hour, and walking took in average 15 minutes per kilometer.[53] I assume that passengers participated in the labor force in the same proportion as the general population.[54] I also assume that the value of time was equal to the opportunity cost of time, i.e. the salaries foregone by traveling instead of

[52] This calculation is based on information from Costa y Laurent (1908), which reports the time spent by all railroads. I calculated a weighted average of the speeds of railroads, where the weights were the level passenger service of each railroad.
[53] See a previous note in this section for more information on speed of mules and waking.
[54] I interpolated the percentages of labor force in total population and of labor force in agricultural in total labor force using data from the Censuses of 1876 and 1904, as explained in a previous note in this section.

working. I assume the following wages for rural and urban workers: 9.9 cents per hour in agriculture, and 22 cents per hour in the rest of the economy.[55] I also assume that second-class passengers earned in average those wages, and that first-class rail passengers earned in average twice as much as those wages.[56]

Table 6 reports the main calculations. The average passenger journey for first-class passengers declined over time, especially after the construction of the electrical railroads in 1904, which were much shorter than other railroads and mostly had first-class passengers. For second-class passengers, however, the average passenger journey remained between 12 and 14 kilometers. Peruvians increased their hour savings over time. The number of hours that Peruvians saved due to the railroads increased from less than 6 million hours in 1890 to 18 million hours in 1914 and 23 million hours in 1918. The value of time savings, however, was not very high: time savings were only 0.2% of GDP in 1890; and although they increased over time, they were only 0.42% of GDP in 1918.

INSERT TABLE 6

4 Comparative analysis

The introduction of railroad led to an increase in consumer surplus. The total social saving of the railroad is calculated as the sum of freight savings and passenger savings. Table 7 summarizes the social savings of the railroads in 1890-1918, using the estimations from the

[55] I estimated those salaries in 1900 prices using secondary sources. The sources and methods employed to estimate the agricultural and non-agricultural salaries are indicated in a previous note in this section.

[56] Later I will assume that second-class rail passengers earned in average these wages, so first-class rail passengers are assumed to have earned twice as much as second-class rail passengers. A similar assumption is made by Coatsworth (1979) for Mexico and Summerhill (2005) for Brazil.

previous two sections. Social savings ranged between 0.4% of GDP and 1.4% in 1890, increasing to a range between 3.7% and 9.5% in 1918.[57]

INSERT TABLE 7

Table 8 compares our results with those for other countries. The main difference in the Latin American sample is related to freight social savings. In all of these countries, passenger savings were usually much lower than freight savings. In fact, upper passenger savings were usually below 2.1% of GDP. The only exception was Brazil, where passenger social savings were more than 4% of GDP. There were some important differences in freight savings across countries. Freight social savings were much lower in Uruguay and Peru than in Mexico, Brazil and Argentina. Whereas the upper bound of freight savings was higher than 19% of GDP in Mexico, Brazil and Argentina, it was below 11% in Uruguay and Peru.

INSERT TABLE 8

The decomposition of freight savings into the size of the railroad sector and the relative price factor — may help us understand the differences across countries. Table 9 shows the decomposition of freight savings. In Peru the size of the railroad sector was always below 2% of GDP, whereas the freight rate of non-rail transportation ranged between 3.2 and 5 times the average rail freight rate in 1914 and between 5.5 and 8.5 times in 1918. Peru had lower freight social savings than Mexico, Brazil and Argentina due to the smaller size of the railroad sector (as percentage of GDP) and the low relative price of non-rail transport with respect to railroads. Uruguay and Colombia had a similar social savings as Peru, mostly because the size of its railroad sector was very low, as low as that for Peru.

INSERT TABLE 9

[57] With the alternative method of estimating mule freight rates, the social savings are similar. For 1918, for example, social savings range between 3.8% and 10.3% of GDP.

One explanation for the relatively low level of social savings of Peru is the small size of the railroad sector. In Peru, the size of the railroad sector was below 2% of GDP, whereas it was more than 4% in Mexico, near 3% in Brazil and 3.75% in Argentina. Even with the reduction in freight rail rates in 1918, the revenues of the Peruvian railroad sector represented a much lower portion of the economy than in Mexico, Brazil and Argentina.

