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THE CASES OF MEXICO, BRAZIL AND ARGENTINA

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The Contribution of Railways to Economic Growth in Latin America before 1914: the cases of Mexico, Brazil and Argentina

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RESUMEN

El objetivo de este artículo es ofrecer estimaciones preliminares de la contribución de la tecnología ferroviaria al crecimiento del PIB en Argentina, Brasil y México entre el inicio de la era del ferrocarril y 1914, así como comparar dichas estimaciones con las cifras disponibles para dos economías europeas (España y Reino Unido). De acuerdo con las estimaciones presentadas en el texto, la contribución de los ferrocarriles al crecimiento económico fue, en términos absolutos, significativamente más alta en los tres países latinoamericanos citados que en el Reino Unido o España. No obstante, en Argentina y México esa elevada contribución quedó, en cierta medida, disminuida en términos relativos, debido a las altas tasas de crecimiento económico que experimentaron esos dos países durante el periodo analizado. Estos resultados se interpretan en el artículo como una indicación del papel crucial que desempeñaron los ferrocarriles durante los procesos de crecimiento exportador que vivieron esas tres economías durante el periodo anterior a la Primera Guerra Mundial.

Palabras clave: ferrocarril, América Latina, contribución al crecimiento, transporte interior, crecimiento exportador

ABSTRACT

This paper presents preliminary estimates of the contribution of the railway technology to GDP growth in Argentina, Brazil and Mexico before 1914, and compares them with the available figures for two European economies (Britain and Spain). The results of the estimation indicate that the growth contribution of railways was substantially higher in those three Latin American economies than in Britain or Spain, although in Argentina and Mexico that high contribution was disguised behind the fast growth of the aggregate economy. This result is interpreted as a sign of the central role that the railways performed in the export-led growth episode of those three economies.

Keywords: railways, Latin America, Growth Contribution, Internal Transport, Export-Led Growth

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The Contribution of Railways to Economic Growth in Latin America before 1914: the cases of Mexico, Brazil and Argentina

1. Introduction

Between the mid nineteenth century and the eve of the Great War, Latin America was one of the world regions with a faster economic growth. According to Maddison's figures, the region grew well above the world average in 1870-1913, and its growth rate was comparable that of the "Western Offshoots" (Table 1). To a large extent, that growth episode was a result of the expansion of exports of primary products during the so-called "first globalisation boom".

Table 1. Growth rates in the first globalisation boom (1870-1913)
Percentage points per year

	GDP	GDP per capita
Western Europe	2.10	1.32
Western Offshoots	3.92	1.81
Japan	2.44	1.48
Asia (excluding Japan)	0.94	0.38
Latin America	*3.48*	*1.81*
Eastern Europe and former USSR	2.37	1.15
Africa	1.40	0.64
World	*2.11*	*1.30*

Source: Maddison (2001), p. 126.

In many Latin American economies the construction of railway networks constituted one of the bases of the economic expansion of 1870-1914. In the context of the process of export-led growth, railways allowed the transport of freight to the main ports of the area and the integration of the inner parts of each country in the world economy. Opposite to what happened in the industrialised economies, such as the UK or the US, which had already developed relatively efficient and competitive market structures at the advent of the railways, in Latin America the railways were essential to create or to strengthen the links between previously fragmented local markets, and also

between them and the world markets. In this regard, they had a much more "developmental" character in Latin America than in the core economies (Coatsworth, 1981, pp. 77-78).

In this context, the *dependentista* interpretation of Latin American economic history has usually blamed the railways for having promoted and supported a purely extractive economic model. According to that view, railways would have reinforced the export orientation of the economies of the region and its dependence on foreign powers, and would have constituted an obstacle to the emergence of a different development pattern, more oriented to sustained economic growth and industrialisation and to the expansion of internal markets. Actually, in most Latin American economies (except, perhaps, Mexico, Argentina and Uruguay), the railways just connected the areas of export production with the main ports. And even in Mexico, where a real national railway network was established, Coatsworth (1981, p. 191) has indicated that the railways "*may be seen as foreclosing other* [development] *possibilities with very large effects over the longer period*", and has pointed out that most of the benefits of the railway technology were finally channelled to the North-Atlantic economies through the repatriation of dividends and interest payments and the demand for industrial products.

By contrast, other authors have been much more positive about the long-term benefits of railways in some Latin American countries. In the case of Brazil, for instance, railways would have "*laid the groundwork for Brazil's transition to rapid economic growth after 1900*" (Summerhill, 2003, p. 1) and, in Argentina, "*while the impact of railway development was most directly experienced by areas of the economy related to export activities, other sectors and the "internal" economy also responded to the dynamism of infrastructure modernisation*" (Lewis, 1983, p. 220). In those countries where the railway network reached a relatively high density, the railways would not only have generated large increases in aggregate productivity, thanks to the reduction in transport costs, but they would also have stimulated labour mobility and the emergence of scale and agglomeration economies. In addition, they would have increased the economy's stock of exploitable natural resources, and would have stimulated the inflow of foreign capital and investment growth. These effects might be observed even in countries like Brazil, which did not develop a national railway network, but where a high degree of market integration was achieved on the basis of the complementarities between the railways and coastal navigation (Summerhill, 2003, p. 33).

The aim of this paper is to provide preliminary estimates of the contribution of railways to economic growth in three of the largest Latin American economies (Argentina, Brazil and Mexico) before 1914, through the application of growth accounting techniques, in order to obtain an aggregate and comparable indicator of the direct impact of the railway technology on those three economies during the period of export-led growth. Next section offers a very short summary of the process of railway expansion in Latin America. Section 3 describes the growth accounting framework that has been used to approach the growth contribution of railways, and discusses some of its main empirical problems. Finally, Section 4 presents the available evidence on the growth contribution of railways in Argentina, Brazil and Mexico, comparing it with the British and Spanish cases. Section 5 concludes.

2. Railway expansion in Latin America before 1914

By 1913, railways were present all over Latin America, although their development had been highly unequal among countries. The first railway line in the region was open in Cuba in 1837, only 12 years after the inauguration of the first British railway. Cuba would not be joined by any other Latin American economy until the 1850s, when railway construction started in Argentina, Brazil, Mexico, Peru, Colombia and Chile. By 1900, the railways were already present in all countries in the region.

Railway construction was especially intense in Argentina, Brazil and Mexico. These countries accounted, since the late 1880s, for approximately 75 percent of the whole Latin American railway mileage. However, in per capita terms, the Brazilian and Mexican networks fell behind the countries of the Southern Cone, Cuba and Costa Rica, as may be seen in Tables 2 and 3.