The size of the railroad sector may be explained by the low levels of investment in railroad construction. Railroad length increased in the early 20th century. However, rail density was very small for Latin American standards. In 1913, for example, railroad length per 1,000 inhabitants in Peru was 0.7, below the Latin American average of 1.4. In comparison with Mexico, Argentina, Brazil and Uruguay, Peru had a low railway density.

It seems that railroad companies did not face a high demand for rail transportation, which led to low revenues and a small size of the railroad sector. This problem was certainly more severe in the 19th century. According to Bonilla (2005), for example, the demand for the Central Railway was limited prior to the operations of the Cerro de Pasco Corporation. The Central Railway incurred in losses in 1892, and from 1894 to 1899. Similarly, the Southern Railway incurred in losses between 1893 and 1899. These problems were less severe in the 20th century, but profitability in the 1900s and 1910s was still low. Miller (1976a), for example, estimates that the rate of return of the Peruvian Corporation was below 2% in the 1890s, remained between 2% and 3% in the 1900s and only exceeded 5% in the 1920s. There were then low incentives to invest on this sector.

Most of the demand for rail transportation came from exports. Railroads mostly served the copper export sector of the central highlands, and the sugar and cotton haciendas in the coast, especially in the Northern coastal departments. For example, more than 50% of

the freight transported by the Central Railway in 1923-24 corresponded to silver and copper. In contrast, agricultural products from the Mantaro Valley in the department of Junin represented only a small fraction of the volume of freight transported by the Central Railway. In 1923-24, agricultural products only represented 5% of the volume of freight and represented 10% of the revenues of the railroad for transporting freight.[58] As Miller (1979) indicates, "The [Central] railway, against expectations, provided no incentive to export to Lima low-value, high-bulk crops. In pastoral farming only a few haciendas were reorganized along capitalist lines. Most remained in an archaic state, farming extensively, and with production increasing only slowly."[59] More research needs to be done, but it seems that the railroads in Peru did not develop significant linkages with non-exporting sectors, which reduced the impact of the railroad on the Peruvian economy.

Another explanation for the low freight savings of the railroad is that the construction of railroads did not lead to a reduction in freight rates as large as in other countries. The evidence shows that rail freight rates in Peru were relatively high for Latin American standards. By 1914, for example, average rail rate in Peru was 0.03 dollars of 1900 per ton kilometer, greater than the Brazilian rate, and much higher than in Mexico, Argentina and Uruguay. On the other hand, the cost of non-rail transportation in Peru was also high in comparison with other countries in the region. Mule rates were 0.15 dollars per ton kilometer in 1914, whereas wagon rates were less than 0.1 dollars per ton kilometer in Mexico, Argentina and Uruguay. Only in Brazil the cost of non-rail transport was higher than in Peru. In average, railroads in Peru charged lower freight rates than mules and llamas. However, the reduction in freight rates in Peru due to the railroad was not as large as in Mexico, Brazil and Argentina.

[58] These figures were collected by Miller (1976b).
[59] Miller (1979), p. 47.

The high rates of the railroads in Peru certainly generated discontent among the population. Peruvians usually complained that the Central Railways´ rates were very high, retarding the development of the economy. In an editorial, the newspaper *El Pais* indicated that it was notorious that the department of Junin (located in the central highlands) alone could supply not only Lima and Callao and potatoes, wheat, and other foodstuff, but also much of the Peruvian coast, but high transport costs did not make it possible.[60] In 1899, the *Financial Times* quoted the Peruvian government´s position as expressed in an official publication: "The rates of freight charged by the [Peruvian] Corporation, especially on the Central line … are exorbitantly high, so much so that they are actually 16 times higher than those charged on the railway between Veracruz and Mexico. As a result of these high freights we still see in Peru the ridiculous competition of mules, asses and llamas with the railways in the carriage of produce and merchandise …"[61]

Railroad rates in Peru may have been high as a result (at least, partly) of high operating costs. Miller (1976b) indicates that "on certain grounds the Peruvian Corporation could justify relatively high tariffs on the Central Railway. Both the mountain railways of Peru [the Central Railway and the Southern Railway] faced considerable technical problems that raised their costs, and led them to charge higher tariffs than elsewhere in South America. Both climbed to over 15,000 feet. In any circumstances the gradients involved would have increased the cost of locomotive power by raising fuel and maintenance costs."[62]

5 Conclusions

[60] El País, August 31 1895, cited by Miller (1976b), p. 36.
[61] Financial Times, April 28 1899, cited by Miller (1976b), p. 41.
[62] Miller (1976b), p. 42. Miller reaches this conclusion from an interview with D. Russell, in Arequipa, in November of 1972. Some railroads represented extraordinary engineering accomplishments, especially those that connected the coast and the highlands, passing through the Andes Mountains. The Central Railway, for example, which ran from Callao to La Oroya, was built through the Andes Mountains, reaching an altitude of 4,147 meters in Casapalca.

One might conclude from the literature that the lack of waterways led to large social savings of railroads. In the United States and Great Britain, for example, canals and rivers provided a low-cost transportation service; whereas in Brazil and Mexico, the lack of waterways implied that shippers and passengers had to rely on the costly wagon system if railroads had not been built.

In the case of Peru, however, waterways were not available, and the only substitute to railroads was the costly system of mules and llamas. Contemporary sources indicate that transportation in most of the Peruvian territory was conducted on the backs of mules and llamas. This system was slow and expensive. Then the construction of railroads from the mid-19th century generated much optimism.

Peru devoted resources into the construction of railroads. However, its railroad length was highly limited. Only a few towns were linked by railroads, so most Peruvians had to rely on the traditional system of mules and llamas for their transportation. As a result, the size of the railroad sector was very small. In addition, the evidence indicates that railroads in Peru reduced freight rates. However, rail freight rates in Peru were relatively high, probably as a result of the complex geography of the Peruvian Andes and the consequent high operating costs.

Railroads certainly reduced transport costs, but their direct benefits were not as large as expected. In 1914, for example, social savings of the railroad ranged between 2% and 7% of GDP. The social savings were similar to those in the United States (even though the substitute to railroads in the United States was constituted by canals and navigable rivers), and were much lower than in Mexico, Brazil and Argentina. It seems then that railroads in Peru did not meet the expectations of their 19th century promoters.

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Table 1

Freight social savings, 1890-1918

		1890	1904	1914	1918
First scenario					
(A1)	Freight service	19.29	62.41	163.41	208.10 million ton-kilometers
(A2)	Rail freight rate	0.11	0.07	0.06	0.04 soles per ton kilometer
(A3)	Freight rail revenues (line A1 X line A2)	2.18	4.32	10.38	7.75 million soles
(A4)	Freight rate by mule	0.32	0.32	0.32	0.32 soles per ton kilometer
(A5)	Freight revenues by mule (line A1 X line A4)	6.12	19.79	51.81	65.98 million soles
(A6)	Savings on freight rates (line A5 - line A3)	3.93	15.46	41.43	58.24 million soles
		1.50	3.50	6.65	7.48 % GDP
Second scenario					
(B1)	Freight service	19.29	62.41	163.41	208.10 million ton-kilometers
(B2)	Rail freight rate	0.11	0.07	0.06	0.04 soles per ton kilometer
(B3)	Freight rail revenues (line A1 X line A2)	2.18	4.32	10.38	7.75 million soles
(B4)	Freight rate by mule and llamas	0.21	0.21	0.21	0.21 soles per ton kilometer
(B5)	Freight revenues by mule and llama (line B1 X line B4)	3.98	12.86	33.68	42.89 million soles
(B6)	Savings on freight rates (line B5 - line B3)	1.79	8.54	23.30	35.14 million soles
		0.68	1.93	3.74	4.51 % GDP

Notes: Figures in soles are in 1900 prices.