Table 2. Railway mileage in Latin America (1890-1912) (km)

	1890	*1900*	*1912*
Argentina	9,254	16,767	32,212
Brazil	9,973	15,316	23,491
Mexico	9,718	13,585	20,447
Chile	2,747	4,354	7,260
Cuba	1,731	1,960	3,803
Peru	1,599	1,800	3,276
Uruguay	983	1,730	2,522
Bolivia	209	972	1,284
Colombia	358	644	1,061
Venezuela	454	858	858
Guatemala	186	640	808
Costa Rica	241	388	619
Ecuador	92	92	587
Paraguay	240	240	373
Puerto Rico	18	223	354
Nicaragua	143	225	322
El Salvador	87	116	320
Dominican Republic	115	182	241
Honduras	96	96	170
Haiti	0	37	103
Panama			76
TOTAL	*38,244*	*60,225*	*100,187*

Source: Mitchell (2003).
Note: Panama is included within Colombia both in 1890 and in 1900.

Table 3. Railway mileage per capita in Latin America (1890-1912)
(km per 10,000 pop)

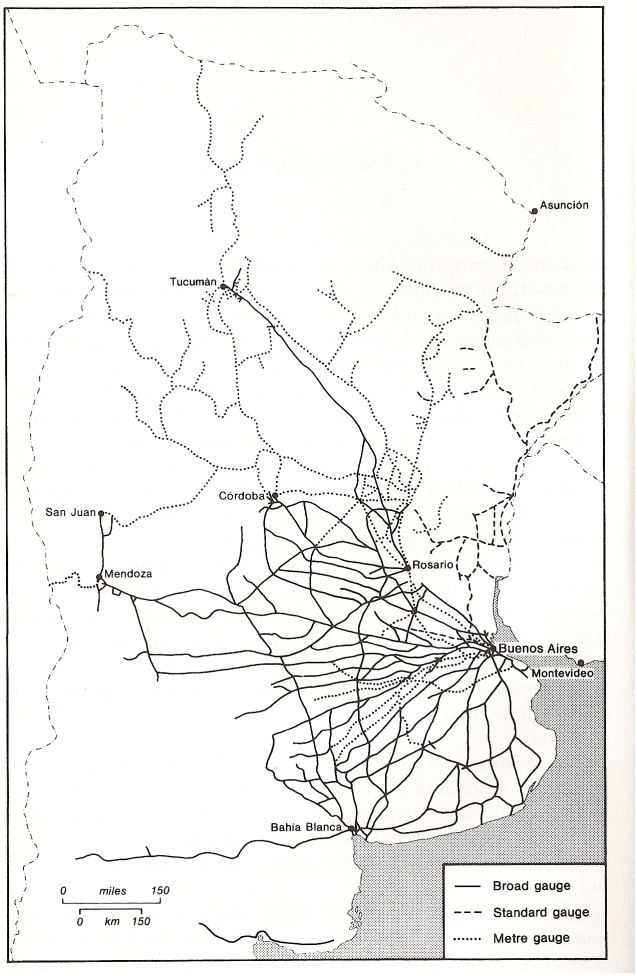
	1890	*1900*	*1912*
Argentina	24.39	34.93	42.65
Uruguay	13.90	18.89	21.78
Chile	10.46	14.77	21.20
Costa Rica	10.46	12.64	16.51
Cuba	11.23	12.25	16.13
Mexico	8.25	10.41	14.22
Brazil	6.92	8.34	9.53
Peru	5.99	5.79	7.46
Guatemala	2.33	7.23	7.08
Bolivia	1.04	5.15	6.03
Paraguay	5.96	4.79	5.83
Nicaragua	3.61	4.86	5.67
Ecuador	0.81	0.71	3.81
Venezuela	2.03	3.90	3.31
Dominican Republic	2.60	3.03	3.14
El Salvador	1.29	1.45	3.13
Puerto Rico	0.21	2.33	3.05
Honduras	2.51	2.14	2.96
Colombia	0.89	1.53	2.09
Panama			1.78
Haiti	0	0.29	0.58
TOTAL	*7.33*	*9.94*	*12.94*

Sources: Mitchell (2003), Maddison (2001) and Banks' CNTS Archive.
Note: Panama is included within Colombia both in 1890 and in 1900.

Tables 2 and 3 may be taken as preliminary evidence of the different role that railways performed in the growth of each Latin American economy before 1914. In both tables, Argentina stands out as a special case, where railway expansion reached levels comparable to some European networks. Leaving aside the case of Argentina, Latin American economies might be divided in three different categories, according to the dimension of their railway networks. A first group, with relatively dense networks, was made up by other Southern Cone economies (Uruguay and Chile), Cuba, Costa Rica, Mexico and, to some extent, Brazil. Secondly, Peru, Bolivia, Paraguay and two Central American economies (Guatemala and Nicaragua) were in a mid position within the region. And, finally, in the rest of Central America and the Caribbean economies (including Colombia and Venezuela) railway development was extremely slow. To some extent, the contribution of railways to the economic growth of each country might be expected to be proportional to the development of its railway network. As has already been indicated, in countries with relatively dense networks, railways would be important not only as a reinforcing factor for the export orientation of the economy, but also as an instrument of market integration, alone or in combination with river and coastal navigation.

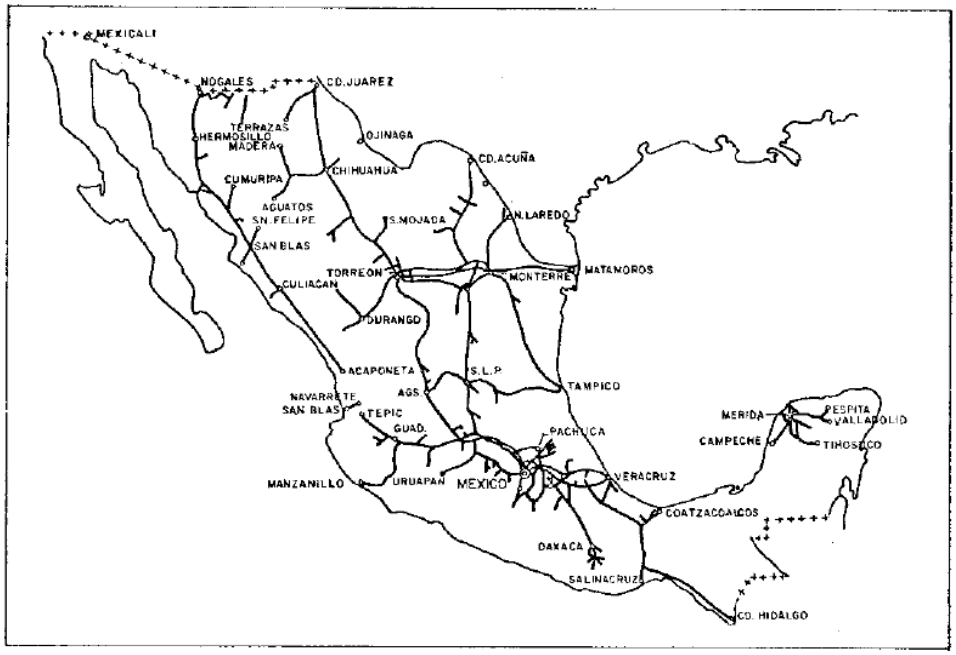
Argentina, Brazil and Mexico are three countries where the railways reached enough extension as to provide substantial direct and indirect gains to the economy. Actually, Argentina and Mexico are two of the rare cases in which an integrated national railway network was built, as may be seen in Maps 1 and 2, whereas in Brazil, Summerhill (2003, p. 33) considers that the different regional railway networks that emerged in the country in the late nineteenth century were well connected among them by coastal transport, constituting to some extent an integrated system (see Map 3).

Map 1. The Argentinean railway network by 1914



Source: Lewis (1983).

Map 3. The Mexican railway network by 1910



Source: Coatsworth (1979), p. 942.

Map 2. The Brazilian railway network ca. 1909

Source: Summerhill (2005), p. 75.

In those three countries, railways were built through routes for which no cheap transport alternatives were available.[1] Therefore, since the railways were mainly substitutes for the much more expensive road transport, the resource savings they provoked in those three economies were very large. This may be seen in the available estimates of the social savings provided by freight railway transport in those countries by 1910/1913, which are compared with other social savings figures in Table 4.

[1] Coatsworth (1981), p. 26; Summerhill (2003), pp. 18-19; Lewis (1983), p. 219. The main exceptions were the Argentinean railways that ran parallel to the river Paraná; see Summerhill (2000), p. 10.

Table 4. Estimates of social savings of freight railway transport in several countries

	Year	Social savings/GNP or GDP (%)
US	1859	3.7
US	1890	4.7
England and Wales	1865	4.1
Russia	1907	4.5
France	1872	5.8
Spain	1878	4.4
Spain	1912	12.7
Colombia	1927	3.37/7.86
Brazil	*1913*	*18.0/38.0*
Mexico	*1910*	*24.9/38.5*
Argentina	*1913*	*26.0*

Sources: Fishlow (1965), pp. 37 and 52; Fogel (1964), p. 223; Hawke (1970), p. 196; Metzer (1977), p. 50; Caron (1983), p. 44; Herranz-Loncán (forthcoming); Summerhill (2003), p. 89; Coatsworth (1979), p. 952; Summerhill (2000), p. 31; and Ramírez (2001).

These social saving estimates have been interpreted as a preliminary indicator of the high contribution of the railway technology to economic growth in those three countries. For instance, in the case of Argentina, Summerhill (2000, p. 5) indicates that: "*In the aggregate, railroad technology accounted for an appreciable portion of the productivity growth enjoyed by the Argentine economy between 1890 and 1913. Railroads were certainly not the sole determinant of overall gains in productivity in the economy, but they were no doubt among the most important*". For Brazil, the same author points out that: "*the railroad conferred on Brazil benefits that probably exceeded, by far, those stemming from the other major changes in economic organization in this period*" (Summerhill, 2003, p. 96). In the case of Mexico, Coatsworth also recognises the huge growth impact of the railways, although he also stresses the negative structural long-term consequences of the railway technology.[2]

However, social saving figures estimated for specific years cannot be taken as unambiguous indicators of the contribution of railways to those countries' economic growth. In fact, a direct comparison among social saving estimates in order to draw conclusions on the relative role that railways performed in each country may be highly misleading, as may be seen in the comparison between the British and Spanish cases carried out in Herranz-Loncán (2006). In this context, a more adequate procedure to measure the contribution of railways to economic growth is provided by the growth accounting framework. The following sections are aimed at applying this methodology to the analysis of the Argentinean, Brazilian and Mexican cases.

[2] "*Precisely because savings were high in the first period, railroads may be seen as foreclosing other possibilities with very large effects over the longer period*" (Coatsworth, 1981, p. 191).

3. The measurement of the contribution of railways to economic growth.

The most usual way to measure the global contribution of technological changes to economic growth is the estimation of the so-called "Solow Residual", on the basis of a typical Cobb-Douglas production function and competitive assumptions. The "Solow residual" ($\Delta A/A$) was originally interpreted as the total factor productivity growth provided by new technology, and is estimated from the following expression:

$$\Delta Y/Y = s_K \Delta K/K + s_L \Delta L/L + \Delta A/A \quad (1),$$

where Y is total output, K denotes the services provided by the capital stock, L is the total number of hours worked, and s_K and s_L are the factor income shares of labour and capital, respectively.

Some recent research on the contribution of information and communication technologies (ICT) to economic growth has been based on a generalization of expression (1), which aims at incorporating the hypothesis of endogenous innovation and embodied technological change. Oliner and Sichel (2002), for instance, apply a disaggregated version of equation (1), in which different types of capital and different components of TFP growth are distinguished. This allows them to measure the growth impact of ICT, both through disembodied TFP growth and through the embodied capital-deepening effect of investment in ICT. Therefore, they transform expression (1) into:

$$\Delta Y/Y = s_{Ko} \Delta K_o/K_o + s_L \Delta L/L + \gamma (\Delta A/A)_o + s_{KICT} \Delta K_{ICT}/K_{ICT} + \varphi (\Delta A/A)_{ICT} \quad (2)$$

where Y is total output, L is the total number of hours worked, K_{ICT} and K_o are the services provided by capital stock in ICT and in other sectors, respectively, A is the TFP level in the sector indicated by the subscript (ICT and other), s_L, s_{KICT} and s_{Ko} are the factor income shares of labour, ICT capital and other capital, and φ and γ are the shares of ICT and other sectors' production in total output.

The contribution of a new technology to GDP growth might be estimated as the sum of the last two terms of equation (2) which would approach, respectively, the "capital contribution" and the "TFP contribution" of the new technology. In fact, this would be a lower bound estimate of the real impact of the new technology, as there may be spillovers from the sector under consideration to the rest of the economy.

Unfortunately, growth accounting studies usually fail to quantify indirect TFP spillovers, due to the measurement difficulties involved.[3]

When this methodology is applied to the study of non-leading economies, it is necessary to introduce an additional *caveat*. The use of the TFP growth rate in the sector under study as a measurement of the "TFP contribution" of the new technology may be adequate for the analysis of advanced economies, in which new technologies are only introduced when they can provide their services at the same cost as the old technology that they substitute. For instance, in the case of Britain, the railways were introduced when they could provide transport services at a similar unit cost to that of their competitors (mainly waterways and coastal navigation). In that context, the contribution of the railway technology to the aggregate British TFP growth (excluding spillovers) may be approached by the growth of TFP in the railway sector.

By contrast, that procedure may be misleading in the case of peripheral countries, which acquire the new technology from the core economies. Peripheral countries may obtain higher TFP gains from the new technology than those included in the TFP growth rate of the sector under study, for two reasons. On the one hand, the competitors that the new technology is going to replace may be less efficient than in the core economies. On the other hand, peripheral countries may acquire the new technology when it has already been used and improved in the leading economies for a while. As a consequence, at the time of the introduction of the new technology, the difference between the unit cost of its services and the services provided by its competitors may be very large. In a complete growth accounting assessment, the "TFP contribution" of a new technology should include that difference, and TFP growth in the sector under analysis would therefore not provide a complete measure for that contribution.