Table 2

Decomposition of freight social savings

	First scenario			Second scenario		
	Social saving (% GDP)	A	B	Social saving (% GDP)	A	B
1890	1.50	0.83	1.80	0.68	0.83	0.82
1904	3.50	0.98	3.58	1.93	0.98	1.97
1914	6.65	1.67	3.99	3.74	1.67	2.24
1918	7.48	0.99	7.52	4.51	0.99	4.54

Notes: The computation of the freight social savings assumes that the demand for transportation in perfectly inelastic. The first scenario assumes that only mules would have transported freight in the counterfactual economy. The second scenario assumes that llamas would have been used in the highland railroads.

A = Size of the railroad sector (% GDP)

B = (PN-PR)/PR

Table 3

Freight Savings for Alternative Values of the Price Elasticity of the Demand for Freight Services, 1918

	First scenario		Second scenario	
Price Elasticity	Million dollars	% GDP	Million dollars	% GDP
0	58.24	7.48	35.14	4.51
-0.25	41.17	5.29	26.95	3.46
-0.5	29.72	3.82	20.96	2.69
-0.75	21.95	2.82	16.55	2.12
-1	16.59	2.13	13.26	1.70
-1.25	12.85	1.65	10.79	1.38
-1.5	10.18	1.31	8.91	1.14

Notes: Figures are in soles of 1900.

Table 4

Upper and Lower Bounds for Freight Social Savings

	Upper bound		Lower bound	
	Million soles	% GDP	Million soles	% GDP
1890	3.93	1.50	1.31	0.50
1904	15.46	3.50	4.71	1.07
1914	41.43	6.65	12.22	1.96
1918	58.24	7.48	13.26	1.70

Notes: The table reports upper and lower bounds for freight social savings in million soles of 1900 and as percentage of GDP. The upper bound estimates assume that the demand for transportation was perfectly inelastic; whereas the lowest bound considers a price elasticity of -1.

Table 5

Savings on Travel Fares

		1890	1904	1914	1918	
First-Class Rail Passengers						
(A1)	First-class passenger service	9.90	27.50	148.35	191.64	million passenger-km
(A2)	First-class rail rate	0.07	0.03			soles per passenger-km
(A3)	First-class passenger rail revenues (line A1 X line A2)	0.65	0.74			million soles
(A4)	Passenger revenues by mule	0.75	2.09	11.29	14.58	million soles
(A5)	Savings on travel fares 1/	0.10	1.35			million soles
Second-Class Rail Passengers						
(B1)	Second-class passenger service	24.61	46.99	39.07	46.11	million passenger kilometers
(B2)	Second-class rail rate	0.04	0.02			soles per passenger-km
(B3)	Second-class passenger rail revenues (line B1 X line B2)	1.00	0.78			million soles
(B4)	Passenger revenues by alternative mode of transport (walking)	0.00	0.00	0.00	0.00	million soles
(B5)	Savings on travel fares 2/	-1.00	-0.78			million soles
All Rail Passengers (for 1914 and 1918)						
(C1)	Total passenger service (line A1 + line B1)			187.42	237.74	million passenger-kilometers
(C2)	Average rail rate			0.02	0.01	soles per passenger-kilometer
(C3)	Total passenger rail revenues (line C1 X line C2)			2.92	2.39	million soles
Total savings on travel fares 3/		-0.90	0.57	8.37	12.20	million soles
		-0.34	0.13	1.34	1.57	(% GDP)

Note: All figures in soles are in prices of 1900. Passenger revenues by mule in line A4 was calculated as line A1 times the estimated passenger rate by mule.

1/ For 1890 and 1904, savings on travel fares for first-class passengers are equal to line A4 - line A3.

2/ For 1890 and 1904, savings on travel fares for second-class passengers are equal to line B4 - line B3.