This issue was already stressed in Herranz-Loncán (2006) for the case of the Spanish railways. Whereas, as has already been indicated, the first British railways had no great cost advantage over their main competitor (i.e. water transportation) when they were established, the first Spanish railway services were considerably cheaper than the alternative modes they displaced (mainly traditional overland transportation), and the difference between railway and traditional transport costs should be included in the contribution of the railways to TFP growth in the economy (and added up to the last

[3] See Oliner and Sichel (2002), pp. 16-20, and Crafts (2004b), pp. 339-340.

term of expression 2). Similarly, an estimate of the whole TFP effects of Latin American railways should not only include TFP improvements within the railway sector itself (as in the British case) but also those TFP gains that were associated to the shift from old forms of transportation to the railways (as in the Spanish case).

In this context, instead of approaching the "TFP contribution" of the railways through TFP growth in the railway sector, it may be estimated on the basis of the available social saving estimates. Social savings are usually calculated as:

$$SS = (P_{ALT} - P_{RW}) \, x \, Q_{RW} \qquad (3)$$

where P_{RW} and P_{ALT} are, respectively, the price of railway and counterfactual (alternative) transport, and Q_{RW} is the railway transport output in the reference year. This expression was interpreted by Fogel (1979, p. 5) as a measure of the resources released by the railway technology. It is actually an upward biased estimate (due to the assumption of a price-inelastic transport demand) of the equivalent variation consumer surplus provided by the railways which, if perfect competition in the rest of the economy is assumed, provides a general equilibrium measure of the entire direct real income gain obtained from reducing resource cost in transportation (Metzer, 1984; Jara-Díaz, 1986).

As Crafts has recently stressed, the price dual measure of TFP allows considering such gain in real income as equivalent to the TFP increase provided by the railways. According to the previous considerations, in a country like Britain, where railways were only introduced at the point where they could offer transport at the same cost as water transportation, it should actually be equivalent to TFP gains in the railway sector itself (Crafts, 2004a, p. 6). By contrast, in Spain (or in the Latin American economies), the total gain in real income (obtained from the social savings estimations) would not only reflect TFP growth in the railway sector but also those TFP gains associated with the shift from old forms of transportation to the railways. As a consequence, estimates of TFP increases based on the Spanish (or Latin American) social savings might be compared with the British figures based on the TFP growth rate in the railway sector, in order to analyze differences in the whole TFP growth impact of the railway system (including the substitution among different transport modes).[4] This comparison is carried out, in the cases of Spain and Britain, in Table 5.

[4] Actually, although small, there was also some potential transport cost reduction in Britain from the substitution of the railways for alternative transport modes; see Hawke (1970). Therefore, an account of the growth contribution of the British railways such as that in Table 5, which is just based on the increase

Table 5. Railways' Contribution to Growth in Britain and Spain before 1913
(percentage points per year)

	Britain (1830-1850)	Britain (1850-1870)	Britain (1870-1910)	Spain (1850-1912)
a) Railway capital stock growth	23.5	6.7	1.3	4.7
b) Railway profits share in national income	0.6	2.1	2.7	0.86
c) Railway capital contribution (a x b)	*0.14*	*0.14*	*0.03*	*0.040*
d) Railway TFP growth	1.9	3.5	1.0	-
e) Railway share in national output	1.0	4.0	6.0	-
f) Railway TFP contribution (d x e)	*0.02*	*0.14*	*0.06*	*0.069/0.092*[a]
g) TFP Spillovers	-	-	-	-
h) Total railway contribution (c+f+g)	*0.16*	*0.28*	*0.09*	*0.109/0.132*
(as % of GDP growth)	*8.89*	*12.9*	*5.54*	*7.67/9.29*

Sources: Own elaboration from Crafts (2004b) and Herranz-Loncán (2006) and (forthcoming).
Note: (a) Calculated directly from the available social savings estimate.

In both countries, the railway technology accounted on average for approximately 8 percent of GDP growth in the six/eight decades before 1913. This is indeed a substantial contribution for a single sector. On the other hand, the similarity between the estimates for both countries critically depends on the inclusion of the effects of the shift from alternative transport modes to the railways in the Spanish case. If this shift were not considered, the direct economic impact of railways would just amount to approximately 4 percent of Spanish GDP growth, i.e. half the contribution estimated in Table 5. It is also interesting to see that, although the contribution of railways to Spanish economic growth is sizeable, it is not higher than the British equivalent figure. This contrasts with the traditional interpretation on this matter, based on the available social saving estimates, which considered that railways were more vital in a poor country like Spain, with fewer opportunities for water transport, than in a rich country like Britain, well endowed with waterways.

The next section applies this methodology to the estimation of contribution of the railway technology to GDP growth in Argentina, Brazil and Mexico, in order to evaluate the role that railways performed in those countries during the first globalisation boom.

4. The contribution of railways to economic growth in Argentina, Brazil and Mexico before 1914.

As has been described in the previous section, the contribution of railways to economic growth may be estimated as the sum of two terms. The first is the product of

in TFP within the railway sector, would contain certain downward bias associated with the exclusion of those gains, which must be kept in mind in the comparison between the British and the Spanish cases.

the growth rate of the railway capital stock times the factor income share of railway capital (the "capital contribution"). The second is the TFP growth rate in the transport sector times the share of railway production in total output (the "TFP contribution"). This second term may be measured directly, through the estimation of the direct real income gain obtained by the economy from reducing resource cost in transportation, expressed as a yearly contribution to the aggregate growth rate. The next two subsections are devoted to the estimation of those two terms in the cases of Argentina, Mexico and Brazil before 1914.

4.1. The contribution of railways to economic growth: the capital term.

There are no available estimates of railway capital stock for Argentina, Brazil or Mexico during the second half of the nineteenth century and the first few years of the twentieth century. Therefore, as is customary in this kind of exercises, I have assumed the growth rate of railway capital to be similar to the growth rate of railway mileage. In the case of Argentina, railway mileage grew at a yearly 12.5 percent between 1857 (the year when the first line was open) and 1913. The equivalent figures for Brazil between 1854 and 1913 and Mexico between 1864 and 1910 were, respectively, 11 and 12 percent.[5] These percentages are much higher than the British or Spanish equivalent figures during the same period, due to the fact that, after the first few decades of the railway era, railway construction stagnated in Spain and Britain, but went on at a very fast pace in the three Latin American economies, stimulated by the first globalisation boom.

In order to estimate the capital term of the growth contribution of the railways in each country, those rates should be multiplied by the factor income share of railway capital, i.e. the average ratio between railway net operating revenues and nominal GDP during the period under consideration. An exact measurement of this ratio is almost impossible, due to the scarcity and bad quality of the statistics on railway operation (especially in the case of Brazil) and the absence of reliable series of nominal GDP for the whole period under study. As a first approach, Table 6 shows the gross and net revenues of the railway system of each country and the available estimates of nominal GDP for the end-point year of the analysis.

[5] Railway mileage data have been taken from Mitchell (2003), except for Mexico in 1868 and 1872, taken from www.docutren.com, which is based on Calderón (1955). Although the first Mexican railway line was open to the public in 1850, I have taken 1864 as the start of the Mexican "railway era", due to the stagnation of Mexican railway mileage at negligible levels between the early 1850s and the mid 1860s.

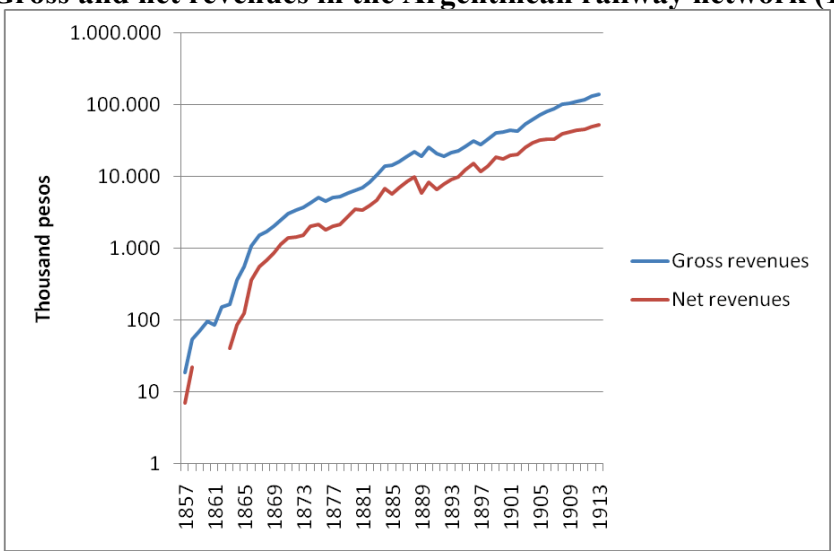
Table 6. Gross and net railway revenues and nominal GDP in 1910/1913

	Argentina (1913)	Brazil (1913)	Mexico (1910)
a) Gross railway revenues (million pesos/milreis)	140.113	250	103.555
b) Net railway revenues (million pesos/milreis)	52.838	73.3	(37.9)
c) Nominal GDP (million pesos/milreis)	2,497	5,687.6	3,100
d) Railway share in national output (a/c) (%)	*5.61*	*4.40*	*3.34*
e) Railway profit share in national income (b/c) (%)	*2.12*	*1.29*	*(1.22)*

Sources: for Argentina, revenue data come from www.docutren.es, which summarises Dirección General de Ferrocarriles' *Estadística de los ferrocarriles en explotación*, and nominal GDP comes from the Oxlad database. For Brazil, see Summerhill (2003).[6] For Mexico, gross revenues have been taken from Coatsworth (1981), p. 43, net revenues have been estimated on the basis of the operating ratio of the *Ferrocarriles Nacionales*, which accounted for two thirds of the network in 1910, from Grunstein Dickter (1996), p. 202, and nominal GDP comes from the Oxlad database.

The possibilities to bring backward the ratios in the last row of Table 6, in order to obtain average figures of net revenues/nominal GDP for the whole period under study, are different for each country. In the case of Argentina, complete information on the gross and net revenues of the whole railway network is available since 1857 (see Figure 1).

Figure 1. Gross and net revenues in the Argentinean railway network (1857-1913)



Source: www.docutren.es

Net revenues of the Argentinean railways may be expressed as a ratio of the available nominal GDP figures for the period 1884-1913.[7] Before 1884, nominal GDP

[6] Summerhill (2003), p. 148, provides two different estimates of Brazilian nominal GDP in 1913. Here I have taken the "B" estimates, which is closer to the Oxlad figure.

[7] Nominal GDP for 1900-1913 is available in the Oxlad database, and may be extended backward until 1884 on the basis of the price series published by Della Paolera, Taylor and Bózzoli (2003). These authors also provide estimates of nominal GDP for Argentina since 1884, but they are unlikely low (implying a ratio between gross railway revenues and GDP of 32 percent in 1913), and therefore have not been used here.

is not available, but there is information on the evolution of prices of some agrarian products, which would allow making a very rough price index that arrives back to 1857. Since this shows no clear trend, here I have assumed that the growth rates of nominal and real GDP were similar in 1857-1884.[8] The average ratio between net revenues and GDP in 1857-1913 that results from those calculations is 2.06 percent. This percentage is similar to the average British figure in 1830-1910 (2.03 percent) and much higher than the equivalent Spanish figure in 1850-1912 (0.9 percent). Always keeping in mind the uncertainty associated to the evolution of Argentinean nominal GDP, this percentage would be a first indicator of the importance that the railway sector reached in Argentina before 1913, as we stress below. As a result, the railway capital contribution to growth of the Argentinean railways between 1875 and 1913 might have been around 0.26 percentage points per year, a very high figure, compared to both the British and, specially, the Spanish estimates.

In the case of Brazil, it is much more difficult to bring backward the percentages of the last row of Table 6. Since reliable estimates of the net revenues of the Brazilian railway network are lacking,[9] I have taken the series of freight gross revenues of a sample of Brazilian railway lines, estimated by Summerhill (2003), as a proxy of their evolution. In other words, I have assumed that the operating ratio of the Brazilian railways was constant throughout the period under study, and that the lines of the sample analysed by Summerhill (2003) represented a constant share of the total revenues of the network. It is difficult to know how far away these assumptions are from the real situation of the Brazilian railways, and they, therefore, may have introduced some biases in the final figures of unknown magnitude.[10]

The evolution of Brazilian nominal GDP since 1861 is also taken from Summerhill (2003, p. 148). The resulting estimate of the average ratio between net revenues and nominal GDP for the Brazilian railway network (which is subject to a high degree of uncertainty) is 1.16. According to this ratio, the "capital term" of the growth contribution of the Brazilian railways would be around 0.127 percentage points of

[8] Real GDP for 1875-1884 comes from Della Paolera, Taylor and Bózzoli (2003). Before 1875, I estimate real GDP growth under the assumption that real GDP per capita was stagnant, as suggested by Della Paolera and Taylor (2003).

[9] IBGE (2003) provide figures of revenues and expenditures of the Brazilian railway network since the 1850s, but they are very incomplete.

[10] The sample of lines analysed by Summerhill (2003) accounted for a relatively constant share of the Brazilian railway mileage only since the mid 1870s (around 55 percent). Before that date, however, they represented approximately 80 percent of the total mileage of the network. See Summerhill (2003), pp. 66-67.

growth, still much higher than the Spanish figure, although clearly lower than the British one.