3/ For 1890 and 1904, total savings on travel fares are equal to line A5 + line B5. For 1914 and 1918, total savings are equal to line A4 + line B4 - line C3

Table 6

Time savings for Rail Passengers

		1890	1904	1914	1918	
(A1)	Portion of passenger-kilometers by agricultural workers	0.23	0.23	0.24	0.24	
(A2)	Portion of passenger-kilometers by non-agricultural workers	0.26	0.28	0.29	0.30	
(A3)	Portion of passenger-kilometers by non-workers	0.52	0.49	0.47	0.46	
First-class Rail Passengers						
(B1)	First-class passenger service	9.90	27.50	148.35	191.64	million passenger-km
(B2)	Average passenger journey	13.52	11.45	4.03	4.13	km
(B3)	Time saved per journey	0.95	0.81	0.28	0.29	hours
(B4)	Time savings for agricultural workers (line B1/ line B2) X (line B3 X line A1)	0.16	0.45	2.49	3.24	million hours
(B5)	Time savings for non-agricultural workers (line B1/ line B2) X (line B3 X line A2)	0.18	0.54	3.07	4.04	million hours
(B6)	Time savings for non workers (line B1/ line B2) X (line B3 X line A3)	0.36	0.95	4.89	6.22	million hours
(B7)	Value of time saved in agriculture (2 X S/.0.099 X line B4)	0.03	0.09	0.49	0.64	million soles
(B8)	Value of time saved in non-agriculture (2 X S/.0.22 X line B5)	0.08	0.24	1.35	1.78	million soles
(B9)	Total first-class time savings (line B7 + line B8)	0.11	0.33	1.85	2.43	million soles
Second-class Rail Passengers						
(C1)	Second-class passenger service	24.61	46.99	39.07	46.11	million passenger-km
(C2)	Average passenger journey	13.76	12.55	12.67	13.61	km
(C3)	Time saved per journey	2.85	2.60	2.62	2.81	hours
(C4)	Time savings for agricultural workers (line C1/ line C2) X (line C3 X line A1)	1.15	2.27	1.93	2.29	million hours
(C5)	Time savings for non-agricultural workers (line C1/ line C2) X (line C3 X line A2)	1.32	2.71	2.37	2.85	million hours
(C6)	Time savings for non-workers (line C1/ line C2) X (line C3 X line A3)	2.63	4.74	3.78	4.39	million hours
(C7)	Value of time saved in agriculture (S/.0.099 X line C4)	0.11	0.23	0.19	0.23	million soles
(C8)	Value of time saved in non-agriculture (S/.0.22 X line C5)	0.29	0.60	0.52	0.63	million soles
(C9)	Total second-class time savings (line C7 + line C8)	0.40	0.82	0.71	0.86	million soles
Total time savings (line B9 + line C9)		0.51	1.15	2.56	3.28	million soles
		0.20	0.26	0.41	0.42	% GDP

Note: All figures in soles are in prices of 1900.

Table 7
Social Savings of the Railroad (% GDP)

	1890	1904	1914	1918
Savings on passenger services				
(1) Savings on Travel fares	-0.34	0.13	1.34	1.57
(2) Time Savings	0.20	0.26	0.41	0.42
(3) Total	-0.15	0.39	1.75	1.99
(4) Savings on freight services				
(a) Upper bound	1.50	3.50	6.65	7.48
(b) Lower bound	0.50	1.07	1.96	1.70
(5) Total social savings				
(a) Upper bound (line 3 + line 4a)	1.35	3.89	8.41	9.46
(b) Lower bound (line 3 + line 4b)	0.35	1.46	3.72	3.69

The figures in this table comes from Table 4, Table 5 and Table 6.

Table 8
Social savings, Upper bound (% GDP)

		Freight savings	Passenger savings	Social savings
Mexico	1910	38.50	1.38	39.88
Brazil	1913	38.37	4.03	42.40
Argentina	1913	19.90	1.72	21.62
Uruguay	1912-13	3.83	1.92	5.75
Colombia	1927	7.86		
Peru	1914	6.65	1.75	8.41
Peru	1918	7.48	1.99	9.46

Notes: In all cases, it is assumed that the demands for transportation is perfectly inelastic.
Sources: For Mexico, Coatsworth (1979); for Brazil, Summerhill (2005); for Argentina and Uruguay, Herranz (2011); for Colombia, Ramírez (2000); for Peru, see Table 7.

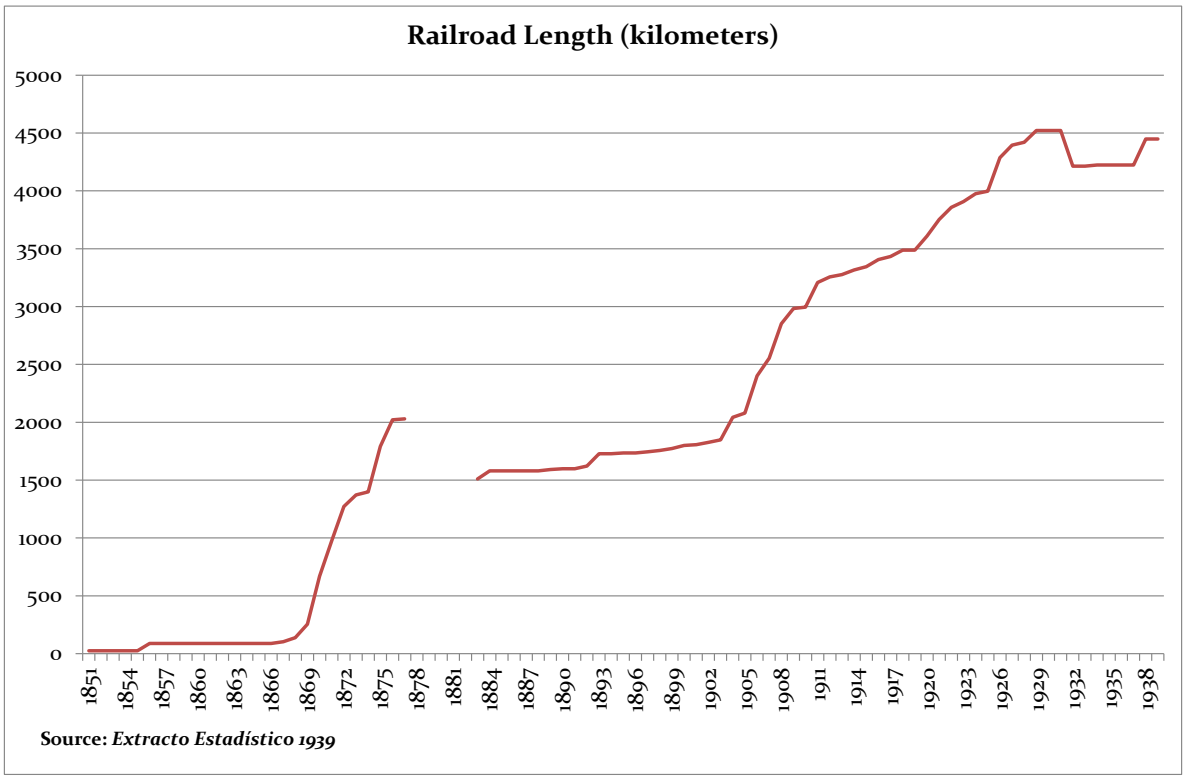
Table 9

Decomposition of freight social savings

	Freight social saving (% GDP)	Size of railroad sector (% GDP)	(PN - PR) / PR	Freight rates PR (1)	Freight rates PN (2)	Ratio (2) / (1)	Non-rail transport
Mexico (1910)	24.6 - 38.5	4.05 - 5.93	4.1 - 9.5	0.006-0.009	0.05 - 0.07	5.15 - 10.51	wagons
Brazil (1913)	18.7 - 38.4	2.88	6.5 - 13.3	0.024	0.182-0.347	7.50 - 14.31	wagons
Argentina (1913)	19.9	3.62	5.50	0.008	0.049	6.50	wagons
Uruguay (1912-13)	3.83	1.44	2.67	0.012	0.045	3.67	carts
Colombia (1927)	7.86	1.12	7.00	0.049	0.391	8.00	mules
	3.37	1.12	3.00	0.049	0.195	4.00	carts
Peru (1914)	6.65	1.67	3.99	0.032	0.158	4.99	mules
	3.74	1.67	2.24	0.032	0.103	3.24	mules & llamas
Peru (1918)	7.48	0.99	7.52	0.019	0.158	8.52	mules
	4.51	0.99	4.54	0.019	0.103	5.54	mules & llamas