Finally, in the case of Mexico, I have assumed the evolution of railway net revenues to be similar to that of the gross revenues of the network, which are available in Coatsworth (1981, pp. 42-43).[11] This means, as in the case of Brazil, that I assume a constant operating ratio in the Mexican railway network. As for nominal GDP, it is available since 1895 in the *Estadísticas Históricas de México*.[12] Before that date, the growth of real GDP has been obtained from Maddison (2001) through interpolation, and has been expressed in nominal terms on the basis of the evolution of prices in Mexico City.[13] The resulting average ratio between net revenues and nominal GDP would be 0.75 percent. According to this rate, the upper bound of the "capital term" of the contribution of railways to Mexican economic growth would be around 0.09 percentage points, slightly lower than the Brazilian one.

4.2. The contribution of railways to economic growth: the TFP term.

The estimation of the "TFP term" of the growth contribution of Mexican, Argentinean and Brazilian railways is based on the available social saving estimates for those three countries. Those estimates have not the same quality and coverage. Whereas in the cases of Mexico and Brazil they are the result of the careful and deep analysis of a large amount of evidence by John Coatsworth (1981) and William Summerhill (2003), respectively, and cover both freight and passenger transport, in the case of Argentina they are the outcome of a very preliminary exercise, also carried out by Summerhill (2000), and which measures just the social savings of freight railway transport.

The estimation of the "TFP term" of the contribution of the railway technology to GDP growth requires the transformation of those social saving figures into estimates of the direct real income gain due to the railways in each country. In order to do this, the social savings must be expressed as additional consumer surplus, and corrected for the potential presence of supernormal profits in the railway system, as in Herranz-Loncán

[11] Gross revenues are only available since 1873 in Coatsworth (1981), pp. 42-43. Before that date, I have assumed the ratio between net revenues and nominal GDP to grow at the same rate as the network mileage.

[12] http://biblioteca.itam.mx/recursos/ehm.html

[13] I asume a stagnant real GDP per capita before 1870. The price index has been taken from *Estadísticas Históricas de México*, in http://biblioteca.itam.mx/recursos/ehm.html. For 1878-1885, the price index is assumed to have the same growth rate as the index of export prices in Coatsworth (1981), p. 42, and, for 1864-1875, I assume that the growth rate of real and nominal GDP were the same.

(2006). Starting with freight transport, Table 7 shows the social savings of Mexican, Brazilian and Argentinean railways in 1910/1913.[14]

Table 7. Social savings of freight railway transport in Argentina , Brazil and Mexico in 1910/1913

	Argentina (1913)	Brazil (1913)	Mexico (1910)
a) Railway freight output (million ton-km)	8.895,4	1.697,3	3,456.1
b) Railway rate (pesos/milreis per ton-km)	0.010	0.097	0.023
c) Railway freight revenues (million pesos/milreis) (a x b)	90.64	165.32	79.52
d) Alternative transport rate (pesos/milreis per ton-km)	0.083	1.388/0.727	0.241
e) Alternative transport output (million pesos/milreis) (a x d)	745.79	2,356.71/1.234,21	833.61
f) Social savings (million pesos/milreis) (e – c)	*655.15*	*2,191.39/1.068,89*	*754.08*
g) As a percentage of GDP	*26.24*	*38.45/18.75*	*24.33*

Sources: Own elaboration from Coatsworth (1981) and Summerhill (2000) and (2003).

The three social savings figures are very high in terms of GDP; much larger, indeed, than the equivalent figures for Spain or Britain. In order to obtain unbiased estimates of the additional consumer surplus of railway freight transport, these figures must be corrected according to the price elasticity of demand in each country. Coatsworth estimates this elasticity as approximately 0.5 in the case of Mexico, whereas Summerhill estimates it as 0.6 in the case of Brazil and 0.49 in the case of Argentina. All these figures are very similar, and lower than the Spanish equivalent estimate (0.79). According to these price elasticities, the additional consumer surplus of railway freight transport would have been, approximately, 356 million pesos in Mexico in 1910, 510 to 783 million milreis in Brazil in 1913 and 343 million pesos in Argentina in 1913.

These figures must be increased by the additional consumer surplus of railway passenger transport (which should include both gains in transport costs and travel time). No social saving estimate is available for this category of railway transport in the case of Argentina, but Coatsworth (1981) and Summerhill (2003) have produced careful estimates for Mexico and Brazil, respectively. These are based on the assumption that, in the absence of the railways, first class passengers would have use stagecoach transport, but second class passengers would have walked instead. Since my interest is the additional consumer surplus of passenger transport, instead of the mere social savings, here I follow a different approach. Firstly, I estimate the social savings of railway passenger transport in both countries considering stagecoach transport as the counterfactual transport system for all passenger classes. And, secondly, I correct the social saving estimates according to the price elasticity of demand, but allowing for

[14] Figures in Table 7 exclude the "hidden" or "indirect" costs of alternative transport means, due to the difficulty to measure them; see Coatsworth (1981), pp. 104-105, and Summerhill (2003), p. 61.

different elasticities in the first and second class railway transport. More concretely, for first class passengers, I consider the price elasticity of transport demand to be approximately -1,[15] and, for second class passengers, I consider railway transport as a completely new good. This is equivalent to assume that, in the year under analysis, the users of second class passenger transport would not have travelled at all at the price of the most comparable alternative overland transport system, i.e. stagecoach transport.[16] Table 8 shows the estimates of the social savings of passenger railway transport, before correcting them for the elasticity of demand.

Table 8. Social savings of railway passenger transport in Brazil (1913) and Mexico (1910)

A) First class

	Brazil (1913)	Mexico (1910)
a) Railway output (million passenger-km)	605.2	229.9
b) Railway rate (pesos/milreis per passenger-km)	0.047	0.037
c) Railway output (million pesos/milreis) (a x b)	28.44	8.45
d) Unit value of working travel time (pesos/milreis per hour)	0.891	0.356
e) Working travel time by railway (million hours)	8.023	2.299
f) Value of the working travel time by railway (million pesos/milreis) (d x e)	7.148	0.818
g) Counterfactual transport rate (pesos/milreis per passenger-km)	0.36	0.120
h) Counterfactual transport output (million pesos/milreis) (a x g)	217.87	27.61
i) Counterfactual working travel time (million hours)	24.068	6.131
j) Value of the counterfactual working travel time (million pesos/milreis) (d x i)	21.443	2.183
k) Savings on transport costs (million pesos/milreis) (h – c)	189.43	19.16
l) Savings on travel time (million pesos/milreis) (j – f)	14.30	1.36
m) Total savings (million pesos/milreis) (k + l)	*203.72*	*20.52*
n) As a percentage of GDP	*3.57*	*0.66*

[15] See, for instance, Boyd and Walton (1972), pp. 247-250, and Metzer (1977), p. 73.
[16] See, for instance, Hausman (1994).

B) Second class

	Brazil (1913)	Mexico (1910)
a) Railway output (million passenger-km)	1,012	830.5
b) Railway rate (pesos/milreis per passenger-km)	0.0265	0.0143
c) Railway output (million pesos/milreis) (a x b)	26.82	11.90
d) Unit value of working travel time (pesos/milreis per hour)	0.445	0.178
e) Working travel time by railway (million hours)	13.415	8.305
f) Value of the working travel time by railway (million pesos/milreis) (d x e)	5.976	1.478
g) Counterfactual transport rate (pesos/milreis)	0.36	0.120
h) Counterfactual transport output (million pesos/milreis) (a x g)	364.32	99.74
i) Counterfactual working travel time (million hours)	40.246	22.148
j) Value of the counterfactual working travel time (million pesos/milreis) (d x i)	17.928	3.942
k) Savings on transport costs (million pesos/milreis) (h – c)	337.50	87.84
l) Savings on travel time (million pesos/milreis) (j – f)	11.95	2.46
m) Total savings (million pesos/milreis) (k + l)	*349.45*	*90.31*
n) As a percentage of GDP	*6.13*	*2.91*

Source: own elaboration, from Coatsworth (1981) and Summerhill (2003).

When these figures are corrected according to the elasticity of demand, and under the described assumptions, the additional consumer surplus of first class passenger railway transport becomes 68.90 million milreis in Brazil in 1913 and 11.81 million pesos in Mexico in 1910. In the case of the second class, the equivalent figures are much lower (4.03 and 1.29 million), as a result of the assumption that this category of passenger transport was a completely new good. The resulting total additional consumer surplus for passenger transport is, therefore, much lower than in the case of freight (9 to 14 percent of the estimate of the additional consumer surplus of freight transport in Brazil, and 4 percent in Mexico), which is consistent with the low importance that passenger transport had in the direct benefits that Mexico and Brazil received from the railways, according to Coatsworth (1981) and Summerhill (2003).

As has been indicated, in the case of Argentina, no social saving estimates for railway passenger transport are available. However, one possibility to approach the additional consumer surplus of railway passenger transport is to use the ratio passenger-km/ton-km in 1913 as a proxy of the relationship between the additional consumer surplus of passenger and freight transport, using the Mexican and Brazilian data as reference. This procedure may, of course, introduce several biases in the final "guesstimates". For instance, the savings in travel time might be higher in Argentina due to the higher level of wages in the country. By contrast, the savings in transport

costs might be lower, due to the relatively high level of railway passenger fares in Argentina, compared to freight transport rates.[17] Nevertheless, it must be stressed that the low importance of passenger transport in the total additional consumer surplus of railways reduces the relevance of these biases.

On the basis of these assumptions, I estimate the additional consumer surplus of passenger railway transport in Argentina to be around 13 million pesos in 1913, i.e. 3.8 percent of the additional consumer surplus of freight railway transport. This percentage is similar to the Mexican one, since the ratio between passenger-km and ton-km in 1913 in Argentina and in Mexico were very similar (0.32 and 0.31 respectively). By contrast, that ratio was much higher in Brazil (0.95).

The lack of information prevents from including in the additional consumer surplus estimates other sorts of freight transport (essentially high-speed freight), which accounted for a non-negligible share of railway revenues.[18] Their absence would introduce certain downward bias in the additional consumer surplus figures. This bias, however, is probably small. Since, as in the case of second class passenger transport, most of that traffic might be considered as a completely new commodity, its contribution to the additional consumer surplus may be expected to be rather low.

Finally, the estimates of the additional consumer surplus of freight and passenger transport should be corrected for the potential presence of supernormal profits in the railway system, in order to obtain a measure of the real income gain due to the railways in each country. Supernormal profits should be calculated as the difference between gross revenues and total expenditure, including capital costs. The latter, in turn, may be estimated as a percentage of the value of the stock of railway capital, which should include both the amortisation rates and the opportunity cost of capital. This calculation, however, is far from easy, due to the accounting procedures that were followed at the time. On the one hand, operating costs often included some replacement and new investment expenditures, which were not, therefore, incorporated to the capital account. On the other hand, railway capital was rarely depreciated, leading to an

[17] By contrast, the ratio between counterfactual and railway passenger transport fares would be rather similar in the three countries. Lewis (1983), p. 22, indicates that the price of the travel by stagecoach from Buenos Aires to San Fernando was 6 to 10 shillings in the 1870s. If this figure is transformed into pesos per passenger-km and deflated according to the evolution of prices, the resulting figure (0.15 pesos approximately) would be 8-9 times the average passenger fare of the Argentinean railways in 1913. This ratio would be in the same range as the Brazilian and Mexican ones.

[18] For instance, this kind of traffic would have accounted for 11.8 percent of the total revenues of the Brazilian railway companies in 1913 (percentage estimated from Summerhill, 2003).

overstatement of the capital stock figures.[19] In addition, in those countries, such as Argentina and Brazil, where railway subsidies mainly consisted on guaranteed returns upon investment, capital figures used to be artificially inflated by the companies.[20] In this context, it is very difficult to obtain an accurate estimate of supernormal profits. Therefore, here I just compare the difference between the net returns of each system and the opportunity cost of capital, approached through yields to government bonds, in order to have a preliminary idea of their potential size.

Net operating returns were 4.1 percent of total investment in the British-owned Argentinean railways by 1913 (Lewis, 1983, p. 199), and 3.6 percent in the Brazilian railways in the same date.[21] Given that the yields to government bonds were 4.97 percent in Argentina and 4.9 percent in Brazil at the time (Flandreau and Zumer, 2004), it seems likely that supernormal profits were absent from those two railway systems. Apparently, net revenues might not have been sufficient to cover capital costs. Therefore, the additional consumer surplus estimates coming from the previous calculations should be decreased by the difference between the cost of capital and the net returns in the system. However, compared with the additional consumer surplus of railway transport, those negative "supernormal profits" would be relatively small. For instance, in the case of Argentina and Brazil, if I take the yields on bonds capital as a proxy of the opportunity cost of capital and ignore amortization needs, that correction would amount to just 3-4.5 percent of the additional consumer surplus. Therefore, given the uncertainty on the real value of investment in those railway systems, I have decided to exclude this correction from the final figures.

Table 9 summarises the results of the estimation of the direct real income gain of railway transport in each country. These figures allow calculating the "TFP term" of the growth contribution of railways, by expressing that income gain as a contribution to the yearly growth rate of the economy between the start of the railway era and the reference year of the estimation. Broadly speaking, the resulting estimates are substantially higher than the British and Spanish equivalent figures.

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[19] See Summerhill (2003), p. 169.

[20] This would be the typical Averch-Johnson effect; see Averch and Johnson (1962). In the case of the *Ferrocarril Central Argentino*, López del Amo (1989), pp. 240-241, estimates that the company's accounts exaggerated investment figures by 57 percent between 1908 and 1930.