Notes: Freight social savings are decomposed into the size of the railroad sector (as % of GDP) and the factor (PN-PR)/PR, where PN is the non-rail freight rate and PR is the rail freight rate. Freight rates in (1) and (2) are in constant dollars of 1900. Original data are in pesos of 1900 for Mexico, milreis of 1913 for Brazil, sterling pounds of 1913 for Argentina and Uruguay and soles of 1900 for Peru. The sources are Coatsworth (1979) for Mexico, Summerhill (2005) for Brazil, Herranz-Loncan (2011) for Argentina and Uruguay, Ramírez (2000) for Colombia, and Table 1, Table 5 and Table 6 for Peru.

Figure 1


Railroad Length (kilometers)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1851
1854
1857
1860
1863
1866
1869
1872
1875
1878
1881
1884
1887
1890
1893
1896
1899
1902
1905
1908
1911
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1920
1923
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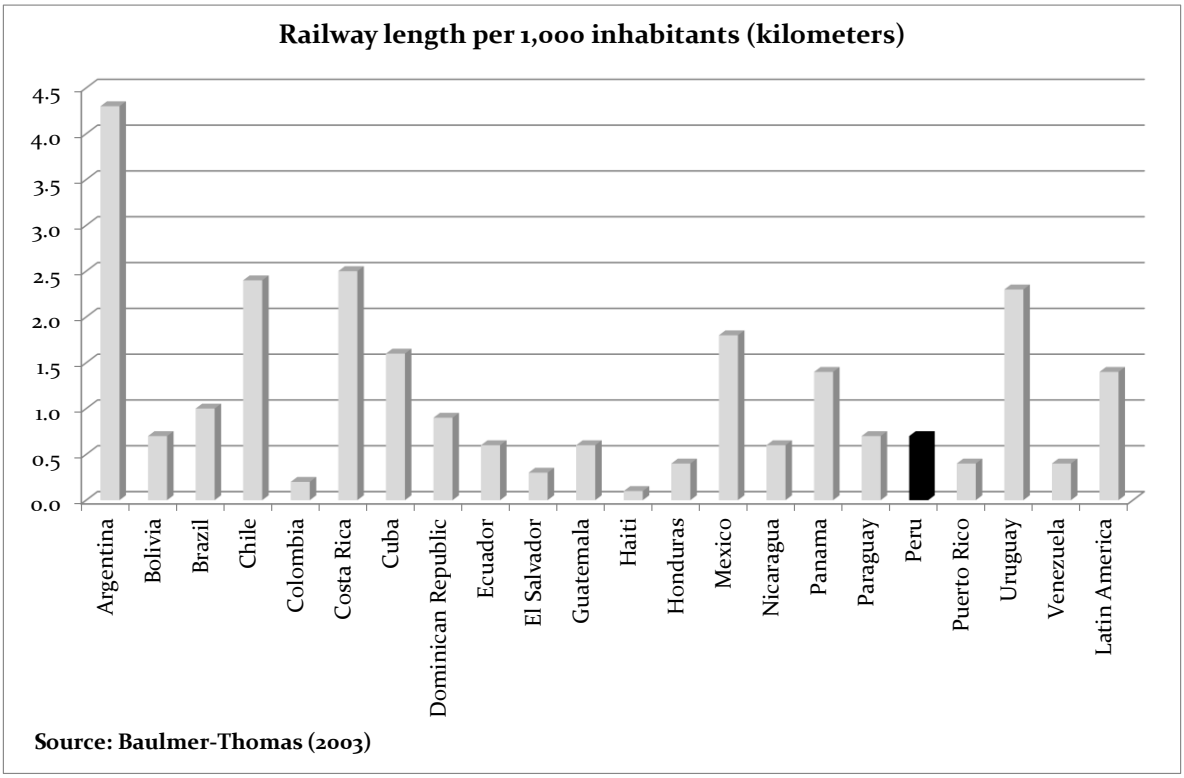
1929
1932
1935
1938
Source: *Extracto Estadístico 1939*

Figure 2



Source: Baulmer-Thomas (2003)