[21] In the case of Mexico, there are no available estimates of the total capital invested in the network and, therefore, it is not posible to calculate an average rate of return; see Ortiz Hernán (1996), p. 28. However, if the net revenues in Table 5 are combined with the estimate of 1,130 million pesos of foreign investment in Connolly (1997), p. 83, the resulting percentage is less than 3 percent.

Table 9. Direct real income gain from railway transport in Argentina, Brazil and Mexico in 1910/1913

	Argentina (1913)	Brazil (1913)	Mexico (1910)
a) Freight transport additional consumer surplus (million pesos/milreis)	342.93	510.31/783.05	355.91
b) First-class passenger transport additional consumer surplus (million pesos/milreis)	13.06	68.90	11.81
c) Second-class passenger transport additional consumer surplus (million pesos/milreis)		4.03	1.29
Total (a+b+c)	355.98	583.24/855.98	369.01
As a % of GDP	14.26	10.25/15.05	11.90
As a contribution to the yearly growth rate since the beginning of the railway era (%)	0.234	0.163/0.233	0.240

Sources: see text.

4.3. Summary.

The figures presented in the previous subsections have been used to make a preliminary estimation of the contribution of railways to economic growth in Argentina, Brazil and Mexico before World War One, which is offered in Table 10.[22]

Table 10. The contribution of railways to economic growth in Mexico, Brazil and Argentina before 1914 (percentage points per year)

	Argentina (1857-1913)	Brazil (1854-1913)	Mexico (1864-1910)	Britain (1830-1850)	Britain (1850-1870)	Britain (1870-1910)	Spain (1850-1912)
a) Railway capital stock growth	12.5	11.0	12.0	23.5	6.7	1.3	4.7
b) Railway profits share in national income	2.06	1.16	0.75	0.6	2.1	2.7	0.86
c) Railway capital contribution (a x b)	*0.258*	*0.127*	*0.091*	*0.14*	*0.14*	*0.03*	*0.040*
d) Railway TFP growth	-	-	-	1.9	3.5	1.0	-
e) Railway share in national output	4.85	3.94	2.07	1.0	4.0	6.0	1.89
f) Railway TFP contribution (d x e)	*0.234*	*0.163/0.233*	*0.240*	*0.02*	*0.14*	*0.06*	*0.069/0.092*
g) TFP Spillovers	-	-	-	-	-	-	-
h) Total railway contribution (c+f+g)	*0.492*	*0.290/0.361*	*0.330*	*0.16*	*0.28*	*0.09*	*0.109/0.132*
i) GDP growth	6.06	2.07	3.48	1.81	2.17	1.71	1.42
j) Railway contribution as % of GDP growth (h/i)	*8.12*	*13.98/17.41*	*9.49*	*8.89*	*12.9*	*5.54*	*7.67/9.29*

Source: see text.

Figures in the table indicate that the contribution of railways to GDP growth was much higher in the three Latin American economies than in Britain or Spain. The railway technology provided half a percentage point of GDP growth to Argentina and one third to Brazil and Mexico yearly between the mid nineteenth century and the eve of the First World War. By contrast, the contribution of railways to growth was substantially lower in the two European economies considered (except for Britain in the 1850s and 1860s).

The reason for that situation was two-fold. On the one hand, the growth of the railway capital stock was much higher in the three Latin American economies

[22] The calculation of the output shares, which is included in row (e) for the sake of comparison with Britain and Spain, has followed the same procedures as the estimation of the profit share ratios which are presented in section 4.1.

throughout the period under study. As has already been indicated, whereas the construction of new railways stagnated in Britain and Spain since the last decades of the nineteenth century, it went on at a very high pace in Argentina, Brazil and Mexico until 1910/1913, stimulated by the first globalisation boom. On the other hand (and this is the main reason for the difference between both sides of the Atlantic), the "TFP term" of the contribution of the railway technology to GDP growth was two to three times larger in the three Latin American countries. This was the result of two main factors. First, the difference between the cost of railway transport and the best available alternatives was much higher in Argentina, Brazil and Mexico than in the UK, or even in Spain, as may be seen in Table 11. And, secondly, as is shown in row (e) of Table 10, the output share of the railway sector was relatively high in Argentina and Brazil (although not in Mexico), reaching levels comparable to the British, and much higher than the Spanish ones. In other words, in Argentina and Brazil the relevance that railway transport achieved within the whole economy, which was to a large extent the result of the export boom, was probably comparable to the importance that the sector reached, although for different reasons, in the industrialised economies before 1914. By contrast, in Mexico the size of the railway sector remained more moderate in relative terms.

Table 11. Ratio between railway and alternative freight transport costs in different countries.

US (1859)	0.30
England and Wales (1865)	0.38
France (1872)	0.32
Russia (1907)	0.38
Spain (1912)	0.14
Mexico (1910)	0.10/0.19
Brazil (1913)	0.07/0.14
Argentina (1913)	0.12

Sources: see Table 4.

If the whole direct contribution of the railway technology is expressed as a percentage of GDP growth, the advantage of Argentina and Mexico vanishes, as a result of the high growth rate that those two economies, and specially Argentina, enjoyed during the period under study. In both Argentina and Mexico, the railway technology accounted for a percentage of aggregate growth which, although very high for a single sector, was similar to the British or Spanish one (8-9 percent). By contrast, in Brazil, the railway technology accounted for almost one sixth of all GDP growth between 1854 and 1914. This is, of course, the reflection of the much slower growth rate of the Brazilian

economy, but also confirms Summerhill's consideration that: "*the railroad conferred on Brazil benefits that probably exceeded, by far, those stemming from the other major changes in economic organization in this period*" (Summerhill, 2003, p. 96).

Finally, it is necessary to recall that the growth accounting figures in Table 10 exclude TFP spillovers, due to the difficulty to quantify them. The relevance of TFP spillovers from the railways is a non negligible potential source of downward biases in growth accounting estimates, and this is specially so in the case of the Latin American countries, where the railways allowed the exploitation of a growing amount of natural resources that would have remained idle without them (Summerhill, 2003, p. 78). This impact is therefore a crucial source of understatement of the growth contribution of the railway technology, which may be considered to have been more relevant in the Latin American countries (and especially in the new settlement areas, such as Argentina and, to a large extent, Brazil) than in Europe. Therefore, the absence of estimates of these dynamic gains probably transforms the figures in the last rows of Table 10 into a lower bound of the "true" growth contribution of the railways in those three Latin American countries.

5. Concluding remarks

Railways constituted one of the most important technological breakthroughs of the nineteenth century, leading to a substantial upward shift in national economies' production functions worldwide. This paper has provided preliminary estimates of the direct contribution of railways to GDP growth in three of the most important Latin American economies during the first globalisation boom. The results of the estimation indicate that the contribution of the railway technology to GDP growth in Argentina, Brazil and Mexico during the decades before 1914 was substantially higher than in Britain or Spain, although in Argentina and Mexico it was somehow disguised behind the fast growth of the aggregate economy. This high contribution was, indeed, a sign of the central role that the railways performed in the export-led growth episode of those three economies.

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